Chapter 2

New Puzzles and New Findings

Henry Chesbrough
Executive Director
Center for Open Innovation, IMIO
Walter A. Haas School of Business, F402
University of California, Berkeley
Berkeley, CA 94720-1930
Office: 510 643-2067
FAX: 510 642-2826

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Introduction

This short chapter is intended to frame the subsequent three chapters within this volume. This section of the volume is focused on research that examines the implications of open innovation on innovation activities *within* the firm. Subsequent sections will address the implications of open innovation outside the firm, and in the surrounding environment, respectively.

Adopting a more open innovation model within a large organization invites the consideration of many puzzles. First, if external innovation is so helpful, why is there so much variation in whether and how much companies utilize it? A second puzzle is, if many technologies go unused within a firm, why aren't more technologies offered for sale to outside organizations instead?

A more subtle puzzle lies in the domain of open source software. The Open Innovation model treats a company's business model as both necessary and sufficient for innovation success. How then are we to regard the open source software movement? By construction, many of the key elements of open source eschew the exclusionary aspects of intellectual property protection and traditional business models. Yet this lack of a business model does not seem to be impairing the advance of open source, which is growing in its impact. Does this growth contradict, or at least sharply qualify, the claims of Open Innovation with regard to the importance of business models?

I will develop each of these three issues to some degree, and provide some remarks on each of the three subsequent chapters that follow in this section. I will conclude by synthesizing the findings of the three chapters in light of these issues.

Puzzles in the Limited Use of External Innovation

Open Innovation (Chesbrough, 2003a) argued that "not all the smart people work for you", and maintained that there was an increasingly dispersed distribution of useful knowledge in companies of all sizes, and outside the US as well as within the US. More recent data continue to strongly suggest a more level playing field for industrial innovation activity. Data from the National Science Foundation, in **Table 2.1**, show that small firms (defined here to be those firms with less than 1000 employees) continue to increase their share of the total amount of industrial R&D spending, amounting to almost 25% of total industry spending in 2001. Large firms (defined here at firms with more than 25,000 employees) has seen their collective share of industrial R&D fall to under 40% of total industry spending in that year.

[Table 2.1 about here]

Data on patent awards shows a similar pattern, along with an increasingly global component, with foreign companies claim a rising share of US patents, as shown in **Table 2.2**. Corporations of all sizes comprise about 88% of all US patents issued in 2003, but the % of patents held by organizations that received 40 or more patents amounted to less than half of all issued patents.

[Table 2.2 about here]

These data, and other data such as the growth of employment in small enterprises, relative to employment in large firms, all combine to suggest that the playing field for innovation is becoming more level. Put differently, there appear to be fewer economies of scale in R&D in a growing number of industries than there were a generation ago.[i]

If this is indeed the case, this more level playing field has powerful implications for the organization of innovation. In a more distributed environment, where organizations of every size have potentially valuable technologies, firms would do well to make extensive use of external technologies. The limited large sample data currently available though (e.g., Gassmann and von Zedwitz, 2002; Laursen and Salter, 2004b) suggest that there is substantial variation in the use of external technologies in a firm's innovation process. What might explain this variation?

Part of the explanation may lie in the behavioral response of internal employees to the introduction of external technologies, which has long gone by the name of "the Not Invented Here" syndrome (Katz and Allen, 1985). This "NIH" syndrome is partly based upon an attitude of xenophobia: we can't trust it, because it is not from us, and is therefore different from us. But there are more rational components that might induce internal employees to reject external technologies as well.

Rational reasons for resisting the incorporation of external technologies

One such component is the need to manage risk in executing R&D projects, especially when the cycle time to complete a project is accelerating (Fine, 1998). When cycle times accelerate in a project, there is less time to evaluate and incorporate external technologies into a fast-moving project. More subtly, when projects are moving fast, project leaders seek to minimize the risk of unexpected outcomes in the project. Internally sourced technologies pose enough risk to the project meeting its scheduled ship date already. Externally sourced technologies, coming from a much wider variety of sources about whom much less is known (when compared to internally generated technologies), may greatly increase the perceived risk to the project. The expected value of an external technology may be as high – or even higher- than an internal technology. But the variance around that expected value likely may be much higher as well.

This suggests a researchable question: do projects incorporating external technologies experience higher variance in project outcomes (e.g., cost, time, quality) than those that rely upon internal technologies? A more behavioral variant of that question would be: are projects that incorporate external technologies *perceived* by project participants to increase the risk to project outcomes? If so, are those perceptions subsequently validated by the data, or do these perceptions shift as new outcomes appear?

The above line of inquiry presumes that internal employees are simply unaware of the real characteristics of externally sourced technologies, and that there are costs incurred to find out these characteristics. A more subtle challenge is the impact on the internal staff's subsequent actions if *and when externally sourced technologies prove to be highly effective*. In this instance, the overall project's success may be enhanced by the inclusion of externally sourced technology. But the top managers in the firm might infer from this experience that the firm doesn't need quite so many internal R&D staff to accomplish the *next* project, that the next project ought to rely more on external technology as well. In this case, the short term success of the project might be to the long term detriment of internal R&D staffing levels and internal research funding. This is also a researchable question: when companies employ external technologies successfully in their innovation process, do internal R&D staffing levels rise or fall in subsequent periods?

This suggests that there may be an asymmetry in the risks and rewards (from the perspective of the project leader and the project team) from greater utilization of external technologies in R&D projects. The project team must bear responsibility for the success or failure of the project, and therefore must have the final decision over whether and when to incorporate external technologies into the project as part of the project's development. If the external technology fails (and remember that it may have a higher variance in expected outcome), the project team bears the responsibility. But "success" in the use of external technologies in this process may jeopardize internal staffing levels in future. So, the project team confronts a risky situation in which they bear full responsibility if the use of external technology "fails", yet the team may bear other long term costs if the use of external technology "succeeds".

