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In This Issue: Real Options and Corporate Strategy

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The Challenge of Valuing Patents and Early-Stage Technologies

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Clearly, there is enormous risk associated with commercializing inventions. The statistics are daunting: only 10-15% of the best ideas are commercially successful. To financial analysts, it is also obvious that standard valuation tools, such as discounted cash flow (DCF), break down because of their inability to capture this risk. The models "feel" irrelevant to managers and investors, so they are not used in key business decisions such as ranking projects for further investment or setting the terms of a transaction. The problem is compounded by the role of most valuation professionals, who follow detailed guidelines for accounting and financial reporting, but whose valuation results seldom influence management's strategy or actions.

This article is about building relevant valuation models for patents and early-stage technologies. A model is deemed relevant when it is used by experts and non-experts to attract and speed business transactions. Many academics have suggested that patents and early-stage technologies can be thought of as a series of options, and that the real options framework can be applied to obtain quantitative results. The question at the center of this article is this: "What is the best match between valuation models and the intrinsic features of the assets that are being valued?" And this question is followed by a narrower one: "Can the real options approach improve the valuations of patents and early-stage technologies?" But it is the answers to other questions that ultimately determine the success of a valuation model: "Are the results credible? Are they transparent? Are they relevant to the stream of commerce?"

The many challenges that arise when valuing patents and early-stage technologies are illustrated using four different examples. The first, the valuation of a public company with products in development but no revenues, shows the intrinsic challenge of valuing early-stage technologies and the limits of any valuation approach. The second example, a patent, points to the importance of screening tools to complement formal models. The third case, a software project, discusses the problems in valuing works-in-progress that can be flexibly managed to accommodate changing objectives. The final example, a technology license, highlights the challenges of valuing deal terms as contingent decisions in business transactions. In each case, there is a discussion of the models typically used by professional valuation experts followed by an assessment of the potential gains from using real options models.

The first conclusion of this article is that valuing patents and early-stage technologies is a problem with no easy answer. There is no best valuation model; instead, one must select and customize a model to match the salient features of the application. The second conclusion is that while quantitative models of real options are likely to be of limited use, real options *thinking* has a major role to play in framing the valuation of patents and early-stage technologies.

The importance of valuing innovation goes beyond the details of dueling models. Numerous academic studies have placed technology and science-based innovation at the center of economic growth.[1] The entire $250 billion venture capital industry exists to commercialize innovations.[2] And while less visible, there is an enormous amount of economic activity that surrounds the business of inventions. Each year $4.5 billion is spent on patent applications, and over $500 billion is paid in technology licensing royalties.[3] Moreover, since July 2001, mergers and acquisitions have required the valuation and reporting of intangible assets (which includes patents and early-stage technologies) at the time of acquisition and annually thereafter in corporate filings with the SEC.[4] Improved and widely accepted valuation models for patents and early-stage technologies can help to attract capital and facilitate transactions, thereby strengthening incentives for innovation.

From Idea to Product: The Bumpy Path to Maturity

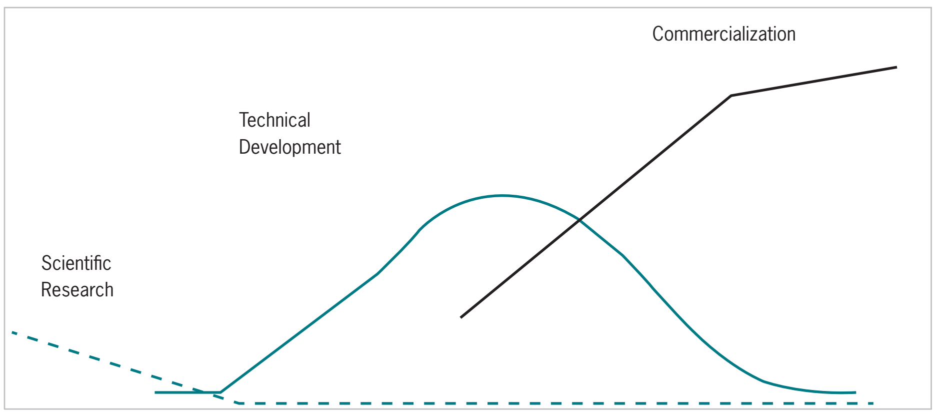
Despite the continual buzz surrounding cutting-edge innovation, the valuation of patents and early-stage technologies rests not on the fine details of the invention, but on future

1. For a review, see Elhanan Helpman, *The Mystery of Economic Growth* (Cambridge: Harvard University Press, 2004, Ch. 3).
2. See the National Venture Capital Association website for economic studies on the impact of venture capital financing on R&D, job creation, and revenue growth (www.nvca.org).
3. Sources: Mark Lemley, "Rational Ignorance at the Patent Office," Northwestern University Law Review, Vol. 95 (2001); Douglas Elliot, "Investing Wisely in Intellectual Property," in Bruce Berman, Ed., *From Ideas to Assets* (New York: John Wiley and Sons, 2002).
4. The accounting rules are SFAS 141 and 142. See www.fairmarketvalue.com for an introduction.

Figure 1 **From Idea to Product**

Stage	Concept	Early Development	Late Development	Shipping	Sustainable Business
Risk by Stage (Approx.% success)	1 – 20%	50%	65%	60%	85%
Cumulative % Success					10 – 15%

Pattern of Annual Expenditures



Sources: George S. Day and Paul J.H. Shoemaker, *Wharton on Managing Emerging Technologies*, John S. Wiley (2000), p.vii; PDMA Foundation, *Comparative Performance Assessment Study* (CPAS), 2004, www.pdma.org; F. Peter Boer, *The Valuation of Technology*, John Wiley (2000); author's calculations.

events: how the technology will be developed, the plans for commercialization, and exogenous market forces. The typical stages of development are shown in Figure 1. The valuation process typically begins at the final stage, with a vision of a sustainable business, and then works its way back toward the concept stage, providing valuation results for each stage.

Sustainable Business. The sustainable business opportunity drives much of the valuation results for early-stage technologies. Experienced investors in innovation, such as venture capitalists, clearly understand the math. The first question they often put to young companies is: "What's the size of the market?" Without a sustainable profit opportunity at maturity, there is no value in a young company or idea.

Commercialization. The product begins shipping in the commercialization stage, with profits expected to follow. Many valuation analyses of early-stage technologies underestimate the expenditures required in the commercialization phase. As Figure 1 shows, the commercialization phase has a higher peak and larger total spending than the scientific research phase. It is a frequent corporate problem to focus on a burst of new ideas in the lab but then run out of money to develop them.[5] The commercialization stage is also risky. For example, a recent survey by the Product Development and Management Association (PDMA) estimates that 40% of new products fail.[6]

Development. Development can take years and, as the data in Figure 1 show, only about a third of projects complete development successfully. Late-stage development is also a period of high financial risk, with development costs reaching their peak just as commercialization spending ramps up. To complicate matters further, the PDMA survey also reports that 50% of corporate projects involve "interlocking co-development," which means that a firm's people, schedules, and spending must be intricately coordinated with those of other companies.[7]

Concept. In some companies and industries, the concept stage is particularly fruitful, but this blessing is also a liability. Without good screening tools, resources will be wasted on mediocre opportunities. For example, pharmaceutical companies routinely discover thousands of chemical compounds each year. A small number will be selected for patenting, and very few of those will be chosen for pre-clinical development. The quality of the drug development pipeline depends in part on screening out a plethora of ideas.

