Chapter 3 - The Open Innovation Paradigm

In this chapter, we will explore an emerging paradigm that is replacing the earlier paradigm of Closed Innovation. This new approach is based on a different knowledge landscape, with a different logic about the sources and uses of ideas. Open Innovation means that valuable ideas can come from inside or outside the company, and can go to market inside or outside the company as well. This approach places external ideas, and external paths to market, on the same level of importance as that reserved for internal ideas and paths to market during the Closed Innovation era.

Figure 3.1 below provides a depiction of the knowledge landscape that results from the flow of internal and external ideas into and out of firms A and B. Ideas abound in this environment, both within each firm, but also outside the firms. These ideas are available to be used, and often the people who created them are similarly available for hire.

The availability and quality of these external ideas change the logic that led to the formation of the centralized R&D silos of the closed innovation paradigm.

How to Access Useful Knowledge: The thought experiment one hundred years later

Let's return to the thought experiment of the last chapter. What if you had become a leading company in your industry in the year 2000, rather than in 1900? How would you go about creating a mechanism to generate useful knowledge, to continue to advance the technologies that support your growing business? Would you choose to create an internal, central R&D organization that was responsible for investigating all the important areas of science behind the technology you plan to use?

The knowledge landscape in which you operate makes a big difference in how you would answer that question. Today, there is an abundance of knowledge in virtually every field around you. The proliferation of public scientific databases, online journals and articles, combined with low cost internet access and high transmission rates can give you access to a wealth of knowledge that was far more expensive and time consuming to reach even ten years ago.

The universities are full of professors with deep expertise. Better yet, these professors are surrounded by graduate students, who apprentice themselves to these professors. While the science being done is excellent, it is clear that many professors and their graduate students are eager to apply that science to business problems. The norms of science and engineering have changed as well: there aren't many Henry Rowlands in university science departments anymore.

As government funding for basic scientific research declines in real terms in most scientific fields, faculty even have learned to seek out industry support for their research. Their search has helped them become more astute about the needs and problems of industry. Their future research agendas are coming to reflect important problems being confronted in industry.[i]

And this abundance of knowledge is not limited to just the top handful of universities. There are literally dozens of universities with world class research capabilities in at least a few areas (though only the top universities can maintain scientific excellence across a broad range of areas). Moreover, the demonstrable success of US higher education has led to the imitation of that model in many areas of the world. Whether it is the top technology Institutes in India, the Hong Kong University of Science and Technology, the National University of Singapore, or the Technion in Israel, the quality of scientific knowledge has spread well beyond the shores of the US, to reach much of the developed world. In the world of the Internet, leading scholars from around the world contribute new papers to online archives, creating a global community of scholars.

The End of the Knowledge Monopolies

The rise of excellence in university scientific research, and the increasingly diffuse distribution of that research, means that the knowledge monopolies built by the centralized R&D organizations of the last century are over. Knowledge is far more widely distributed today, when compared to, say, thirty years ago. And this far greater diffusion of knowledge changes the viability and desirability of a Closed Innovation approach to accessing and taking new ideas to market.

Another piece of evidence that supports the greater distribution of knowledge in the knowledge landscape, for example, is the changing level of concentration in patent awards. Patents are one outcome of a knowledge generation process, and thanks to the US Patent and Trademark Office, there are good data available on who receives US patents. Table 3.1 shows which firms were the top 20 patent recipients of US patents during the 1990s. As the table shows, of the more than 400,000 patents issues by the USPTO over that decade, these top 20 companies only received only 11% of the awarded patents. Relatedly, the number of patents held by individuals and small firms has risen from about 5% in 1970, to over 20% in 1992.[ii]

[Table 3.1 about here]

A second indicator of increased knowledge diffusion is how many US patents are now held by non-US companies. As the text at the bottom of the Table 3.1 shows, 45% of these patents were held by companies headquartered *outside* the US. Some of these are now among the top twenty recipients of US patents. This is a second indication of knowledge diffusion, a diffusion beyond the national borders of the US.

A third indicator of this diffusion is reflected in US government statistics of R&D

by size of enterprise. Industrial research and development is one key process that generates ideas, and makes use of them. As Table 3.2 shows below, the share of industrial R&D has increased greatly for companies with less than 1,000 employees from 1981 through 1999. While large company R&D remains an important source of R&D spending, the majority of R&D spending in the US is now done by companies with less than 25,000 employees – a marked change from just 18 years earlier, when the largest companies did more than 70% of industrial R&D spending. And, as the table shows, most of this shift occurred in the past ten years, between 1989 and 1999. There seem to be fewer economies of scale in R&D these days.[iii]

[Table 3.2 about here]

A fourth indicator is the rise in college graduates and post-college graduates in the US. This rise reflects the social investment in human capital, that creates the raw material to discover and develop ideas. This rise is a great success of US public policy after the second world war, though one reads little about this triumph.