This prompts a re-examination of two important cases cited by Open Innovation (Chesbrough, 2003a): IBM and P&G. In IBM's case, the company operated with a highly vertically integrated and inwardly focused innovation model since the inception of its System 360 (Pugh, 1995). IBM's shift towards a far more open, less vertically integrated approach came from the arrival of Lou Gerstner into the CEO role at the firm. However, immediately prior to Gerstner's arrival, IBM reported what was at that time the largest quarterly loss in US business history, and IBM made the first major layoffs in its corporate history. This dramatically shifted the previous culture of internal focus towards innovation, and many of those laid off were in the R&D organization. When IBM began to adopt a more open approach, it did so at a time when the organization had recognized that the status quo ante was no longer sustainable. A more complete discussion of this transition can be found in (Chesbrough, 2003a: Chapter 5)

Procter and Gamble's embrace of open innovation also was immediately preceded by a significant layoff in the R&D organization of P&G (though a far less severe layoff than the one at IBM). P&G had embarked on a growth campaign in 1990 to double its $20 billion in revenue by 2000. When 2000 came, the organization had only reached $30 billion in revenue, and many spoke of the "growth gap" for the company. P&G cut expenses significantly, and laid off a large number of people. After these cuts, P&G consciously told its R&D staff that its shift to what it called "Connect and Develop" would not lead to any further reductions in staff. Instead, the shift in innovation models was positioned to enable P&G to generate more innovation with the (recently reduced) R&D resources on hand (see Sakkab, 2002). Again, the effect was to minimize the perception of asymmetric risks among the R&D project leaders and staff. My hypothesis is that this shift would have been received very differently by P&G's internal organization, had Connect and Develop been launched *prior* to the layoffs of P&G's R&D staff. In that context, Connect and Develop might have been viewed as a thinly veiled excuse for downsizing and outsourcing R&D.

This suggests a control variable that could be used in a large sample study of the adoption of external technologies within a company's innovation process. The control variable would be recent changes in R&D staffing levels in the previous period (or, if that were not available, recent changes in R&D spending). If staffing had already declined, perhaps external technologies would be received with less resistance.

Puzzles in the Limited Offering of Unused Technologies Outside the Firm

A second kind of puzzle emanates from looking at the innovation process from the other end, where companies choose to deploy certain technologies and commercialize them, while leaving a larger set of technologies unutilized. When Procter & Gamble surveyed all of the patents it owned, it determined that about 10% of them were in active use in at least one P&G business, and that many of the remaining 90% of patents had no business value of any kind to P&G (Sakkab, 2002). Dow Chemical went through an extensive analysis of its patent portfolio starting in 1993, as reported in Davis and Harrison (2001:146). In that year, about 19% of Dow's patents were in use in one of Dow's businesses, while a further 33% had some potential defensive use, or future business use. The remaining patents were either being licensed to others (23%), or simply not being used in any discernable way (25%). In the typical pharmaceutical development process, a company must screen hundreds or even thousands of patented compounds, in order to find a single compound that makes it through the process and gets into the market.[ii] From a naïve perspective, it seems wasteful in the extreme to create and develop a large number of technologies, and then only utilize a miniscule fraction of the technologies in any way, shape, or form.

This raises at least two subsidiary questions. First, why do firms develop so many possible technologies, instead of just the most likely ones? A second question is, what inhibits firms from making much greater use of unutilized technologies in other ways? These will be considered in turn.

The first question makes an implicit assumption that turns out not to be true in many organizations. That assumption is that the R&D activities of the firm are tightly coupled to the business model of the firm. If one grants this assumption, then it is truly puzzling why so many technologies are so little used. However, the reality is that often the assumption is simply wrong: many firms consciously keep their R&D process only loosely uncoupled to their business model.

Further, R&D managers often use the number of patents generated by an R&D research or an R&D organization as a metric to judge the productivity of that person or organization. Similarly, some R&D organizations count the number of publications generated by their R&D staff as another measure of productivity.[iii] Unsurprisingly, when organizations reward the quantity of patents or papers produced, the R&D organization responds by generating a large number of patents or papers, with little regard as to their eventual business relevance.

To carry this point further, there may be a budgetary disconnect between a research and development group on the one hand, and a business unit on the other. To see this, examine **Figure 2.1.**

[Figure 2.1 about here]

In this figure, the R&D operation produces research results, and operates as a cost center. This is usually how such organizations are funded, since they do not sell their output, and since it is hard to estimate how much money a particular R&D project will need in order to be successful. Instead, companies determine an amount of funding that they can sustain over time, which can be dedicated to R&D tasks. The R&D unit manager must in turn decide how many projects to support with the budgeted funds she has that period. It is bad for her to exceed her budget, since the organization may not be able to sustain the additional expenses. It is also bad for her to come in much under the budget that year, because that may suggest that next year's budget can be reduced as well. So the manager tries to develop as many projects as she can, subject to the budget constraint.

The internal business unit customer, by contrast, is typically managed on a profit-and-loss (P&L) basis. The business unit typically does sell its output to customers, and giving each business unit its own P&L enables that business manager to make the best use of his information to maximize profits for the business. That manager wants to buy low, sell high, and avoid risk. So the business unit manager wants any R&D project coming from his internal "supplier" to be as fully developed as possible. This reduces any additional costs the manager must incur prior to using the technology in the business. It also reduces any risk to that business's profitability that period.

The stage is now set for the budgetary disconnect between the two functions. The R&D manager wants to push out the project as soon as the publications and patents have been generated. Further development within the R&D budget crowds out other, newer projects that have greater potential for generating still other new patents and publications. So the R&D manager's incentives are to transfer the project sooner rather than later to the business unit. Meanwhile, the business unit manager's incentives are to wait as long as possible before taking over the further funding of the R&D project onto his P&L.