In sum, the value of patents and early-stage technologies depends on the profile of what follows. Given the substantial risk of failure at all stages shown in Figure 1, a well-thought-out financial strategy is needed to manage capital demands,

5. For a classic example, see strategy guru Gary Hamel's description of events at Royal Dutch/Shell, where a fruitful year-long "revolutionary" innovation effort was put on an indefinite hold due to lack of funds; Gary Hamel, "Bring Silicon Valley Inside," *Harvard Business Review* (September-October 1999).

6. PDMA Foundation, *Comparative Performance Assessment Study* (CPAS), 2004, www.pdma.org.

7. Ibid.

particularly with development spending peaking at the same time commercialization spending begins.

Valuing a Development-Stage Company

Onyx Pharmaceuticals (ONXX) is a public biotech company with 18 products in clinical trials. At the time of this writing (early 2005), the company's lead drug candidate product, known as BAY 43-9006, is about two years away from commercial launch, and yet the company is valued at over $1 billion. Is this the return of dot.com madness, or is there some logical rationale for this value?

Onyx is an excellent case study for a quantitative analysis of value, because as a public company it must disclose enormous detail about all its development-stage products. A typical approach to corporate valuation is to sum the value of the entire pipeline, using the lead drug to build a project valuation template. The example below will show that despite the relative abundance of information, there are limits to the precision of the results.

About Onyx

Onyx Pharmaceuticals is developing a portfolio of drugs that attack cancer at the molecular level. Its lead drug candidate, BAY 43-9006, is in Phase III clinical trials for the treatment of kidney cancer. Onyx and Bayer have agreed to co-develop and co-promote this product around the world, with costs and profits shared equally.[8]

To reach market, BAY 43-9006 must clear at least three hurdles:

- Successful completion of the Phase III trials (industry average is 68% chance of success);
- Successful approval of its new drug application (industry average is 81% chance of success); and
- Successful product launch (only three out of ten drugs in the market recover their R&D costs).[9]

An Expected Value Model

An expected value model involves a very simple characterization of risk. At each stage, information arrives that could cause the project to continue or to be terminated. There is almost no salvage value to the project. In the development stages, information arrives about scientific success or FDA approval. In the commercialization stage, information arrives about the product market success. An expected value model begins at the back, valuing the product as a sustainable business. Then at each earlier stage, the payoff value is discounted to reflect the time value of money, success rates, and stage costs.

A recent article in *Motley Fool* showed how to construct a "ballpark" sales forecast for a drug in development using

Figure 2 **Calculation of Mature Product Value BAY 43-9006, Onyx Pharmaceuticals**

Range of U.S. Product Revenues ($MM)

		US Market Share		
		10%	**25%**	**45%**
Monthly cost (avg. wholesale price)	$2,000	35	88	158
	$2,300	40	101	182
	$2,500	44	110	198

Assumptions & Data: 11 months of treatment; 32,000 new cases per year in the U.S.; approx. 50% of cases are metastatic cancer and candidates for treatment with BAY 43 -9006.

Comments: Number of patients stable; length of treatment based on BAY 43-9006 clinical data; market share range covers best to worst case; price range may be high as there are close competitors also in development.

Range of U.S. Product Value ($MM)

		Market Value/Sales		
		3.5	**9**	**14**
	35	123	317	493
Revenue	**101**	354	911	1417
	198	693	1782	2772

Assumptions & Data: Market Value/Sales Ratio is the range over the past five years for Amgen and Genentech.

Comments: Revenue range covers potential endpoints in first matrix; 5-year history of market value/sales is probably indicative of the longer-term as well.

Range of Product Value at Launch ($MM)

		Market Value/Sales		
		3.5	**9**	**14**
	35	57	210	348
Revenue	**101**	239	678	1076
	198	506	1364	2144

Expected Product Value at Launch: $736

Assumptions & Data: Launch value is received 2.5 years from launch date; 10% discount rate used. Shaded numbers indicate continue. Initial launch cost is $40MM.

Comments: Even at 15% market share and a low value for sales, the project continues. Because the project continues under all cases, the expected value is a reasonable summary measure.

Source: Author's calculations.

8. Information on Onyx's partnership agreements is available from the corporate website, www.onyx-pharm.com, and from a biotech industry resource, www.recap.com.

9. H. Grabowski, J. Vernon, and J. DiMasi, "Returns on Research and Development for 1990s New Drug Introductions," *Pharmacoeconomic*, Vol. 20 (2002).

10. See Charley Travers, "Unraveling Biotech Potential," *The Motley Fool* (June 7, 2004).

Figure 3 **BAY43-9006, Onyx Pharmaceutical**
Calculation of the Current Product Value ($MM)

	Phase III	NDA	Launch
Product Value at Start of Launch			**$736**
PV Expected Product Value (90% success rate)		*$574*	
NDA Costs		*($20)*	
Product Value at Start of NDA Phase		**$554**	
PV Expected Product Value (75% success rate)	*$360*		
Remaining Phase III costs	*($24)*		
Current Value of BAY 43-9006	**$336**		
Value of Onyx's Share of BAY 43-9006*	**$168**		

Assumptions & Data:

NDA Phase: 90% chance of success; 1.5-year phase; 10% discount rate; $20M cost, including pre-sales expenditures.

Phase III: 75% chance of success; 1 year remaining; 10% discount rate; $24M remaining cost of phase, including pre-sales expenditures.

* Onyx and Bayer have agreed to split all costs and profits in the U.S. for BAY 43-9006.

Comments: The success rates are in line with data from several sources, but there are differences across publications. These differences will not change the overall results. The timing of the launch date has a significant effect on value because a longer time horizon delays the option payoff.

Onyx as an example.[10] The approach, which is similar to that used by most corporate and equity analysts, begins by estimating the potential annual U.S. revenues from BAY 43-9006 at about $100 million per year. The analysis factors in the potential patient population, length of treatment, and current pricing for similar drugs. As the author notes, the revenue estimate relies on two key assumptions: a market share of 25% and an average wholesale price of $2,300 per month. The author also suggests that there is a reasonable range around these inputs, which is translated into a sensitivity analysis in this example. Also, potential competition from an established drug from Genentech and drugs in development from Wyeth and Pfizer suggests that market share assumptions should be challenged in the valuation analysis.

The top panel of Figure 2 displays the range of potential U.S. product revenues suggested by the data. The second panel converts revenues into company value by multiplying revenues by the price-to-sales ratio. Biotech stocks are notorious for substantial sector-wide swings, so a wide span of values for the multiple is used. The results in the second panel show a potential value of BAY 43-9006 that ranges from $123 million to $2.7 billion. Of course, the outcomes are not equally probable, but the business case behind each is of interest.

The bottom panel shows the results for the product value at launch, after discounting for the time it takes to ramp up sales (assumed to be two and a half years) and after subtracting launch costs of $40 million. If the payoff net of these adjustments is positive, the product should be launched, as indicated by a shaded cell. (Note that one would launch the product in all cases represented by the cells in the bottom panel.)

Figure 3 completes the valuation calculations for Bay 43-9006. Starting with the expected value of the product at launch (taken from the bottom panel of Figure 2), the value of BAY 43-9006 is calculated by stage, after accounting for the probability of success, the elapsed time in the phase, and the cost of the phase. After the profit split with Bayer, the value of BAY 43-9006 is estimated to be $168 million, or about 15% of Onyx's market value.