There is an international dimension to this diffusion of knowledge as well. The days of the intellectual autarky enjoyed by many US firms after the second world war are over. As noted above in Table 3.1, nearly half of all US patents issued in 1999 went to companies outside the US. At Stanford and MIT, for example, more than 50% of the post-doctoral scientists and engineers came from outside the US (source: NSF/Scientific Resource Study, Science and Engineering Indicators, 1998).

These diffusion forces seem likely to persist. Within the US, the pattern of high labor mobility is unlikely to return to the earlier pattern of long term or "lifetime" employment.[iv] Pension systems in the US are increasingly portable, meaning that they travel with the worker, rather than with the job, further promoting mobility. While venture capital has retreated from the heady days of the dot.com bubble, it remains a reality that will not go away.[v]

Knowing all this, what mechanisms would you create to access this abundance of knowledge? Would these mechanisms bear any resemblance to the central R&D lab of the previous chapter?

No. The central R&D lab is based on a logic of deep vertical integration. This logic posits that in order to do anything, one must do everything; from tools and materials, to product design and manufacturing, to sales, service and support. But this do-it-all-yourself approach only makes sense in a world of scarce external knowledge. If instead, a leading firm wishes to advance its technology in a world of abundant knowledge and competence, it will find a great deal of value on the outside. Expertise is readily available for hire, and need not require extensive internal training, or the inducement of life-long employment. One can choose ideas off of a diverse menu of discoveries at a variety of universities. A wealth of capable suppliers applying their own impressive expertise across a variety of businesses is another resource, ready to be tapped to harness and develop these ideas. Venture capital startups may be developing useful technology, which was sitting on the shelf of another company, or coming out of a university.

The logic underlying the innovation process now is completely reversed. Even the expression “Not Invented Here” today has an entirely different meaning. Today NIH means reinventing a completely unnecessary wheel, since external sources can be relied upon to do the job effectively. Indeed, internal sources may deliver products at lower volume and higher cost, relative to what a world class outside vendor, serving a worldwide market, can provide. In an abundant landscape, one can now do a great deal by focusing in a particular area, without having to do everything.

If you were trying to develop mechanisms to access useful knowledge today, you would start by surveying the surrounding knowledge landscape. You would like to use as much of the surrounding knowledge as possible, and fund the creation of as little new knowledge as necessary to get the knowledge you need in a timely basis. In addition to the specialized knowledge your researchers developed to enact a strategy of deep vertical integration, your researchers also will need the conceptual ability to scan a wide range of science and technology, and envision how to integrate promising discoveries together into new systems and architectures.

What would you do to access external knowledge? At the simplest level, you might employ university professors for a summer, to work alongside your own people. An even cheaper idea would be to hire some graduate students of a professor to work with you. If you wanted to carry this further, you could even choose to fund external research at a nearby university. While you could not expect to own the results of this research, you could expect to gain early access to any promising results, and perhaps get a head start on applying those results to your industry.

If you funded a number of projects, you could expect to get proposals from researchers looking for funds. This is a low cost way to scan the opportunity horizon in scientific and engineering fields in which you are interested. Before you spend any money, you get to review a variety of research proposals from scholars who know a great deal about the state of the art in that area.

You might scout the activities of young startup companies working in areas of interest to you. There are a number of ways to learn about their efforts, ranging from occasional business development discussions, to strategic alliances, to giving money to interested venture capitalists to invest in areas of value for you, to investing directly yourself in promising startup companies.

As we will explore in Chapter 6, some companies such as Intel have actually conducted our thought experiment. Intel is a rather young company, founded in 1968. Despite its impressive size, it only really began a formal advanced research and development strategy back in 1989. It relied almost entirely upon external research up to that point in time. Today, while Intel has created an internal research capability to some degree, it plans its research efforts by assessing what is available from the outside, before charting its own course inside. Intel has a very well thought-out program of funding university research projects, spending over $100 million a year. Intel also follows closely the activities of startups in the computer and communications industries, through a variety of means that range from informal alliances to corporate venture capital investment.

In the life sciences, a number of even younger companies such as Millenium and Genzyme are thinking hard about their innovation strategies, in another very scientifically-intensive industry. Yet, as we will see in Chapter 8, their solutions for managing innovation also depart significantly from the traditional paradigm of R&D. Even large, successful firms such as IBM and Merck, who prospered in the Closed Innovation regime, are also broadening their approach towards research, beyond their internal programs, towards building access mechanisms to tap into the wealth of external knowledge around them.

Towards a New Logic of Innovation

Some long-time observers note these trends, and throw up their hands in despair. "The research game is over". "Where will the seed corn that fuels the next generation of discovery come from?", is another concern often voiced. Even more measured published work has concluded that industrial research is "at the end of an era".[vi]

The traditional paradigm that companies used to manage industrial R&D is indeed over is most industries. But that does not mean that internal R&D itself has become obsolete. What we need is a new logic of innovation to replace the logic of the earlier period. Companies must structure themselves to leverage this distributed landscape of knowledge, instead of ignoring it in the pursuit of their internal research agendas. Companies increasingly cannot expect to warehouse their technologies until their own businesses make use of them.