The resolution of this budgetary disconnect is to place a buffer between the R&D operation, and the business unit, as shown in **Figure 2.2**. This buffer provides temporary storage for the R&D project, until the time when the business unit is ready to invest in its further application within the business. This lets the R&D manager get onto work on her next project, without requiring the business unit manager to commit to further funding on his P&L until he judges it to be beneficial.

[Figure 2.2 about here]

While this solves the local problem of each manager, from a system viewpoint, the "solution" causes many R&D projects to pile up in this buffer. These projects are often termed "on the shelf", because they are no longer being actively pursued by the R&D organization, nor are they actually being used by the business unit.

The structure of research funding also influences the subsequent utilization of research results within the firm. Some research organizations obtain a significant percentage of their funds from "research contracts" with their internal business units. These contracts tend to be fairly specific, near term in time frame, and are likely to be utilized by the business units, which pay directly for the output of the work. But other funds for those same research organizations come from a corporate allocation of funds (which is generated from a "tax" on all of the businesses within the firm). These corporate funds are not tied to any specific business unit objective, and are allocated by research managers to longer term projects whose output may benefit multiple businesses, but may not be immediately relevant to any. Still other research funds come from government research contracts. These funds tend to be academically peer reviewed, and may therefore have little or no relevance to any business unit activity within the firm. So the hypothesis might be that the type of research funding received is correlated to the subsequent business utilization of the research output. Contractual funding with business units would be predicted to lead to higher utilization, while government funded research would be predicted to lead to a much lower level of utilization.

The foregoing analysis suggests that R&D processes are only loosely coupled to the business models of firms (though the tightness of coupling may vary with the type of research funding provided), which may explain why there are a substantial number of technologies that are un- or under-utilized within those businesses. This could lead to research on how better to align the incentives of the two units, and potentially how better to manage any buffer that emerges between them. This loose coupling also heightens interest in the second question: what prevents the business from enabling others to utilize those underperforming technologies in their own respective businesses?

There may be parallel forces at work on this question, as well as on the previous one. The expected value of an unused internal technology may be quite low, but there may still be variance in that value. Indeed, the internal view of the technology's potential is likely biased by the business model of the company (Chesbrough and Rosenbloom, 2002). This may suggest that an external view of the technology's value may be more unbiased (if less informed, at least initially) than the internal view. But by itself, this analysis would suggest a potentially substantial market for underutilized technologies. After all, when buyers have higher valuations of projects than sellers, it is natural for those parties to find a mutually beneficial transaction that shifts those projects to the party with the higher valuation.

A second concern may be adverse selection. Buyers may worry that the sellers of unutilized technologies will only offer the "bad" ones (Akerlof, 1970). Adverse selection presumes that both parties are rational and unbiased, so the seller (who has more information sooner) will inevitably have an information advantage over the buyer. But the dominant logic of a company's business model would actually suggest countervailing forces that might support the use of external technologies. While companies have significant prior information on a technology project, (and therefore might be assumed to enjoy a tremendous information advantage), that information will nonetheless be evaluated within the context of the company's business model. If the buyer has, or can identify, a very different business model, the buyer's evaluation of the project may differ greatly from that of the seller.

To give an example here, consider the experience of Xerox PARC with its many technology spinoff projects (Chesbrough, Business History Review, 2002). In that work, I identified 35 projects that left Xerox after the further funding for the work had been ended within Xerox. Xerox judged that there was little or no additional value to be gained from continuing this work. In 24 of the 35 projects, there was little business success after separation. But for 11 of the projects, each of which developed under a very different business model from that of Xerox, there turned out to be substantial value. The collective market value of the companies that emerged from these 11 projects turned out to exceed the total market value of Xerox by a factor of two. I interpret these data to mean that Xerox's estimates of the value of these projects were biased by its business model.

Other barriers to greater utilization of unused technology may lurk inside the budgetary mechanisms of &RD organizations and their business unit customers. There may be a behavioral analogue to NIH that sits within the business units, which I term the Not Sold Here (NSH) virus. NSH is a syndrome that argues that, if we don't sell it, no one should. It is rooted in the surface perception that, if our organization cannot find sufficient value in the technology, it is highly unlikely that anyone else can either (a restatement of adverse selection). At a deeper level, however, the NSH virus seeks to forestall competition with outside entities for accessing internal technology. Most business units enjoy a monopsony position relative to their R&D unit suppliers. Because they have a de facto exclusive right to the technology, they can defer costs and delay commitments to the technology without penalty.

Enabling greater external use of unused technologies alters the business unit's calculation. If a business unit chooses not to incorporate a technology, and that allows others the chance to do so, the business unit now faces a previously latent cost: if it doesn't use the technology itself, it might "lose" that technology to an external organization. Typically, internal business units have some defined interval of time during which they can "claim" the technology. After that interval expires, the technology is then made available to other firms.[iv] Depending on who that external firm is, the internal business unit may even have to compete against that technology in the market. Worse (from the business unit's perspective), the external use of the technology might reveal previously unrealized value from the technology, leaving the business unit in the awkward position of explaining why it failed to utilize this now apparently valuable technology. Another asymmetry presents itself: if the technology is licensed externally, the corporation may "win" through additional licensing revenue, but the business unit may "lose" through additional competition in its market.

Here, there may be mechanisms that firms can employ to align incentives within the business unit to more closely approximate those of the overall firm. GE and IBM, for example, share any licensing revenues from a technology with the business unit associated with the technology. So the business unit P&L not only bears the risk of competing with the technology in the market (thus negatively impacting the P&L of the unit), but also receives credit for licensing revenue from the technology on its P&L (thus boosting the revenue and profit of the P&L of the unit).