The expected value model (also known as risk-adjusted NPV or rNPV) is widely used to value drug development projects.[11] It is far simpler than Monte Carlo simulations and the real options approach, while still incorporating uncertainty and scenario analysis.

The expected value model works well for two reasons. First, drug development projects are seldom voluntarily abandoned. As the shaded cells at the bottom of Figure 2 indicate, if BAY 43-9006 survives the FDA gauntlet, management will authorize a launch. This is a typical feature of drug development projects: they are hugely positive NPV projects that are seldom voluntarily abandoned.[12] (Of course, bad scientific or FDA news may force abandonment.) There is a very active market in which biotechs license promising young drugs to large pharmaceutical companies (deals driven by upside potential). At the same time, there is a small amount of licensing in the reverse direction—deals in which large pharma companies license mediocre drug projects to others for completion (deals typically motivated by a scarcity of corporate resources at big pharmas). The simple expected value framework captures managerial decisions and the risks faced by the project.

The second reason the expected value model works well is that the range of uncertainty is grounded in the business case. The analysis shows a huge range of potential value for BAY 43–9006—from $57 million to $2.1 billion—yet the logic behind each extreme point is clear. Analysts can easily trace through the layers of assumptions, or find their preferred set of assumptions and valuation outcome.

In sum, the expected value model meets the relevance criteria for business use.

11. For more information about the risk-adjusted NPV method, see Chapter 6 of my book, *Value Sweep* (Cambridge: Harvard Business School Press, 2002); and Jeffrey J. Stewart et al., "Putting a Price on Biotechnology," *Nature Biotechnology* (2001). Spreadsheets are also available at www.valuesweep.com and http://www.nature.com/nbt/journal/v19/n9/suppinfo/nbt0901-813_S1.html.

12. The use of real options and decision analysis for the valuation of drug development is discussed in more detail in a previous article I co-authored with Nalin Kulatilaka in this journal: "Strategy and Shareholder Value Creation: The Real Options Frontier," *Journal of Applied Corporate Finance*, Vol. 13, No. 2 (2000).

Can a Real Options Model Add Value?

Many books about real options present a valuation model for drug development, so it is reasonable to ask what real options might add to the simple expected value model. In the real options framework, drug development is seen as a series of call options (the right to buy the upside potential of a given drug at a known cost) with exercise rights held by the FDA and the company. Biotechs and pharmaceutical companies will attempt to exercise their call options (which are almost always in the money), but are frequently prevented from doing so by bad news from the FDA.

The problem with the real options framework for drug development is that it leads to fairly complex models. A typical example appears in *Real Options: A Practitioner's Guide*.[13] The drug development case study in the book uses the same simple expected value framework for technical uncertainty as shown above. But in what amounts to a real options approach, uncertainty about the drug's value in the market is modeled using a binomial lattice.

Two significant, and fairly common, problems arise in this application. First, the inputs take on different meanings than intended in the real options/financial options analogy. In this case study, the inputs to the binomial lattice are "back-fitted" to allow the price of the drug to grow at 8% per year. Yet in the real options/financial options analogy, it is the volatility estimate that determines the lattice inputs. And the fact that most real options models for drug development are forced to rely on such *ad hoc* adjustments instead of market-based volatility estimates negates one of the main reasons for using such models—namely, the introduction of financial market discipline through option pricing methodology to internal project analyses. A real options model without this layer of discipline is no more rigorous than other conventional, NPV-based approaches.

Complexity is the second problem for real options models of drug development. The case study in *Real Options* requires 13 pages. In addition to the many equations, the binomial lattice itself is forbidding to managers. The intrinsic features of drug development—relatively high potential market value, huge technical and launch risk, little or no abandonment value—allow for a much simpler valuation model, one that fits with managerial intuition.

Valuing Intangible Assets in Accounting and Financial Reporting

Suppose that Onyx were acquired by another public company. How would valuation professionals put a number on its assets for accounting and financial reporting purposes? They, too, would value the company as the sum of its products, but would use an entirely different set of valuation models.[14] The organizing framework for valuing intangibles is the accounting concept of *fair value*, which is defined as an amount paid in a voluntary transaction between two parties. In the absence of comparable transactions, estimates provided by models of fair value can be used. In the language of merger accounting, most of Onyx's value would come from its in-process R&D (IPRD), which is valued using the discounted cash flow model with a risk premium added to the discount rate.[15]

The cash flows can be calculated in one of several different ways.[16] In the most frequently used *cost method*, the cash flows are the costs to reproduce the asset. The *income method* values the incremental profits from using the new technology. The *market method* establishes value by comparison to similar recent transactions, but is seldom used because of the difficulty in identifying comparables. The *relief-from-royalties method* estimates value by using the royalty rates that would otherwise be paid to gain access to the technology.

In a world of smooth transactions and full information, the models should all produce similar answers. The reality, however, is that the choice of model determines the answer. Both the cost and relief-from-royalties methods tend to provide lower valuation results than the income and market methods.

Not surprisingly, the models used for accounting and financial reporting seldom seem relevant to managers. Each formulation introduces a new set of assumptions and model biases, as well as a new set of uncalibrated data. Although their perspective is based on simple and straightforward economic arguments, the accounting models fail to capture the key risks and full costs of early-stage technologies. In practice, poor implementation often makes the valuation results easy to challenge, and thus easily ignored by business managers.

Corporate Value: Not the Sum of the Product Pipeline

Thus far, the valuation analysis has focused on BAY 43-9006, a treatment for kidney cancer. To complete the company valuation of Onyx, the other projects in development must be valued. The next drug candidate in the pipeline is a treatment for liver cancer, which is also in Phase III clinical trials. The value estimate for this project will rely on much of the same data on costs, chance of success, time in each phase, and potential use outside the U.S. that have already been compiled for BAY 43-

13. Tom Copland and Vladimir Antikarov, *Real Options: A Practitioner's Guide* (New York: Texere LLC, 2001), pp. 323-339.

14. Three excellent references on intangibles valuation for accounting and financial reporting are: Weston Anson, Ed., *Intellectual Property Valuation* (The American Bar Association, 2005); Michael J. Mard et al., *Valuation for Financial Reporting* (New York: John Wiley & Sons, 2002); and Robert F. Reilly and Robert P. Schweihs, *Valuing Intangible Assets* (New York: McGraw-Hill, 1999).

15. In the literature, a risk-adjusted discount rate of 25% is suggested for IPRD. Mard et al., (2002, p. 26), cited earlier.

16. See Reilly and Schweihs (1999, Ch. 24), cited earlier, for an overview.

9006.[17] For patents and early-stage technologies, the data are seldom sufficiently rich to make distinctions from the industry-average experience.

Onyx also has a third drug that is expected to start Phase III soon. Because all three drug candidates are under the partnership agreement with Bayer, a reasonable conclusion is that their total value is less than $756 million (three times the $168 million valuation for BAY 43-9006.) There is simply not enough information to be more precise about the value of each drug.

Onyx has 13 drugs in Phase II trials and one in Phase I trials. If Onyx is valued as the sum of its drugs in development, a rough estimate of the company's value is over $3 billion, with $2 billion from the Phase II drugs. (The Phase II values are discounted from the Phase III valuation established above using industry averages for risk, cost, and timing.) At the time this article was written, Onyx's market value was "only" $1.1 billion. Thus, a market value that at first might have seemed too high could well be an *under*estimate!