The new logic will *exploit* this diffusion of knowledge, rather than ignore it. The new logic turns the old assumptions on their head. Instead of making money by hoarding technology for one's own use, you make money by leveraging multiple paths to market for your technology. Instead of restricting the research function exclusively to inventing new knowledge, good research practice also includes accessing and integrating external knowledge. Instead of managing intellectual property as a way to exclude anyone else from using your technology, one manages IP to advance your own business model, and to profit from your rivals' use. One's own R&D strategy should benefit from external startup companies' abilities to initiate multiple organizational experiments to commercialize technologies. One might even occasionally help fund a young startup, to explore an area of potential future interest.

This is not to say that firms should discontinue all internal research activity. It is to say, though, that what research is done internally should take into account the wealth of activity outside the firm. Nor does the new logic maintain that all result outputs will henceforth fit with the company's current business. There will be research outputs that will not be well utilized by the firm's own businesses. However, it is to say that these underutilized outputs will not last long on the shelf, and should be managed accordingly. The projects that sat on the shelf between R and D were part of "the cost of doing business" in the old paradigm. They become revenue opportunities and new business platforms in the new paradigm.

There will also be technologies needed by the business that the internal research organization did not know to create. Research takes a long time to deliver useful outcomes, and company strategies change at a far faster rate than the rhythm of basic research. In the new paradigm, the businesses cannot (and should not) wait for the internal technologies to arrive; instead, they should access what they need, as soon as they need it – either from inside the company's own research labs, or from the knowledge created in someone else's lab.

[box] New reasons for internal R&D: in a bountiful knowledge landscape, one organizes internal research and development to:

- Identify, understand, select, and connect to the wealth of external knowledge that is available
- Fill in the missing pieces of knowledge not being externally developed
- Integrate this knowledge to form more complex combinations of knowledge, to create new systems and architectures
- Generate additional revenues and profits from selling research outputs to other firms for use in their own systems.

These factors that promote knowledge diffusion at the same time create new opportunities. These factors reward focused execution. One need not invent the *most* new knowledge, in order to win. One need not invent the *best* new knowledge in order to win. Instead, *one wins by making the best use* of internal and external knowledge in a timely way; creatively combining that knowledge in new and different ways to create new products or services.

The New Role of Research: Beyond Knowledge Generation to Connection

Open Innovation thinking changes the role of the research function. It expands the role of internal researchers to include not just knowledge generation, but also knowledge brokering. Previously, researchers simply added to the knowledge sitting in the silos. Today, they are also charged with moving knowledge into and out of the silos.

In this new role, knowledge located from outside may be just as useful as knowledge created from within – and it should be similarly rewarded.

The additional role of identifying and accessing external knowledge, in addition to generating internal knowledge, changes the career paths of researchers inside R&D firms. While deep understanding remains valuable, its utility is multiplied when it is linked to and builds upon the investigations and achievements of others. This causes research managers to evaluate researchers' performance in different ways. It may require different paths of promotion, and rotational assignments for researchers in areas that interact with external participants outside the company, such as business development.

One example of this new role comes from Merck, perhaps the leading pharmaceutical firm in the world, in terms of doing its own research. Merck is well known for its commitment to conducting significant internal scientific research, and is proud of the research discoveries that its scientists have made during the past century. But in its Annual Report for the year 2000 (p.8), it noted that,

> "*Merck accounts for about 1% of the biomedical research in the world. To tap into the remaining 99 percent, we must actively reach out to universities, research institutions and companies worldwide to bring the best of technology and potential products into Merck. The cascade of knowledge flowing from biotechnology and the unraveling of the human genome- to name only two recent developments – is far too complex for any one company to handle alone.*"

Toward that end, Merck has now charged its internal scientists with a new task: create a virtual lab in your research area. This means: don't just create excellent science in your own lab; rather, identify and build connections to excellent science in your area, wherever it may be. In the words of Merck's head of R&D, "*Every senior scientist here running a project should think of herself or himself as being in charge of all the research in that field. Not just the 30 people working in our lab but the 3,000 people, say, in the world working in that field.*" [source: Merck A/R 2000, p. 8]

This is a case where the messenger is as important as the message. Few would dispute that Merck is among the most scientifically capable pharmaceutical firms in the world. When a firm with Merck's reputation for the excellence of its own science determines that it needs to connect deeply with the external knowledge base to be successful, other firms would do well to follow Merck's lead.

A New Perspective Towards Venture Capital

Venture capital is a reality that will not go away. While VC returns have recently been terrible, and the amount of VC funding has dropped by over 70% from its peak in 2000, the amount of money available for investment remains at levels that were considered historic highs as recently as 1998.[vii] The recent drop has wrung out some of the excesses in the VC industry, and weeded out many of the marginal participants. But the leading firms have billions of dollars of capital under management, and making new investments, in a number of promising areas.

Open Innovation companies accept that venture capital, and the myriad startup firms they fund, will be an enduring part of the landscape for innovation. Companies caught in the closed innovation paradigm view the VCs as “pirates and parasites” – people to be punished if possible, and avoided if not. But Open Innovation Companies have gotten beyond the negative consequences of venture capital. They have come to understand that there are some markedly positive benefits from having a vibrant VC community around them.