Companies that enable competition for their unutilized technologies might experience more rapid flow of those technologies into the market, both for those taken outside, AND for those that remain inside. The latter implication may require some further explanation to motivate the hypothesis. When business units face external competition for the use of internal technologies, and a defined time limit in which to consider a technology before it is made available to others, it is likely that this limit accelerates the evaluation process within the business unit. It is really a form of buffer management. Technologies get incorporated faster into the business, or else they flow out to other organizations, instead of sitting on the shelf. This increases the flow of ideas from R&D through the business unit, and into the market.

There is a further, more human dimension that could be researched. Companies in which NSH is pronounced likely frustrate many of the R&D staff, because many of the ideas these people work on are never deployed in the market. It is reportedly quite common for a pharmaceutical researcher to never see one of her projects ship into the market, over a 30 year career, because the attrition rate of compounds is so high. This is an enormous waste of human talent, and must take a toll on any person's initiative. Companies that overcome NSH allow other pathways for internal ideas to get into the market. These other pathways allow the market to provide feedback on those ideas, and lets researchers see their ideas in action in the wider world.[v]

<u>A Third Puzzle: A Successful Technology without an Apparent Business Model – The Case of Open Source</u>

One of the central tenets of the book <u>Open Innovation</u> (Chesbrough, 2003a) is that business models are essential to unlocking latent value from a technology. On page xxx of the Introduction, the book asserts:

> *"There is no inherent value in a technology per se. The value is determined instead by the business model used to bring it to market. The same technology taken to market*

> *through two different business models will yield different amounts of value. An inferior technology with a better business model will often trump a better technology commercialized through an inferior business model."*

This assertion begs an obvious question: what happens when there is no business model being used to commercialize a technology?

This is apparently the case with open source software development. By construction, open source software is created without any one firm owning the technology. No firm can patent the technology, or exclude anyone else from accessing the software code. Enhancements to the code are available to everyone on an equal basis.

Is this simply an exception to the general rule, is this due to a business model of a different kind, or is there something fundamentally wrong by the above claims of <u>Open Innovation</u> regarding the importance of business models for the behavior of firms? This is a third puzzle in the context of open innovation.

<u>Remarks on each of the Chapters in Section II</u>

While each of these chapters addresses aspects of one or more of the issues above, they go further, introducing additional evidence into the debate. I will briefly highlight some of the insights of each of the authors, and conclude with some synthesis of the material in this section.

Chapter 3: O'Connor

The next chapter by Gina O'Connor discusses how firms that are pursuing long term, ambitious, "breakthrough" innovations incorporate certain aspects of Open Innovation. Building on a fruitful research program on Radical Innovations that has been ongoing at the Rensselaer Polytechnic Institute for many years, O'Connor revisits the extensive data collected in the course of this research. The RPI team studied 14 radical innovation projects in great detail (and some of the investigation is still ongoing). Some of these projects have met with "success", while others clearly have not. Similarly, a few organizations have attempted to instantiate internal business units to pursue radical innovations, while others have not. And of those who have created a dedicated organizational unit, some have subsequently discontinued the unit. So there is a lot going on here, both in the technology side of the organization, and on the business and strategic side of the organization as well.

In this chapter, O'Connor searches this rich dataset for patterns that illuminate the differing outcomes from these projects. While the sample is too small for any statistical analysis, she presents persuasive evidence that the effective pursuit of radical innovations also appears to benefit from the application of some of the concepts of open innovation. In particular, she reports evidence on the extensive use of external sources of technology in many of the successful projects. Open innovation appears to help not least because it is perceived to have the potential to shorten the time to market for some of the higher impact innovations that otherwise suffer under conventional stage gate evaluations. These stage gate processes appear to favor the shorter term projects, and appear to crowd out the longer term, more radical innovation projects. Her concern is not with the evaluation process per se, but rather the over-reliance on short term metrics to conduct those evaluations, which have the practical effect of excluding longer term, but higher potential projects. This is quite consistent with the earlier analysis of Clark and Wheelwright (1992). With books like Execution (Bossidy, Charan, and Burck, 2002), which reinforce a short term contractual view of meeting commitments selling so well right now, there is a need for a timely response such as this.

Among the new findings she reports in this chapter is the significant degree of "openness" among her sample firms who are engaged in trying to pursue radical innovation projects. The chapter also points out the complementary relationship between the internal infrastructures to support long term innovative activity, and the mechanisms created to access external technologies. Instead of seeing open innovation as a substitute for radical innovation practices, O'Connor views them as functioning in mutually beneficial ways.

This is helpful on many levels. There is a tendency for some to view Open Innovation as a thinly disguised argument for simply outsourcing R&D to other companies. The RPI research program on radical innovation was motivated precisely to stimulate industrial R&D managers to refrain from cutting out all long term R&D activity. In O'Connor's chapter, she finds that companies can adopt certain open innovation practices without eliminating internal R&D outright. Indeed, a judicious combination of the two appears to be beneficial, and the embrace of Open Innovation may help sustain the pursuit of longer term, more radical innovation.