The financial community appears to be discounting the value of Onyx's pipeline, and for any of several possible reasons:

- The projects in the pipeline have highly correlated value, in that they are all based on the same discoveries, with their fates closely tied to one another;
- It may be difficult to achieve substantial sales outside North America, and Onyx's management remains untested in this regard;
- Over $800 million is needed to complete development for the pipeline, raising concerns about management's ability to obtain funds;
- There is considerable uncertainty about the length of time before the projects realize their full value, and potential delays sharply reduce the current value of early-stage technologies; and
- There is heavy discounting of the product market valuations because they are based on forecasts of the distant future.[18]

Most important, none of these factors would figure in a standard stand-alone valuation for any of Onyx's products or, for that matter, almost any valuation of an early-stage technology. Yet each is significant and serves to remind us of the inherent lack of precision in the value of early-stage technologies.

In sum, the valuation of Onyx Pharmaceuticals has demonstrated how a simple quantitative framework can provide insight and benchmarks. The results also demonstrate the inability of any model to be precise about the value of early-stage technologies, or to distinguish between the values of two similar early-stage technologies. Although the accounting and financial reporting models have generally been viewed as irrelevant by business managers, accounting bodies have recently accepted expected value models for the valuation of early-stage technology assets and in-process R&D—and the expected value model for Onyx fits within the new accounting guidelines.[19] Thus, it seems there may now be an opportunity to use a single early-stage technology valuation model for both commercial and accounting purposes.

Patents: More Than a Valuation Model Is Needed

The subject of patents evokes the image of a lone inventor in his garage who has a flash of inspiration and then unexpected commercial success. The reality, however, is quite different: more than 95% of patents fail to earn any revenues.[20] This section uses the example of a ski binding patent to illustrate two important issues. First, because the majority of patents are valueless, it is important to quickly identify those that are sufficiently promising to justify the work of a valuation analysis. Recent academic research on patents can be used to inform the screening tools for this winnowing process. Second, there are significant limitations to our ability to value patents with much confidence. The example illustrates some of the key risks, most of which are very hard to quantify.

The Ski Binding Patent

U.S. Patent # 5,653,467 ("Method and Apparatus for Easing the Strain on Legs and Knees While on a Ski Lift") was granted in August, 1997 to three members of the Griffin family of Palo Alto, California.[21] The invention is a belting system that distributes the weight of dangling boots, skis, and snowboards while sitting on chairlifts. The belting shifts the weight away from the ankles and knees to the upper body, avoiding joint fatigue and injury.

The Griffins intended to commercialize their invention and thus originally filed for patent coverage in many countries where ski clothing and bindings are made, including the U.S., Canada, Japan, and 16 countries in Europe. Eventually they dropped their European applications by failing to pay the fees for continued review. On the business side, the Griffins enthusiastically and carefully researched the ski clothing and binding industry, and approached the leading vendors at a key convention. Many expressed inter-

17. Data on the target market suggest that there are fewer liver cancer patients per year in the U.S., but more of them may be helped by Onyx's drug. Potential sales outside the U.S. are difficult to validate. For example, 45% of the world's liver cancer cases are in China. Mature biotech companies—and there are only a handful of them—make about half of their sales outside the U.S., but few to China. There is no clear estimate of the size of the liver cancer market. Further, the liver cancer drug entered Phase III trials about 15 months after the kidney cancer drug, and thus the company must wait a bit longer for payoff. While this assumption turns out to be key to differential value for the two drug projects, it is an unreliable assumption as delays and schedule changes are common.

18. Discounting for the quality of information is discussed in Chapter 3 of Bruce C. N. Greenwald et al., *Value Investing* (New York: John Wiley, 2001).

19. See Mard (2001, p. 25), cited earlier, and also www.fasb.org/project/fv_measurement.shtml#decisions.

20. Lemley (2001), cited earlier.

21. Thanks go to my neighbor, Robert A. Griffin, a co-inventor of the patent, for introducing me to this patent and providing details on the attempts to commercialize it.

est, but only one followed up. The Griffins sent prototypes, and reworked them several times to the vendor's specifications, but interest died out and the matter dropped. The Griffins also set up meetings with leading manufacturers, but again there was no continuing interest. At a later ski show, the Griffins saw a potential infringer displaying his wares. Thinking they might finally monetize their invention—this time through a lawsuit—they began their legal research. But the potential infringer was also using a well-known trademark without license, and was shut down by the threat of a lawsuit from the trademark's deep-pocketed owner. Discouraged, the Griffins gave up, and their patent languishes unlicensed.

Screening Patents

Beginning in the mid-1980s, academics have been using the increasing availability of electronic patent records to study how patent activity is related to innovation, R&D spending, and corporate market value.[22] Based on econometric analyses of large patent databases, researchers have identified four or five patent attributes that correlate with value. Some of the strongest evidence is from studies of patent renewal fees, which must be paid several times during a patent's 20-year life to maintain patent protection. The fees for the U.S. are less than $1,000 per year. But for patents that are simultaneously filed in 8-10 other countries, the annual costs can be $70,000 to $250,000 per year.[23] At each renewal date, the patent holder has the option to renew, but most don't; the data show that only one-third of filed patents have all fees paid at the end of the 20-year patent life. The second approach taken in the academic literature is to regress corporate market values against various patent attributes, such as number of citations, number of claims, and so on.[24]

Both lines of research have found a strong skew in the data. The patent attribute that is most strongly correlated with value is the number of references to the patent by subsequent patents (known as "forward citations"). One-quarter of all patents have no forward citations and approximately one-half have fewer than seven forward citations.[25] Other attributes that are correlated with patent value include the number of claims in the patent, the extent of multi-country filings, the number of backwards citations, the number of backward citations to the same inventor (known as "self-citations"), and whether the patent has been upheld through litigation or opposition (a process in European patent offices where others may challenge a patent within nine months of its publication).

The screening criteria indicate, for example, that the Griffins' ski binding patent has some value. The patent has five forward citations, was filed in 19 countries, and has 29 claims. All of these numbers are higher than average, and are thus indications of potential value. Working against patent value, however, is the fact that the patent was filed by a set of unaffiliated individuals rather than by a company. Individuals generally have neither the financial means to prosecute infringement by others nor the business sophistication to commercialize their invention. Further, this is a lone patent filing—without subsequent patented improvements or additional embodiments—making it easier for imitators to do a technical end run around the patented invention.

Extending the Expected Value Model

In theory, it should be possible to extend the expected value model back one stage for patent valuation. The use of patents varies by industry, and the initial evaluation of the strength of the patent position must consider whether the industry practice is monopolistic protection of inventions or the defensive building of patent portfolios to settle lawsuits quickly by an exchange of patents. The expected value model is then implemented based on these initial findings.

The Griffins' attempts to commercialize their patent illustrate the challenge for valuation models: since the patent's value is seldom obvious to others, the concept must be "sold" to partners and customers. Much of the value predicted for a patent rests on whether the holder has the intent, time, and resources to invest in a long process of commercialization. The rate of product launch success shown in Figure 1 is for projects that have completed development in large corporations. The rate of commercialization success for patents is clearly much lower, and ad hoc adjustments to the data must be made to reflect the increased risk. (Note that most corporate patents are also never commercialized, so the increased risk is to the patents themselves.)

In some ways, patent valuation resorts to the commonly told story about how venture capitalists screen business plans: they first look at the resumes of the founders. In patents and startups, "who" is creating the opportunity matters for valuation. Thus, one might place two conditions on patent valuation models: *if* the patent position is sufficiently strong, *and if* the management team is sufficiently credible, *then* the expected value approach is reasonable. (In the case of a licensing or merger, one would need to evaluate the strength of the management team acquiring the technology.) In this way, the value of a patent is context-specific, and the patent will have a different value if owned by others or intended for another use.