The same VCs that threaten to extract key personnel and technology from within, also comprise a seedbed of new organizations experimenting with new combinations of technologies. VCs often apply new technological combinations to nascent markets that are being neglected by the large companies. These startups function as a series of small laboratories that can guide the technological strategies and market directions of large firms. Open Innovation firms regard companies financed by VCs as pilot fish for new potential market opportunities, because these startup firms are selling real products to real customers who pay with real money. This is the most valid, most useful market research on future technologies and future market opportunities that money can buy.

These novel combinations provide learning opportunities for established companies to monitor, and potentially leverage, if and when they prove valuable. As evidence of the viability of these “lessons” emerges, Open Innovation firms may actually change their own technology strategies as a result. They learn faster, and adapt their own strategies more rapidly, as a result of co-existing with an environment filled with VCs and their startup firms. Dismissing the VCs as pirates and parasites forfeits important learning opportunities from observing the portfolio companies that they fund.

Some Open Innovation companies (OICs) carry this logic even further. They may choose to foster the creation of useful startup firms, investing in some of these experiments early on, [viii] or partnering and allying with them later on. Occasionally, they may even acquire a few of the most promising among them. These companies regard the VC community, and the startups they fund, as mutualistic participants in a complex ecosystem of firms that create, recombine, compete, imitate and interact with each other.[ix]

Other OICs actually utilize venture capital internally, to catalyze their own innovation process. As we will see in Chapter 7, Lucent uses corporate venture capital investing to create new technology companies out of its under-utilized technology within Bell Labs. This internal venture capital pool (called Lucent's New Venture Group, or NVG) is married to underutilized technologies to create new spin-off companies. These spin-offs affect Lucent's internal R&D in at least three important ways.

- First, it provides an outside path to market for technologies that might otherwise sit on the shelf within the Labs. This brings in additional money to Lucent, creates additional options for its research staff, and frees up resources to hire in new researchers.
- Second, it forces technology to move faster out of the Lab. Whenever the NVG identifies a candidate technology for spin-off, at starts a clock within

the company's businesses. If they don't commit to use that technology themselves, then the NVG gets the opportunity to spin it off into a new venture. This creates a forcing function to pull technologies out of the Lab at a faster rate.

- Third, Lucent's NVG ventures provide an experimental setting to see Bell Labs' technologies in different uses in different markets. This provides valuable feedback not available to Lucent, so long as the technology stays bottled up in the lab. By getting the technology out to the market sooner, Lucent learns more faster about customer needs, trends, and new opportunities.

Customers also have important information that can be vital to open innovation. The most advanced, most demanding customers often push your products and services to the extreme. In doing so, they themselves attempt to create new combinations with your offerings as part of the building blocks. In a real sense, they are innovating themselves, what Eric von Hippel calls lead users.[x] These experiments may again yield new knowledge. People may use your technology in ways you never expected. In the process, customers' experiments often yield new features or requirements for what you build yourself. If you respond to these required changes, then a new round of learning can begin.

This process of innovation and discovery seeks out these iterative loops of learning. Before, companies chose to wait until the technology is "ready" to ship to customers. The mindset was "we know what they want, and they'll wait until we say it's ready".   OICs invite the customer into the innovation process as a partner and co-producer. Here the mindset shifts to "here are some of our thoughts, and here's a product that features them. What can you usefully do with them? What can we do to help you do something even more useful?".

Open Innovation and Managing Intellectual Property

Many companies relegate licensing decisions and patent protection to their Legal department. To the extent that intellectual property (IP) is part of a company's technology strategy, it is usually managed so as to preserve design freedom of the company's internal staff. Open Innovation Companies regard IP as an integral part of technology strategy, and insist on managing it at a strategic level within the company. OICs are not only interested in selling IP; they are motivated and informed buyers of IP as well.

These firms accept that the ability to control an important technology exclusively for an extended period of time is seldom achieved, and even more rarely maintained. The forces that diffuse knowledge are so many and so strong, that prudence suggests that the wiser course is to plan one's own technology strategy under the assumption that it will be rapidly diffused and imitated.

In a world of powerful forces that rapidly diffuse useful knowledge, the mindset towards IP changes greatly. One implication of Open Innovation is that companies must increase their own “metabolic rate” at which they access, digest, and utilize knowledge. Companies cannot treat their knowledge as static; they must treat it as fundamentally dynamic. One cannot inventory technology advances on the shelf, for the day when they may prove valuable. Open Innovation companies use licensing extensively to create and extend markets for their technology. And the faster technology gets out of the lab, the sooner researchers will learn new ways to apply, leverage and integrate that technology into new offerings.

But doesn’t this run the risk of cannibalizing one’s own business? This fear is based on a false premise: if you don’t obsolete your products, no one else will either. While this may be true on occasion, it will more often be false, in a world of widely distributed knowledge and competence. There are often ways of inventing around a firm’s intellectual property that allow competitors to enter very quickly, even when the firm seeks to exclude rivals from using its ideas.