The chapter breaks other new ground, in its discussion of the discovery/incubation/acceleration stages in the development of a radical innovation. While the path to the development of a radical innovation is tortuous and convoluted, these stages provide a deeper structure within the seemingly ad hoc innovation activities of companies aspiring to radical innovation. In O'Connor's view, Open Innovation is of greater help to companies in the first and second phases of this path. This is likely due to the sample for the RPI work, consisting of very large incumbent firms. Seen from the perspective of smaller firms, Open Innovation may help in the third phase as well, as part of the "exit strategy" for a firm to partner with or sell to a larger firm in order to finish the commercialization of the technology. This is demonstrated in specialty materials by Robert Kirschbaum (2005), who has created an internal venturing process that spins out new companies, and selectively brings some of them back into the originating organization.[vi]

Chapter 4: Christensen

In contrast to O'Connor's chapter on how internal innovation processes can be complemented by incorporating more external inputs, Christensen reverses the perspective. He reports on the journey of externally originating technologies into the market, and conditions under which an external technology does or does not get absorbed into the firm. Using a richly detailed study of the transition from analog to digital amplifier circuits in consumer electronics, he finds a variety of firm responses.[vii]

This is an important finding in itself. The story of the adoption of digitial amplifier circuitry in reveals different approaches by individual firms to innovation in the consumer electronics industry. It is in part a story about the diffusion of research outside a university. It is also in part a story about an individual entrepreneur, and his attempt to commercialize a new technology. It is also in part a story about Open Innovation at Texas Instruments, and TI's search for an external technology to provide a critical function that they lacked internally. It is even a story about some of the disadvantages faced by a closed innovator, Sony. Sony apparently lacked the processes and perspective to appreciate the value of an external technology that they were being offered (perhaps Sony also overestimated its internal capabilities with regard to digital amplifier circuitry as well).

Another lesson from this chapter is that once the battle for the dominant design is won, the winning firm then faces a new round of choices about how open to be with the winning technology. The desire to appropriate some value from the battle for the design (which was undoubtedly costly) is understandable, but not always advisable. If the design is in the service of supporting a larger system, the choice of how open to be must be taken with the perspective of the system business in mind. Here, for example, Sony's pursuit of an internal version of a digital amplifier (presumably to help it earn higher margins) may have impaired its access to a viable external version (which might have helped increase sales of the overall system).

A third lesson is the illustration of de-verticalization of this portion of the consumer electronics industry. While often described at the industry level, Christensen shows us that the de-verticalization results from the actions of individual firms. Shifts in strategy by some players, while other players remain vertically integrated, and the entry of new participations, act to cause the industry to de-verticalize. This also appears to assist in facilitating entry into the industry, as each of the new entrants appear to enter with some variant of de-verticalization. None chose to enter with a vertically integrated approach.

A fourth lesson, and one with which Christensen is eager to engage the academic community, is the implications of Open Innovation for the core competences theories of the firm in strategy.

Prahalad's emphasis on "core competence" (Prahalad and Hamel, 1990) follows an earlier article he did with Bettis (Prahalad and Bettis, 1986) on dominant logic. In the 1986 piece, Prahalad and Bettis were concerned that the dominant logic might filter out important information when that information did not fit with the dominant logic (which, in Christensen's parlance, refers to the specialized but narrow). These concerns vanished by the time of Prahalad and Hamel's 1990 paper on core competences (which now correspond to the more aggregate, integrative competences in Christensen's chapter). In this later incarnation, core competences are viewed as unambiguously good (until qualified by Dorothy Leonard-Barton's article in SMJ in 1992 on core competences leading to core rigidities). A more recent paper by Prencipe, Brusoni and Pavitt (2001) situates the knowledge acquisition of firms as being broader than that strictly necessary to make its products, so that competences must be larger than the set of products currently offered.

How to reconcile these different perspectives, in light of Christensen's research on digitial amplifier circuitry? One place to start, from an Open Innovation point of view, is with the business model. Texas Instruments has chosen to focus its competences upon an OEM business model, whereby TI makes highly complex components, but leaves it to its customers to build system products that utilize those components. It must continually develop new generation component technologies, in order to remain attractive to its systems customers. Sony, by contrast, has developed a business model whereby it makes most of the major componentry in its systems itself, a strategy of vertical integration. Sony makes television displays, DRAM, game consoles, and even uses its own proprietary memory devices (such as Memory sticks) for moving data from its camcorders to its digital cameras to its stereophonic and television equipment. For Sony, vertical integration is a means to capture more value in a highly competitive industry, and also a way to differentiate its products from the competition, as in the case of its proprietary memory formats.

As the Sony episode in Christensen's chapter shows, a vertically integrated business model can influence the firm's care and objectivity in assessing the quality and reliability of external technologies. In the context of core competences, Sony may have overemphasized its component technology competence, when it evaluated the digital amplifier technology from a Danish university, at the risk of its systems or architectural competence. TI, by contrast, though it struggled initially to successfully transfer the technology into its own development organization, has successfully created new systems and chips that benefit from the technology, which exemplifies the increased importance of architectural competence. TI will now profit still further from licensing the technology to other firms, in addition to its own product sales. This is another practice commended in open innovation, as it spreads TI's costs over a larger market, and makes TI's ongoing investment in R&D more sustainable.

Chapter 5: West and Gallagher

In Chapter 5, West and Gallagher examine the emergence of open source software in more mature companies. These more traditional companies have begun to craft business models around the open source code base. This is a tricky business to manage, because the founders of open source were well aware of the earlier history of Unix, and how that code base ultimately forked into a variety of incompatible versions. In the construction of the legal structure around open source, they have taken steps to prevent this from occurring this time around. As West and Gallagher note in their chapter, there has been a schism between the "open source" software community, and the “free software” community. This schism derives largely from the fundamental disagreement between the two communities over whether the code base ought to remain free in the public domain, or whether it can be incorporated into other software that becomes proprietary.[viii]

What is advancing the embrace of open source in many businesses, West and Gallagher find, is the emergence of what can be termed “open source business models”. Their analysis is particularly illuminating for the incumbent firms who make products that use other, non-open source technologies as well. They probe the conditions under which firms will choose to incorporate open source technologies into their overall innovation efforts, and develop “open innovation business models”. As is consistent with the business model concept, parts of the model are quite open, while other parts are quite proprietary or closed.

As West and Gallagher show, open source is a marked departure from previous “industrial” models of software development. They are also alert to the unique combination of lower marginal production and distribution costs, with strong network externalities on the demand side of the adoption process. It is not surprising that any strategic moves that enhance these economics will be embraced. And open source, notwithstanding the goals of its initial creators, can sometimes be harnessed for this very purpose. Indeed, West and Gallagher report that some firms now actively choose to sponsor open source projects.