Can a Real Options Model Add Value?

Patents have been long identified as candidates for the real options approach. In an early managerial article, Avinash

22. An excellent volume with some of this research is Adam B. Jaffe and Manuel Tratjenberg, Patents, *Citations and Innovations* (Cambridge: MIT Press, 2002).
23. Lemley (2001), cited earlier, and David M. Katz, "A Company's Mind is a Terrible Thing to Waste," CFO.com (July 26, 2001).
24. See Bronwyn Hall et al., "Market Value and Patent Citations," *Rand Journal of Economics*, Vol. 36 (2005).
25. See the presentation slides on Bronwyn Hall's faculty website, http://emlab.berkeley.edu/users/bhhall/bhpapers.html.

Dixit and Robert Pindyck wrote that R&D activity creates options to patent, and that exercise of this type of option was similar to a traded call option contract.[26] Aswath Damodaran, a prolific writer on valuation, has had a real options example of patent valuation (using Black-Scholes) in his books since the mid-1990s.[27] In the past five years, the list of books and articles describing how to use the real options approach to value R&D projects and early-stage technologies has grown enormously.[28]

Within the real options framework, it is assumed that the patent owner holds all of the options. But the Griffins' attempts to commercialize their patent are more typical. While they held the option to pursue commercialization, the ski industry companies held the option on whether to do business with the Griffins. As many patent owners have discovered, patents are commercialized only after a systematic program of marketing and business development. It is not uncommon to co-develop a business plan with a potential patent licensee as a way to demonstrate commercial value. Because one must invest to spread the word, decision analysis, with its well-established frameworks for valuing information, seems better suited to providing insights on how and where to spend. To be sure, real options provides an interesting way of thinking about patents, especially when the problem is expanded to consider all parties holding options. But real options models will rarely provide much help in valuing patents.

Valuing Intangible Assets in Accounting and Financial Reporting

Real options is not the only model that is a poor fit for patent valuation. The valuation models used by accounting professionals seldom include a screening analysis or do a good job of reflecting the risks of development and commercialization. Instead, the patent is valued as the stand-alone product it may engender. Cost-based methods omit the upside potential of the technology, and royalty-based methods assume that the technology is commercialized. Neither of these methods captures the risks of development and launch. And because most patents turn out to be worthless and fail to recover their costs, cost and royalty-based models lead to inflated estimates of patent value.

Are Patent Valuation Results Credible?

Using options thinking, one would expect most patents to have some value, or a positive option premium at a minimum. But when 95% of patents fail to realize any value, it is likely that many do not merit any premium at all. Unfortunately, most reports prepared by valuation experts show substantial patent value, and it is difficult to believe that all of these patents were pre-selected from the top 5%. Screening tools can quickly sort patents into those with potential value and those without—and patent valuation reports without this confirming detail are incomplete and possibly misleading.

Further, if the paucity of information prevents differentiated valuation of two similar early-stage technologies, this problem is only compounded in the case of patents. While not typically done, patent valuation reports should include a comparison of the valuation results to those of a similar technology, so that the reader can correctly infer a confidence level for the results. Again, without the supplemental analyses, the patent valuation report is incomplete and possibly misleading.

And finally, patent valuation is challenged by the need to write a business plan before the patent can be valued. A business plan not only demonstrates to a potential partner the commercial value of the invention, but it also lays out a schedule of the complementary assets that must be contributed by other divisions or other companies along the way. The patent's value is very specific to the plan considered and the complementary assets provided. The business plan brings focus to a key risk (will this partner sign up?) and to the reality that, unless the complementary assets are provided, the patent probably has little value.[29]

In sum, valuing patents is inherently difficult—a difficulty that is compounded by the desire of interested parties in producing results that exceed, in the vast majority of cases, what can be accomplished. Patent valuations are context-specific and thus can vary significantly across different contemplated uses. To strengthen the credibility of patent valuations, the valuation process should begin with reports of patent-screening results that validate the existence of value, and should include parallel analyses of similar patents to establish appropriate confidence levels.

Software Programs: How an Asset Is Created Determines Its Value

Software development expenditures are estimated to exceed $800 billion annually, yet the corporate finance literature has not addressed the question of how to value software projects.[30] Perhaps this is because software projects are even more difficult to value than other early-stage technologies.

26. See Avinash Dixit and Robert Pindcyk, "The Options Approach to Capital Investment," *Harvard Business Review* (May-June 1995).

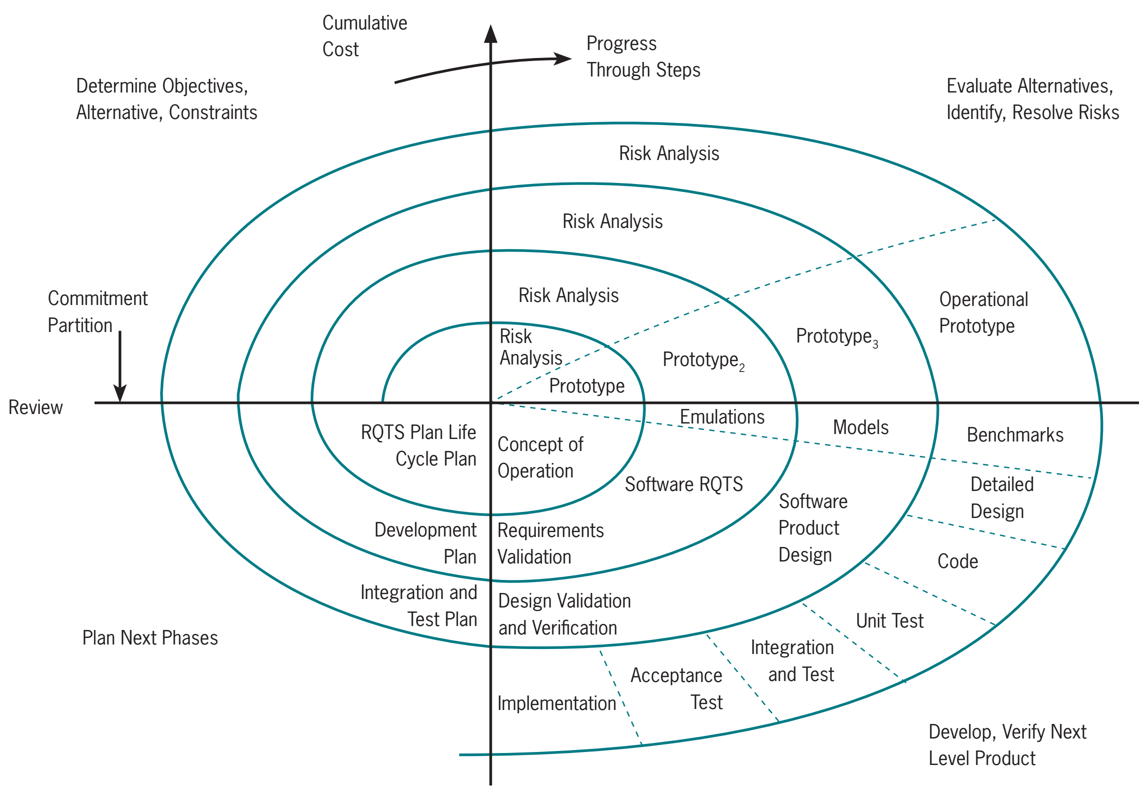
27. For example, see Aswath Damodaran, *The Dark Side of Valuation* (Upper Saddle River, NJ: Prentice Hall, 2001), p. 385.