And the costs are much greater for moving too late, than they are for moving too soon. If you err on the side of premature cannabalization, the cost is that you lose some potential profit you might have been able to eke out otherwise. If you err on the side of delay, the costs are deeper and longer lasting. You lose market share among your customers, and now must confront stronger competitors, who now receive additional resources from your former customers.

There is also a subtle internal cost. Think of your researchers who worked hard to bring the technology through many difficult hurdles, and got it ready to go to market. They then watch as someone on the business side squanders their efforts, by holding it off the market so that current sales and margins will be maximized. How motivated will these researchers be for the next big push, to provide the ammunition to allow the business to recapture the terrain lost to companies who didn't delay the deployment of their new technology? If you were one of these researchers, wouldn't you think of going to work for a company that would make active use of your ideas, as soon as you had them available; which would then allow you to see your ideas in action, and learn from the use that others make of them?

Internal Competition: Increasing the Metabolism of Knowledge

As we saw in Chapter 2, there was a mismatch between the incentives of a laboratory, operating as a cost center, and the incentives of a development group operating as a profit center. Open Innovation companies try to overcome this mismatch by providing additional channels to market for the technology, and enabling business units to source knowledge from places outside of the internal laboratory.

Subjecting the internal path to market (i.e., the business unit expecting to receive the technology) to some competition from other paths to market is an excellent way to increase one's metabolism of new knowledge. Just because your research team comes up with a better mousetrap, does not mean that your sales team is the best way to sell that mousetrap. Your sales team may be distracted by selling earlier successful innovations you have made, while some other organization may be hungry to exploit your discovery in some new and interesting way.

Most companies refuse to countenance licensing to an outside company, or refuse to take equity in a new startup to pursue the technology, because of the risk of internal competition that would result. Open Innovation companies think that a little competition may be no bad thing. They also know that their internal marketing and sales group may pay more attention and move faster toward adopting a new technology if an external group starts having success with the technology.[xi]

Setting and advancing the architecture with internal R&D

The Open Innovation paradigm is not simply an approach that relies upon external technologies for innovation. There remains a critical role for internal R&D in this approach: the definition of an architecture, to organize the many parts of a new system. An architecture is a hierarchy of connections between disparate functions within a system, which joins the technologies together into a useful system. In any early stage of a technology's evolution, there are many possible ways that the different component technologies might relate with one another. The greater the number of components, the greater the number of possible interconnections between them.

Utilizing internal R&D allows the firm to create a new architecture when the many possible connections within a system are not known. Early in the life of a promising new technology, its characteristics and capabilities may be only poorly understood. The complexities of the new approach create many ambiguities about how best to incorporate it into systems. At this stage, it is difficult to specify interconnections between the new technology and the larger system.[xii] There are many possible ways to partition the system to reduce its overall complexity, and there may be no obvious best way to proceed.

Relying entirely upon external technologies in such circumstances to determine these interconnections is doomed to failure, since the companies making these technologies will all differ on the best way to utilize their technology. In fact, each component maker will want its technology to serve as the critical technology in the system, to enable its maker to obtain more profits and more control over the system. Moving the resolution of this interconnection problem within the firm allows the firm to bypass the possible holdups by companies who perceive that they have obtained control over a key portion of the system, due to how the relations among its parts are defined.

In order to coordinate the complexities and resolve the ambiguities, firms must develop deep expertise in many areas, systems-level expertise, to understand how a technology really works. In so doing, they assess what aspects of the new technology have what consequences for the larger system. The activities in one functional area influence the work of another functional area, so there is intensive information exchange both within a function, and between functions. As these influences become clearer over time, companies are able to partition tasks to resolve the earlier ambiguity they faced.

The resulting interdependencies between the parts of the system is shown below in Figure 3.2. In this Figure, components A,B, and C comprise the System, and they all interrelate. Changing one component requires changes in all other parts of the system, because the relations between the parts are not clearly understood.

[Figure 3.2 about here]

Developing this understanding of the relationship between the parts of a system and the system as a whole is a critical role for a company's innovation system. Technically, researchers need to experiment with many varying parameters of the technology, to map out how changes in one part of the system affect the response of other parts of the system. In Figure 3.2 above, if one changes part A in the highly simplified system shown, parts B and C must also change. In real systems of thousands of constituent parts, the possible interactions between parts in the system could number in the millions. Mapping out interactions, and then creating architectures to bound these interactions, without worrying about which parts are advantaged in the struggle for profits and control, are important technical contributions of the internal R&D process.