One delight of this chapter is that the two authors go well beyond the label of “open source”, and unpack it into five different types of code, each with distinguishing characteristics.

Of particular interest to me is the creation of Mozilla – an open source variant of Netscape Navigator – which started in 1998, languished for a long time with few contributors to advance the code. However, it had the ability to serve as a browser for Unix workstations like HP, Sun and IBM (which could not use Microsoft Explorer, since it was tightly integrated with Microsoft Windows, and did not run on each company's respective Unix operation system). These companies made the decision to support Mozilla in the open source domain, in order to continue to sell their (highly profitable and largely proprietary) Unix workstations.

West and Gallagher also consider the use of spin-outs (and later on, spin-ins) from inside the organization to an external body, as another means of harnessing open source to a business model. IBM's strategic placement of its Eclipse technologies into the open source domain was intended to accelerate the adoption of key tools for its overarching WebSphere architecture. Two of its key competitors chose not to join the initiative, but chose instead to create their own open source domains for their technologies. This has not been widely studied in academia yet, and there is likely to be much more of this kind of "competition". Perhaps another step along the logic of this chain is the decision to compete by donating one or more technologies into a nonprofit organization of some kind. Indeed, IBM recently donated 500 of its own software patents into the open source domain, to create more activity in this area. Presumably, IBM will find other ways to profit from this activity in other portions of its business model. This is often missed by the advocates of free software or the elimination of all protection for intellectual property: companies will often have motivations to donate or give away IP in the service of their own business model.

These are novel and intriguing ways to create value and to capture a portion of that value from technology, but they are business models nonetheless. As lawsuits around the source code for Linux arise, and as other legal challenges to open source are made, it is likely that some of the most effective defense of open source software will come from decidedly profit-minded organizations who have crafted business models that embrace open source.

Synthesizing the chapters

The following three chapters in this volume are quite diverse in content, focus, and method. This makes any synthesis of them quite challenging. From the perspective of Open Innovation, though, one can discern five underlying themes that run through all three chapters:

1. The central role of the business model
2. The role of external technology in advancing the business model
3. The problem of identifying, accessing, and incorporating knowledge
4. The role of startup firms and new entrants
5. The role of intellectual property

Let's consider each in turn. The concept of the business model is a key construct in open innovation, and figures prominently in these chapters too. A business model has two important functions. It must create value within the value chain; and it must capture a piece of value for the focal firm in that chain. In O'Connor's chapter, the business model appears to constrain firms in the pursuit of longer term, more radical innovations. In Christensen's chapter, the business model appears to influence the innovation approach of different firms (such as that of

TI vs. Sony). In West and Gallagher, different variants of business models are emerging to enable the advance of open source software.

External technology. Utilizing external technology can help leverage a firm's business model, both by filling in gaps within the firm's own road map, and by creating complementary products and services that stimulate faster and higher acceptance of the internal technology. In O'Connor's chapter, external technologies potentially can reduce the development time for a radical innovation, making more radical projects more sustainable within the confines of the firm's business model. Firms create new roles, such as idea hunters and idea gatherers, to identify potentially useful external technology. In Christensen's chapter, the digital amplifier circuitry emerges out of a university research program, and struggles to take root inside a commercial entity. In West and Gallagher, open source is the envelope of collectively generated external knowledge around a technology platform, such as Linux, Apache, or Mozilla. A community of contributors emerge through this platform, and supply new technologies to it.

Knowledge. Open Innovation requires an increased emphasis on managing knowledge, both in identifying promising sources of external knowledge (and being able to recognize it as such), and in linking that knowledge together with internal knowledge to create new systems and architectures. In O'Connor, companies often lack the knowledge of how to structure development agreements with outside organizations. This presumably slows down their time to market, suggesting that the firm must going through a learning phase before it truly benefits from a faster development cycle. In Christensen, knowledge exists in many places, and is difficult to transfer from a university setting (via an entrepreneurial spin-out) to a larger company. While

TI's discovery of the technology was almost accidental, to its credit, it rapidly developed a working relationship with the inventor and the technology, worked hard over many months to absorb it, and subsequently acquired ownership of the technology. By contrast, Sony lacked the appreciation for the nascent technology's capability, and perhaps overestimated its own internal capabilities to replicate it. Ironically, Sony now may have to negotiate with TI to gain access to this very technology, but at a much higher price than it could have obtained earlier, had Sony worked directly with the Danish entrepreneur. In West and Gallagher, open and transparent parts of knowledge via open source are joined with more proprietary knowledge in the business models of sponsoring companies. Reputations of the individual contributors to the open source code point contributors to those who are contributing the most to the code, and resolving its key issues.

Startups. Startups play an important role, well beyond that of their share of revenues or employment within the economy. They are carriers of new technologies, and sometimes explorers of new markets. They also often represent experiments with new and different business models. In O'Connor, startups provide an initial impetus for radical innovations, and sometimes become important partners in the creation and delivery of those radical innovations. In Christensen, startups represent an important source of novel technologies into an industry, even though startups do not appear to command much market share in consumer electronics. In West and Gallagher, startups experiment with new business models associated with open source. They introduce new variety into the software community or ecosystem, and help that community penetrate into very large enterprises.