28. For an excellent listing, see the website maintained by Professor Alex Triantis of the University of Maryland, http://www.smith.umd.edu/faculty/atriantis/RealOptionsportal.html. Some intellectual property valuation professionals also use real options; see, for example, www.intecap.com and www.inavisis.com.

29. The accounting and financial reporting valuation models often calculate patent value as total business value minus the cost of complementary assets. This adjustment ignores the risk of acquiring the complementary assets and the necessity of doing so if the total business value is to be realized.

30. Barry Boehm and Kevin Sullivan, "Software Economics: Status and Prospects," *Information Software Technology* (1999).

Figure 4 **The Spiral Development Model**



Source: Barry Boehm and Wilfred Hansen, "The Spiral Model as a Tool for Evolutionary Acquisition," *Crosstalk* (May 2001), http://www.stsc.hill.af.mil/crosstalk/2001/05/boehm.html.

While the following issues influence all early-stage projects, they dominate software projects:

• The objective function (the project specification) keeps changing once the project is underway;

• The development process is surprisingly people-intensive, requiring close coordination between developers and business managers;

• Software development is unpredictable, relying on inspiration and perspiration, and resists top-down management; and

• Less than a third of software projects are successfully completed.[31]

Despite these challenges, the following case study illustrates how good software management practices can keep projects on track, and demonstrates how a new valuation method for software projects can be integrated into project management. Because software projects are so flexible, and the planning choices are more varied, the solution method may be of use to managers of other early-stage assets.

Modern Software Development

Modern software development practices began 25 years ago by discarding the project management method (the "Waterfall") that most closely resembles the expected value model introduced earlier. To those outside the software industry, the Waterfall method seems entirely logical: define the requirements, establish the design, write the code, test the software, and deploy the software. Each step is fully completed before the next step begins. (The Waterfall name comes from the shape of a graph in which the stages march down a diagonal from the upper left to the lower right.)

In practice, however, there is a clash between the sequential structure of the Waterfall method and project realities. Too often, software teams must loop back from the testing stage to fix substantial design and coding flaws, causing large budget overruns and delivery delays. Software defects routinely slip through development testing, only to be detected by customers. Experience shows that the Waterfall method is a poor match for software development projects.

31. For example, a recent report by the Standish Group indicates a 29% project success rate; see *The Chaos Report*, Q3, 2004, online at www.standishgroup.com.

The implication is that the expected value model is also poorly suited to software project valuation.

The Spiral model, introduced in 1988, vividly captures the iterative nature of the modern software development methods.[32] As shown in Figure 4, a prototypical software development plan starts at the center, with the requirements and life-cycle plan. It moves on to risk analysis and then to the task of building a prototype. There are frequent reviews (at the points where the horizontal line intersects with the spiral), and a complete cycle across the four quadrants integrates a diverse set of technical and business activities. The Spiral model reduces risk because building the prototypes effectively ensures significant and early learning about the design, coding requirements, and testing needs. The early information is used to revise subsequent iterations of development.

The late 1990s saw the introduction of a second development methodology called the Agile Development method. Also known as eXtreme Programming, or XP, this method reduces formal planning in favor of an incremental development approach centered on the user experience. Working with the customer, developers collect a set of "user stories" (scenarios of user interaction) describing a customer's needs and expectations of the system. A set of 60 to 100 user stories defines the software project requirements, and these are divided into releases every one to three weeks. Large projects might take two years, with over 20 releases, although only the earliest releases will be fully specified at the start. Each release contains at least a few complete user stories, so customers can start testing the software and provide early feedback. The flexible project management style allows specifications to change, and the well-tested, user-centered functionality of each release works to minimize development risks.

The Agile/XP method also introduced changes in how software developers are organized for their daily tasks. Experience has shown that programmers should be encouraged to communicate with each other frequently, and so under Agile/XP they are seated in the same room. Testing starts at the moment of coding, and programmers are often paired to work out issues together in real time. Planning is done over a very short horizon, removing stressful false expectations about the upcoming schedule. Further, the team updates priorities at each review, with features no longer requested by the customer dropped to the bottom of the list. The project then efficiently moves towards completion, even under changing requirements.

Extreme Programming at Sabre

Sabre Airline Solutions™ provides software and consulting services to the airline industry based on its experience with the Sabre reservations system.[33] The software group is divided into a number of ten-person teams, and a recent study documented team performance for one software product over a six-year period. An early version of the product was developed using the Waterfall method, supported by Microsoft Project™ for scheduling. The programmers sat in semi-private cubicles, and product development specialists traveled around the world to gather feedback from customers.

In contrast, a later release was managed using XP. The team sat in an open office environment, with furniture and pair programming stations arranged by the developers. Testing equipment was also present in the room. A representative from Sabre's marketing department served the role of the customer, and made final decisions on product functionality. The representative was on-site about half the time, and easily available the other half. Stand-up meetings were held every morning to monitor progress and to resolve bottlenecks. Planning was done incrementally, only a few weeks at time, so the project seldom veered off schedule. Pair programming was used about half the time.

The later version was clearly a better outcome for Sabre:

- 80% reduction in time to completion, with the entire development cycle down to 3.5 months
- 65% reduction in bugs before release
- 35% reductions in bugs found by the customer after release
- 50% increase in code-building productivity

While these performance improvements are impressive, they are even stronger than suggested by the numbers because the later version was more complex: the lines of executable code grew by 65%, and the number of worldwide customers (with competing demands) grew from five to eleven.

Integrating a Valuation Model

While XP is the work of many years of learning-by-doing in software management, most software professionals would agree with this statement from a founder of Agile Programming: "I'm generally allergic to looking at tables of financial numbers (and I'll guess most of you are, too), so it took some deep breathing exercises before I sat down with my cup of tea and worked my way through the first example…"[34]

32. See Barry Boehm, "A Spiral Model of Software Development and Enhancement," *Computer* (May 1988).

33. The information in this case study is from "Exploring Extreme Programming in Context: An Industrial Case Study," by Lucas Layman, Laurie Williams, and Lynn Cunningham; see www.agiledevelopmentconference.com, 2004 conference program.

34. Alister Cockburn, quoted on the website accompanying *Software by the Numbers*, http://dactyl.cti.depaul.edu/ifm/testimonials.html.

A recent book, however, *Software by the Numbers*, may change the situation significantly.[35] The book introduces a valuation framework to software project management that captures the risks and flexibility in software projects. The valuation methodology helps managers to balance value and feasibility in each XP release. A key to the framework's success is that it doesn't attempt to replace the Spiral method or Agile/XP methods. Instead, the valuation framework is easily applied to those development processes, preserving the years of experience that led to their best practices.

Software by the Numbers reworks user stories into "minimum marketable features," or MMFs, which are blocks of software functionality that can provide value if released separately. MMFs are valued using risk-adjusted NPV, bringing product market information deep into the development process. In the XP method, detailed information on the incremental cash flows expected from the MMFs are readily available because the development team works closely with the customer. The MMF concept provides the missing link between what programmers can build, what the market is asking for, and what it will pay. Often an MMF will require a precursor set of code, or an array of functionality, which turns the selection of the set of MMFs for each release into a value-maximization problem subject to constraints, an exercise in dynamic programming. There is an additional dimension to consider—the release cycle—and the value-maximizing release schedule is also determined using the dynamic program.