Utilizing architectures to reduce interdependencies and limit complexity is only one element of the value added by internal R&D. Companies' architectures also have powerful implications for how the value chain and surrounding ecosystem will be structured. A valuable architecture not only reduces and resolves technical interdependencies; it creates opportunities for others to contribute their expertise to the system being built, even as it reserves opportunities for the firm to carve out a piece of the chain for itself to profit from the research that led to the creation of the new technology. Even very good technologies will flounder if they do not connect effectively together, while seemingly inferior ones may overtake them if they are better integrated. This requires firms to collaborate with others in their ecosystem, as well as to compete with them. [xiii]

Over time, as the technology matures, interdependencies become clearer, and become more manageable. Companies can specify what they want; they can verify what they get, and they can add or drop vendors to reward or punish compliance. Intermediate markets can now emerge at the interfaces in the architecture, and specialist firms can enter to serve one layer within the architecture. The earlier "vertical" character of technological competition in the immature phase of the technology, where internal R&D was critically necessary to sort out the complexities, gives way to a more "horizontal" phase of technological competition, where external technologies compete on the basis of an established architecture. [xiv]

In the bottom of the Figure, 3.3, the system is shown with the component interdependencies now well-understood. In this system, parts A, B, or C could change, without causing any change in the other components. This enables companies to assemble systems more easily, since they can "plug and play" components whose interface characteristics are now well understood. In a well-established architecture, hundreds and even thousands of firms can innovate better component technologies, without worrying about the possible impact of their improvements on other parts of the system.

[Figure 3.3 about here]

Open Innovation firms must be adept enough to shift their approach when this transition arises. Remaining deeply vertically integrated, which was vital to sorting out the intricacies of the immature technology in the earlier phase, now becomes a millstone around one's neck. Companies must open themselves horizontally, by participating in the intermediate markets within the architecture. This may involve buying some parts externally that save money, reduce development time, or provide desired features to the system. It may involve offering parts externally to companies that compete at the systems level.

Crafting an "Architecture" for the Business

Crafting connections between technologies inside a system is a necessary function in order to manage the tremendous complexity of modern day products and services. As challenging as that is, it is only a portion of the task of the innovating firm. It is at least as important to identify how the firm is going to create and capture value from its innovation activities. In the next chapter, we will explore the business model, as a construct that creates an architecture for the business, through a blend of internal and external activities. As we will see, the activities of external firms can help create significant value for a firm and its customers, while the firm's own activities are central to being able to retain a portion of that value for itself.

Figure 3.1 – The Knowledge Landscape
In the Open Innovation Paradigm

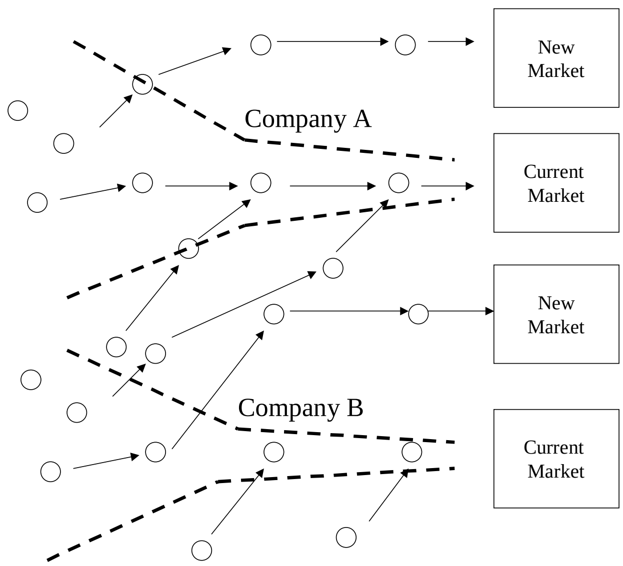


Table 3.1 Ranked List of Top-20 Organizations Holding United States Patents (cumulative)

	Patents by Year of Grant	**Pre-1986**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**Total**
1.	International Business Machines	9,078	598	591	549	623	609	679	843	1,085	1,298	1,383	1,869	1,724	2,657	2,756	26,342
2.	General Electric Company	14,763	714	779	689	819	787	809	937	932	970	758	819	664	729	699	25,868
3.	Hitachi, Ltd.	5,957	731	845	908	1,054	908	929	956	913	976	910	963	903	1,094	1,008	19,055
4.	Canon Kabushiki Kaisha	3,067	523	846	623	954	870	827	1,109	1,037	1,096	1,087	1,541	1,381	1,928	1,795	18,784
5.	Toshiba Corporation	3,598	694	824	751	962	893	1,014	1,023	1,039	968	969	914	862	1,170	1,200	16,881
6.	Eastman Kodak Company	5,780	229	296	433	589	721	863	775	1,007	888	772	768	795	1,124	992	16,032
7.	AT&T Corp.	9,213	437	406	375	387	430	484	440	448	595	638	510	46	150	278	14,837
8.	U.S. Philips Corporation	6,519	503	687	581	746	637	650	501	441	396	504	477	473	725	735	14,575
9.	E.I. du Pont de Nemours and Co.	7,560	329	419	375	443	481	597	599	568	486	441	395	311	393	338	13,735
10.	Motorola, Inc.	3,244	334	414	341	384	394	613	660	729	837	1,012	1,064	1,058	1,406	1,192	13,682
11.	Mitsubishi Denki Kabushiki Kaisha	1,619	360	518	543	770	868	940	959	926	972	973	934	892	1,080	1,054	13,408
12.	Siemens Aktiengesellschaft	6,388	410	539	562	658	508	475	398	371	376	419	418	454	626	722	13,324
13.	NEC Corporation	1,601	234	375	353	480	437	428	453	594	897	1,005	1,043	1,095	1,627	1,842	12,464