IP. As will be explored in the second section of this volume, intellectual property plays an important and nuanced role in Open Innovation. By defining property rights, IP helps to facilitate exchange of ideas and technologies between the many parties who possess useful knowledge. However, property rights that are too strong or too broad might inhibit the flow of ideas and technologies that is necessary for Open Innovation to function well. In O'Connor, IP does not figure prominently. It plays a supporting role to the business strategy of the firms who are pursuing radical innovations. When used, it is primarily to create the design freedom that large company designers require to attack big problems with long term initiatives. In Christensen's account by contrast, the Danish entrepreneur would be completely sunk without IP protection. His discussions with large consumer electronics companies could have resulted in the complete appropriation of the idea by one or more big companies. More subtly, the eventual partner firm, TI, itself had to dedicate considerable time and resources to master the digital technology. That investment would likely not have been forthcoming, if TI could not establish some amount of ownership over the IP. In West and Gallagher, open source has been pressed into service as a marketing complement for decidedly proprietary technologies. If there were no discernable ways to make money from open source software, it might have remained an intriguing curiosity inside university and government laboratories.

A more subtle, and perhaps even more powerful strategy to leverage open source in one's business model is to develop system architectures that build upon it. In a world with lots of useful building blocks, the creation of value shifts from developing yet another building block that is slightly differentiated from the others, to crafting coherent combinations of building blocks into systems that solve real commercial problems. This competition is well underway in Web services (West, 2003). Microsoft is trying to establish its .Net architecture as the platform for these services. That architecture will undoubtedly leverage Microsoft's tremendous franchise in its Windows operating system, and the extensive community of developers and other third parties who have based their livelihood upon it. IBM, by contrast, is countering with its WebSphere architecture, which will have to work with Windows, but has the opportunity to leverage open source technologies far more extensively, along with the extensive community that has arisen around those technologies.

Conclusion

One test of a new paradigm is that extent to which it either identifies new areas of research, or places new emphasis upon previously less salient research areas. This chapter has discussed numerous research areas inside the firm which would benefit from additional scholarly inquiry. The observed variation in utilization of external technologies within the innovation process of a firm raises many interesting questions that were not considered to be of much interest before. The loose coupling between the innovation process of the firm and its business model invites close examination of this coupling, and the ways in which it must be either accommodated or tightened. And the business model construct seems to point the way for very interesting research on the potential for the further adoption of open source development methodologies within industries, and within other sectors of societies.[ix]

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Table 2.1

US Industrial R&D Spending by Size of Enterprise, selected years, 1981-2001

	1981	1989	1999	2001
Less than 1000 employees	4.4	9.2	22.5	24.7%
1000-4999 employees	6.1	7.6	13.6	13.5%
5000-9999 employees	5.8	5.5	9	8.8%
10000-24999 employees	13.1	10	13.6	13.6%
25000+ employees	70.7	67.7	41.3	39.4%

Sources:

For 2001: National Science Foundation, Division of Science Resources Statistics, Research and Development in Industry: 2001 (Arlington, VA, forthcoming).

Science & Engineering Indicators – 2004, Table 4-5

For prior years: Open Innovation, p. 48, citing earlier NSF reports from its Science Resource Studies unit

Table 2.2

US PTO Patent awards by type of recipient, calendar year 1995, 2003

	1995	2003
US Corporation	43.4	44.6
US Government	1.0	0.5
US Individual	12.7	8.0

Foreign Corporation	38.1	43.2
Foreign government	0.2	0.1
Foreeign Individual	4.5	3.6
Companies receiving 40 or more		
Patents as % of total patents	41.6*	48.0

Sources: for 1995, ftp://ftp.uspto.gov/pub/taf/topo_95.pdf

For 2003: ftp://ftp.uspto.gov/pub/taf/topo_03.pdf

- For 1995, report shows organizations receiving 30 or more patents

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Figure 2.1

- A Model of Budgetary Disconnection Between R&D and the Business Unit
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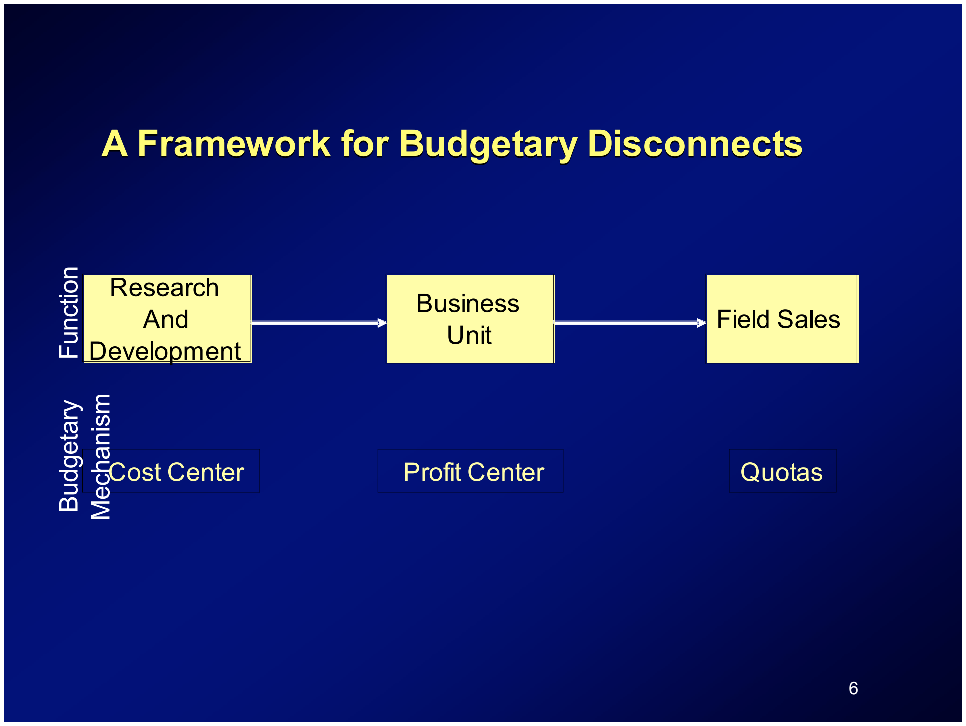
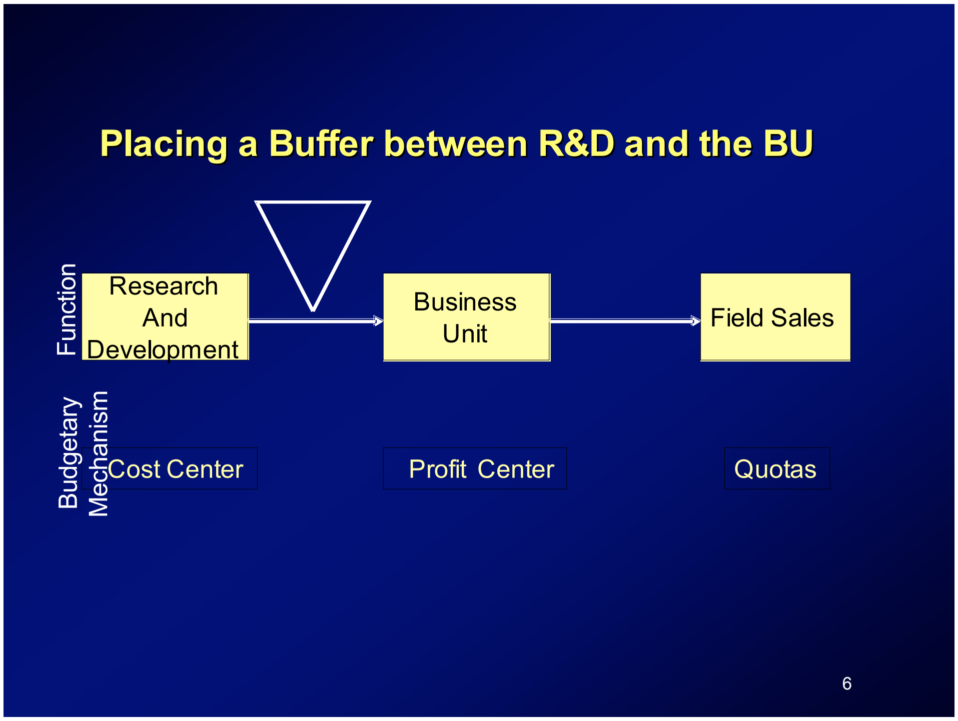