Software by the Numbers provides simple spreadsheet-based tools with visual guides so that software managers can almost mechanically optimize their MMFs and schedules, given the constraints. Using this method, one can easily establish the current value of the unfinished project, while incorporating all of the major anticipated risks. While relatively new, the framework has been used at Sun Microsystems with large customers, and has received excellent reviews in the software industry.

Can a Real Options Model Add Value?

As others have noticed, the Spiral model is a natural candidate for options thinking, since at each review the team has the option to continue development. Within the field of computer science, there is a growing literature on software development as a sequence of real options.[36] Unfortunately, the real options framework breaks down when applied to software development. First, changes in value in the product market are viewed as exogenous and tracked by a portfolio of stocks. This is a passive perspective, one that is at odds with an active learning process in which managers invest in small, early tests to better understand how their product may fit into the market. Active learning cannot be valued within the real options approach; as noted before, decision analysis is a better match.[37] Second, while value-maximization is the clear goal of any software project, real options models provide little guidance on how value should be added, failing to address issues such as feature selection and the optimal order of development.

Valuing Intangible Assets in Accounting and Financial Reporting

As we have already seen for patents and early stage-technologies, managers typically view software project valuations in financial and accounting reports as irrelevant. In the few cases where software is tied directly to revenues, the software is often valued by discounting future profits (using the income method). But for development-stage projects or software that provides general support for corporate functions, valuations typically use the cost method. In this case, the software is divided into modules, and each module is assigned a degree of difficulty based on historical experience. The lines of code per module are counted, and based on the degree of difficulty, an estimate is made of the hours required to recreate the code.[38] Recent advances in software development tools have progressively weakened the relationship between lines of code and value. In acquisitions, for example, such formal, cost-based valuations of software are nearly useless, failing to capture both the upside potential and the challenges that worry software managers.[39]

The good news, however, is that with the introduction of the valuation methodology in *Software by the Numbers*, there is now an opportunity for relevant valuation of software projects. But as the case study presented above is meant to illustrate, how software is coded matters a great deal to its value.

Technology Licenses: Another Layer of Valuation Complexity

Valuing technology licenses is an important activity for two reasons. First, almost all patents and early-stage technologies are licensed in some way, so there is clear need for a reliable method. Second, valuation models for licensing play a large role in the accounting and financial reporting literature since they are also used to value early-stage assets themselves.

35. Mark Denne and Jane Cleland-Huang, *Software by the Numbers* (Upper Saddle River, NJ: Prentice-Hall, 2004).

36. An excellent collection of articles is posted at http://www.cs.washington.edu/homes/taoxie/realoptionse.htm by Tao Xie, a doctoral student at the University of Washington.

37. See Martha Amram, *Value Sweep* (Cambridge: Harvard Business School Press, 2002), Ch. 2.

38. See Mard (2001, pp. 52-54), cited earlier; and Reilly and Schweihs (1999, pp. 484-490), cited earlier.

39. Because the cost-based approaches undervalue software in an acquisition, a large portion of the software's value is assigned to goodwill. The result is that post-acquisition financial statements are weaker reflections of the combined operations.

Figure 5 **Selected Terms from the MIT/Speechworks License**

Term	Comment
Non-exclusive license.	While this clause preserves MIT's option to license to others, the license's value declines with more licensees. Meanwhile, Speechworks is making proprietary improvements which may increase its dependency on the original license.
MIT grants Speechworks the rights to all improvements.	Speechworks is allowed to own all technology improvements. This will form the core of its corporate value.
MIT to be paid royalties by Speechworks.	MIT takes two-thirds of the sales revenue in the early years, tapering down to 9% on average between 1995 – 2000, and 1% of product sales thereafter.
Speechworks required to meet certain business growth objectives.	MIT wants the licensee to grow and flourish, or to return the license. The business objectives include review of a business plan; product development date; and sales goals and dates.
Transfer of technology is restricted, but can be assigned in the event of a merger.	The technology can't be transferred on its own, but transfers in the case of acquisition are allowed. MIT and Speechworks are aligned on getting the most value out of the company.

Source: Martha Amram, *Value Sweep*, Harvard Business School Press (2002), p. 174.

Despite the demand for license valuations, they are quite difficult to do well. One must first develop a valuation model for the early-stage technology and then layer on the license terms. Many license terms are invoked on a contingent basis (that is, they apply only in some states of the world), so valuation models must address a range of uncertain outcomes. The expected value model, with only two outcomes at each stage (success or failure), is often too simple. The case study presented in this section demonstrates the considerable uncertainty that surrounds the value of any technology license and the difficulty of establishing credible valuations.

The MIT/Speechworks License

In August 1994, MIT licensed some early-stage speech-recognition technology to a startup that later named itself Speechworks.[40] How much was the license worth at the time of transaction?

MIT has an established licensing program and an interest in finding parties willing to license its intellectual property. Its negotiating position is the same as that of many large companies that hold a large portfolio of unused patents: As long as the license covers the minimal costs, MIT is better off licensing the technology than letting it sit unused. Thus, as MIT's technology licensing website states, "Terms are flexible."[41]

Speechworks's negotiating incentives were just the opposite. The company was started in August 1994 by former MIT researchers who wanted to build their company around the early-stage technology. The value of the license to the researchers was large, and closing a reasonable transaction critically important. Thus, negotiations started with an inherent "asymmetry" in the perceptions of value. As with all license transactions, the final deal may reflect as much about negotiating skills as it does about intrinsic value.

Figure 5 summarizes the key terms of the transacted MIT/Speechworks license. While the terms are fairly typical, there is significant variation across industries. For example, in this license, MIT grants Speechworks all rights to its innovations, while preserving MIT's rights to the original technology. Owning future innovations is important to Speechworks because they will lead to a constellation of business arrangements. In other industries, it is routine to require non-exclusive rights to all future innovations, a condition driven by fast-paced and overlapping technology development.

Thus, from a valuation perspective, context is critically important. One cannot determine the value of a licensing term in isolation; the value is determined by the nature of the underlying technology, how it will be used, and the norms in the industry of application.

Valuation Challenges

From MIT's perspective, Speechworks was a very successful company. Between 1995 and 2000, Speechworks paid MIT royalties of more than $600,000, or almost 9% of its product revenues. Thereafter it was required to pay 1% of product revenues, about $240,000 per year as of June 2001.

But if we go back in time to 1994 (the year of the license agreement), there was only a distribution of poten-

40. Speechworks was acquired by Scansoft in 2003. The discussion of the Speechworks/MIT technology license is from *Value Sweep*, Chapter 11. A complete copy of the license can be found in Speechworks's IPO Prospectus (S-1/A), June 30, 2000.

41. The full quote is: "Our licensing terms reflect the fact that most licensees will need to invest substantial time and money in product development. Terms are flexible. Exclusivity, field of use, subdivision of patent rights and sublicensing provisions are tools available to shape the license. Running royalties, license issue fees, and other terms are tailored to match a licensee's needs and the realities of the market." See http://web.mit.edu/tlo/www/getstart.html.

tial outcomes. Though Speechworks's eventual success was in the upper tail (a high-value, low-probability outcome), a valuation analysis in 1994 (perhaps generated using Monte Carlo simulations) would have produced an expected value that was quite low, especially since Speechworks had no funding at the time of the transaction.