	Patents by Year of Grant	Pre-1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
14.	Bayer Aktiengesellschaft	6,541	389	371	441	470	499	492	472	443	342	327	323	357	381	341	12,189
15.	Westinghouse Electric Corp.	7,896	398	652	434	452	436	354	358	276	248	170	132	72	81	11	11,970
16.	Matsushita Electric Industrial Co.Ltd.	3,193	224	305	277	365	343	456	608	713	771	854	841	746	1,034	1,052	11,782
17.	United States of America, Navy	7,820	216	170	103	125	265	381	297	344	378	330	285	288	341	348	11,691
18.	General Motors Corporation	6,781	294	370	383	412	379	437	399	438	331	282	297	277	305	275	11,660
19.	Xerox Corporation	5,106	219	227	258	283	252	354	473	561	611	551	703-	606	769	665	11,638
20.	Fuji Photo Film Co., Ltd.	3,092	448	494	589	892	768	733	641	632	545	504	510	467	547	539	11,401
	TOTAL PATENTS AWARDED,																
	Top 20 firms															153,492	

Source: *All Technologies Report January 1, 1963 to June 1, 1999*, United States Patent and Trademark Office, Technology Assessment and Forecast Report, August 1999, pp. B-1-B2.

Foreign Holders of Patents Of the 153,492 patents granted in the United States in 1999 (against 270,000 applications), foreign companies and individuals held 45%. Japanese individuals and firms held 20% of all 1999 U.S. patents issued, making them the largest single foreign owner, and Japanese firms were in eight of the twelve top spots for new U.S. patents granted to companies in 1998, receiving 10,438, that year. Worldwide, the JPO had the highest ratio of domestic to foreign applications, 90%, while both the United States and Japan had high ratios when compared with European systems (Germany had 45% and Britain 29%).

Table 3.2: Percentage of US Industrial R&D by Size of Enterprise

Company Size	1981	1989	1999
< 1000 employees	4.4 %	9.2%	22.5%
1,000 – 4,999	6.1 %	7.6 %	13.6%
5,000 – 9,999	5.8 %	5.5%	9.0%
10,000 – 24,999	13.1%	10.0%	13.6%
25,000 +	70.7%	67.7%	41.3%

Sources: National Science Foundation, Science Resource Studies, Survey of Industrial Research Development, 1991 and 1999.

Figure 3.2:
An Interdependent Architecture

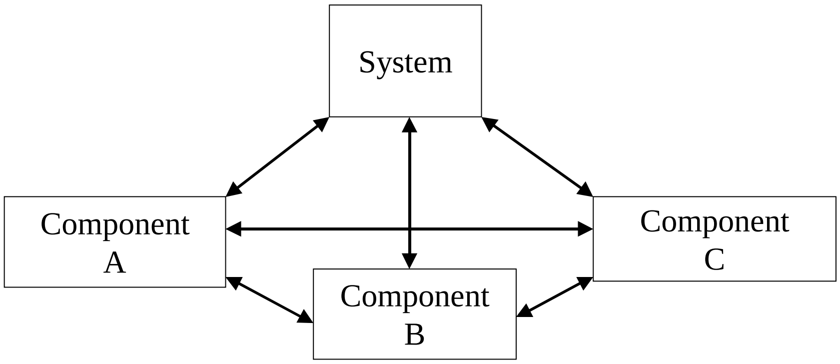
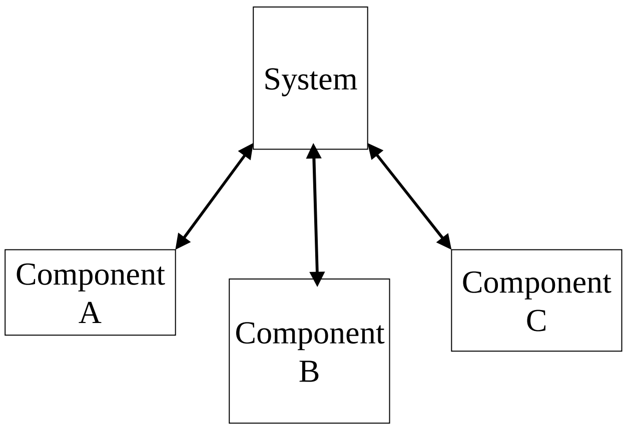


Figure 3.3:
A Modular Architecture



[i] A recent academic article concluded that American universities were becoming more commercially productive with their research. J. Thursby and S. Kemp, in their article "Growth and Productive Efficiency in University intellectual property licensing" (Research Policy, 2002: 109-124) report that university patents have risen from 250 in 1980 to over 1500 annually in 2000, and provide interesting evidence that universities are getting more "output", as measured by the number of licenses they receive for these patents, per unit of "input".

[ii] See Samuel Kortum, and Josh Lerner, 1999. "What is Behind the Recent Surge in Patenting?" Research Policy 28 (January 1999) 1-22.