Figure 2.2 Decoupling R&D from the Business Unit


Placing a Buffer between R&D and the BU
Function
Research And Development
Business Unit
Field Sales
Budgetary Mechanism
Cost Center
Profit Center
Quotas
6

[i] These data are for the US. Thomas Friedman's new (2005) book, The World is Flat: A Brief History of the 21st Century, carries this argument through to an international level. Though his data are largely anecdotal, Friedman's claim that "the world is flat" is another way of saying that there are fewer economies of scale in R&D globally as well as in the US.

[ii] For one study among many at the Tufts Center for Study of Drug Development, which conducts period studies on the attrition rate of compounds in the drug development process, see DiMasi JA. Risks in new drug development: approval success rates for investigational drugs. *Clinical Pharmacology & Therapeutics* 2001 May;69(5):297-307.

[iii] See the comment of Rick Rashid, Microsoft's Senior VP for Research, in 2003: "Our people are judged on peer-reviewed literature, just like they would be in the university environment. And the goal here is to say you have to move the state of the art forward if you're going to be of value to a corporation like Microsoft, and that's what we're trying to do first and foremost. " source: http://www.microsoft.com/presspass/exec/rick/04-16svalley.mspx.

[iv] In two cases I have studied, the interval was quite different. In Lucent's New Ventures Group in the late 1990s, the interval was initially nine months, and later condensed to three months, in which the business units had the right of first refusal. In Procter & Gamble, the interval is set at 3 years after a patent is issued to P&G. If the technology is not in use in at least one P&G business by then, the technology is made available to any outside organization (Sakkab, 2002).

[v] There are further benefits to "selling" technology and avoiding the NSH. Sales of technology to external parties help companies to control the risk of technological leakages (such as by employees that leave the company). In the case of an unwanted employee departure, the firm has no control over the eventual use of its technology. A controlled spin-out, out-licensing agreement or a nurtured divestment, by comparison, enables companies to control how the technology will be used in a future applications, or may provide protections on certain fields of use, or certain time frames, or grantback rights to improvements. In this case, keeping valuable technology on the shelf increases the risks of leakages, and forfeits the ability to direct or control such leakages. I am indebted to my co-editor, Wim vonHaverbeke for this insight.

[vi] Robert Kirschbaum, "Open Innovation in Practice", Research-Technology Management, July-August, 2005: 24-28.

[vii] For a richer discussion of the emergence of the digital amplification technology, see the very recent article by Christensen, J.F., Olesen M. and Kjær J.S. (2005): “The industrial dynamics of Open Innovation - Evidence from the transformation of consumer electronics”, Research Policy, volume 34.

[viii] For a very recent instance of this tension, and the associated risks of co-option, consider the 2005 statements by Jesus Villasante, head of software technologies at the European Community's Information Society and Media Directorate General: "IBM says to a customer, 'Do you want proprietary or open software?' Then [if they want open source] they say, 'OK, you want IBM open source.' It is [always] IBM or Sun or HP open source…. Companies are using the potential of communities as subcontractors -- the open source community today [is a] subcontractor of American multinationals. Open source communities need to take themselves seriously and realize they have contribution to themselves and society. From the moment they realize they are part of the evolution of society and try to influence it, we will be moving in the right direction." (Mason, 2005). Villasante's comments capture in a nutshell the tensions within the open source movement between the “open” and “free” software camps.

[ix] To note just a couple of these examples, the Public Library of Science (PLoS) is utilizing an open publishing model to accelerate the dissemination of scientific research to the wider world. And a group in Australia, called BIOS, is developing an alternative approach to genetic engineering that bypasses the strong patents held (many by universities) on the prevailing technology for genetic engineering.