The wide spread between the realized license value and the expected value of the license at the time of the transaction is a common outcome, one that decreases confidence in the valuation results. When things go well, many armchair quarterbacks (including your boss) will wonder, "How could the valuation be so far off?"—putting pressure on analysts to inflate license values. (But when things go poorly, original license values are seldom reviewed.) Licenses on early-stage technologies and patents are similar: Most are not worth much, but it is difficult for valuation analysts seeking repeat business to say so.

Sparked by reports that IBM earns $1.5 billion per year in licensing profits, many companies hope to gain value from their unused intellectual property. The internal perception is that the unused technology is valuable, and thus the companies promote their technologies to potential business partners. Outsiders, however, view the fact that the technology is not used as a signal of low value, at least initially. Willingness to pay and relative negotiating strengths become the primary drivers of the final transaction agreement—and, under these circumstances, one should not be surprised by the large divergence between valuation model results and the recorded value of the transaction.

A Valuation Model

The valuation begins with a business plan, one that takes account of the complementary assets provided by the business partner. Looking ahead to how the license terms will be incorporated, the business plan should be placed inside a valuation framework that incorporates uncertainty and contingent decisions. The choices include Monte Carlo simulations, decision analysis, scenario analysis, and real options. Which model is best suited for the analysis will depend on the nature of the early-stage technology itself, the complexity of the deal terms, and the need for valuation transparency. With regard to negotiations, for example, it is often necessary to value the tradeoffs between two contingent deal terms. A simple scenario analysis might best fit the requirements of speed and transparency.

Because there are so many deal terms in a typical transaction—fees, exclusivity, scope, payments, territories, controls and quality assurance, termination rights, dispute resolution, and more—analysts often value only those deemed financially important, or they might create "partial" models, supporting negotiations by analyzing alternate negotiating positions. One suggestion is to value the license terms in the order of increasing risk: the fixed (non-contingent) payments of the deal; the fixed in-kind contributions (such as advertising support, consulting services, and so on); the contingent payments; and, finally, the less tangible elements of value.[42] In this way, the analyst can place a separate level of confidence on the results from each group.

Can a Real Options Model Add Value?

Many, including myself, have suggested that real options might be a useful approach to valuing technology licenses. In practice, one or two license terms have been layered onto a real options model of an early-stage technology to gain a better understanding of the interaction of the asset and license. The key problem—and the reason I no longer suggest real options for this analysis—is that the model quickly becomes so complicated that one cannot identify the underlying business scenario that might lead to a model outcome. A simple decision tree coupled with an analysis of four or five carefully selected scenarios can provide the necessary strategic insights, and the results are more easily communicated.

Valuing Intangible Assets in Accounting and Financial Reporting

The models used to value technology licenses for accounting and financial reporting are simplistic in several ways. First, they typically omit the risks depicted in Figure 1, and focus instead on the income expected once the technology is in use. This leads to valuation results that are too high. Fixed payments and royalties, after careful consideration of pricing, unit sales, market expansion, and so on, are then discounted to current dollars.[43] A single sales scenario is used, so the valuation results rest strongly on this one assumption, and the income stream is often capitalized as a perpetual annuity.

Within this framework, the focus is on cash flows, with complementary assets accounted for by a capital charge. Guides for intangible asset valuation provide suggestions for the rates of return that should be used, ranging from a low of 5% for working capital and 7-8% for property, plant, and equipment, to 18% for software and 25% for goodwill.[44] Figure 6 provides a sample technology license valuation that incorporates a large capital charge—42% of after-tax income. The relative size of the charge, coupled with the lack of validated data on the expected return by asset type,

42. See Anson (2005, Ch. 15), cited earlier.
43. See Anson (2005, Ch. 15), cited earlier; and Reilly and Schweihs (1999, p.443), cited earlier.
44. See Mard (2001, pp. 26 and 52), cited earlier, and Anson (2005, p. 51), cited earlier. While it is argued that intangible assets are riskier and should have higher required returns, no justification is given in the practice guides for these exact values. However, they are widely used.

Figure 6 **Sample Technology License Valuation**

Inputs	Projections	
After-tax income from technology	$3,600	
Capital charge for complementary assets	$1,500	
Projected economic income	$2,100	
Profit split to each party		
	Licensee	**Licensor**
Profit share	50%	50%
Projected income	$1,050	$1,050
Capitalization rate	20%	20%
Indicative value of technology to each party	$5,250	$5,250

Source: Robert F. Reilly and Robert P. Schweihs, *Valuing Intangible Assets*, Irwin (1999). From a table on page 443. For simplicity, details on pricing, units, costs and so on are omitted.

suggests that this input is open to the politics of valuation and could easily be manipulated, intentionally or otherwise, to show greater technology license value.

Figure 6 uses a discount rate of 20%, which is consistent with the expected returns to intangible assets provided in the accounting guides. Others suggest using a weighted-average cost of capital plus a premium for intangible assets, noted as a subjective adjustment by the appraiser.[45] While it is common to increase discount rates to account for risk (particularly when no adjustment for risk is made in the cash flows), this practice is criticized by academics.

Technology licenses are also often valued by examining royalty rates of other licenses in the industry. There are several commercial databases that extract this information from publicly disclosed contracts, and the industry average royalty on sales typically ranges from 1-20%.[46] These data are also used to value early-stage technologies themselves. In the relief-from-royalties model discussed earlier, the value of the technology is the present value of the royalties that might have been paid for its use. Typically, only the sales royalty rate is used, and any value transferred through other payment terms is omitted.

The Craft of Valuing Technology Licenses

In sum, there are a number of major challenges in valuing technology licenses. Most worrisome is the lack of a positive feedback loop between model results, transaction data, and improved model inputs. Studies of transaction values can fail to be informative because negotiating power can shift transaction values away from model results, and because uncertainty creates a large gap between the model result (an expected value) and the single realized outcome. Accounting models also neglect the major deal terms and risks of technology licenses, and provide little guidance to managers. For all these reasons, valuing technology licenses remains a craft, not a science, and analysts must proceed with care.

Conclusion

Innovation activity has played a large role in historical economic growth and, as our knowledge economy deepens, its role is expected to grow even larger. At the same time, federal government cuts in R&D for universities and clusters of promising new innovations in biotech, materials science, and computing suggest a growing need to attract capital to fund the commercialization of patents and early-stage technologies. Thus, there is keen interest in valuing the fruits of innovation.

Unfortunately, valuing patents and early-stage technologies is intrinsically difficult. As the examples in this article have demonstrated, the degree and types of uncertainty that attend such projects effectively rule out the possibility of precise valuation results. Further, some of the most widely used models—including those for accounting and financial reporting purposes—lead to wildly misleading valuations. Too often our methods have served only to obscure the reality that the vast majority of patents and early-stage technologies will turn out to be worthless.

While this article has laid out a research agenda as much as a set of solutions, the key to valuation model improvement is to develop models and results that managers find relevant as they negotiate and complete transactions. Once models and, perhaps more important, new ways of thinking become part of the flow of commerce, there is a natural cycle of model and data refinement. Over time, increasingly relevant valuation models will have the power to speed capital to innovations and fuel growth in our modern economy.

MARTHA AMRAM is a founder of Growth Options Insights, the co-author of *Real Options*, and the author of *Value Sweep*. She frequently works with companies on the valuation of risky growth projects, including intellectual property.

45. See Anson (2005, p.51), cited earlier.
46. See Reilly and Schweihs (1999, pp. 440-441), cited earlier, and Anson (2005, Ch. 15), cited earlier.

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