[iii] In the earlier era, large companies also looked down on the quality of R&D activity being done in smaller companies. No more. Today, the quality of technical personnel in startup firms can be surprisingly high. Managers at corporate research centers such as PARC report that their biggest competition in hiring in brilliant new researchers out of leading university Ph.D. programs is not other research centers, such as IBM's Watson Research Center or Lucent's Bell Labs, or even one of the government's national labs. It is startup firms and universities. When startup firms and universities are able to lure "the best and the brightest" to their organizations, away from the large company laboratories, the perceived historic superiority of large firm R&D can no longer be taken for granted.

[iv] The overall length of tenure remains at 3.5 years from 1983 to 2000, but this understates the mobility of the workforce because of the aging of the workforce in those years (older workers are less mobile than younger workers). Within age groups, the length of tenure has declined for *all* age groups between 1983 and 2000. See http://www.bls.gov/news.release/tenure.nr0.htm, Table 1.

[v] Even now after the venture capital bubble has popped and investing has returned to 1998 levels, VC remains a powerful force to be reckoned with, relative to what companies are spending overall in their research and development. The venture capital world invested $48 billion in the US in 1999 (Venture Economics, accessed Oct. 29, 2001). By comparison, the total amount of money US companies spent on industrial R&D for 1999 was $160.3 million (source: NSF,http://www.nsf.gov/sbe/srs//databrf/nsf01326/sdb01326.pdf).

[vi] I heard many variations of these concerns at the annual meeting of the Industrial Research Institute in Williamsburg, in 1999 www.iriinc.org. See also Richard Rosenbloom and William Spencer's book "Engines of Innovation: Industrial Research at the End of an Era", for a wonderful collection of viewpoints on industrial research in this vein, past and present.

[vii] See Venture Economics, www.ventureeconomics.com, for the most recent data on the amount of venture capital investment being made. They report that $19.2 billion in investment was made in 1998, which rose to over $81 billion in 2000, and fell to $36.5 billion 2001.

[viii] In my article in the Harvard Business Review, "Making Sense of Corporate Venture Capital", (March, 2002), I explore the ways in which companies can utilize corporate venture investments to advance their own strategic goals.

[ix] The use of the eco-system as a metaphor for how businesses compete and survive was well made earlier by James Moore, in his book, The Death of Competition (HBS Press, 1996). The point I am making here is how venture capitalists play a very positive role in creating, shaping, and developing the ecosystem.

[x] See Eric von Hippel, The Sources of Innovation, Oxford University Press, 1988, for a superb account of the powerful role that lead users can play in the innovation process.

[xi]Internal competition should not be avoided, but it will need to be managed. For a useful approach to managing such competition, see Julian Birkinshaw, "Strategies for managing internal competition", *California Management Review* (forthcoming). By the way, internal competition cuts both ways. Internal technology groups may move faster to respond to the needs of their marketing and sales divisions when these latter groups have recourse to external technology sources as well. Internal technology groups ignore their downstream division's needs, or are late to respond, at their own peril. If the downstream business can access an alternative technology outside, it chastens the internal upstream group, while protecting the overall firm from being late in the market. A better mousetrap tomorrow may not be as valuable as a good mousetrap available today.

[xii] The argument that follows, about the relationship of technical complexity to organizational integration, is developed at length in a joint paper I wrote with my colleague Clay Christensen, "Technology Organization, Technology Markets, and the Returns to Research", HBS working paper, 99-104, 1999. In that paper, we also show that modularity need not be the end state of a technology's evolution. There can be cycling between vertical integration and modularity, followed by a return to integration. The role of internal R&D in resolving complex technological interdependencies was also discussed in my paper with Ken Kusunoki on the Japanese HDD industry, "The Modularity Trap: Innovation, Technology Phase Shifts and the Resulting Limits of Virtual Organizations", in I. Nonaka and D. Teece, Managing Industrial Knowledge, Sage Press, 2001.

[xiii] In addition to the discussion below, see Michael Cusamano and Annabelle Gawer, Platform Leadership: How Intel, Microsoft and Cisco Drive Industry Innovation, (HBS Press: Boston, MA, 2002), for other examples of how companies coordinate the architecture of a system without making each of its parts. The book does a good job of conveying the need for coordination within a platform, which specifies the relationship among the interdependent parts, as well as the need to evolve the platform, so that its performance does not stagnate over time.

[xiv] In an article I wrote with David Teece, "When is virtual virtuous? Organizing for Innovation" Harvard Business Review, Jan/Feb 1996, we recounted the experience of IBM in the personal computer industry. IBM behaved very virtually for a company of its size, creating an independent business unit to develop an open architecture for its IBM Personal Computer. IBM outsourced the microprocessor from Intel, and the operating system from Microsoft, as part of its drive to move fast and remain flexible. However, IBM subsequently lost control of its architecture, and today the profits from the PC architecture that IBM created flow through to Intel and Microsoft. In the paper with Kusunoki (see footnote xii above), I explore how companies need to shift organizational modes as an industry becomes modular, but nonetheless retain enough systems knowledge to shift back to a more integrated when an architecture reaches its performance limit, and a new generation architecture must be created.