VALUATION APPROACHES FOR TECHNOLOGY TRANSFER: A REVIEW

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Abstract
Technology development is a key factor in the economic success of a country or a business organization, but in some cases it is not economically feasible to develop the required technology. In such situations there arises a need to acquire the required technology for a price. Pricing innovations, new product ideas, and technologies can be complex, even under the best of conditions. Techniques for valuation also depend on a broad range of factors. Furthermore, reliable valuation is essential for portfolio analysis, venture funding, business development, and mergers and acquisition activity. The potential for spin-offs incorporating these technologies and the prospective markets for them are at times ill defined and result in pricing technology being even more complex. Finally, technology is distressingly intangible and financially abstract.

Although at present there are several techniques available for technology valuation, there is often the dilemma of choosing the right technique for the appropriate situation. Some of the main factors that directly affect the valuation of technology are the time value of money, the risk of technical failure, and the cost already incurred for the development of the technology itself. The majority of techniques treat R&D as a strategic capital cost rather than an expense. There has been a longstanding misconception that the more quantitative a model, the better the valuation, but in reality, simpler valuation models perform much better. In this paper the authors will review possible techniques for technology valuation and outline the situations for which each technique would be suitable. The known advantages and disadvantages of each technique will also be discussed.

Introduction
In the following discussions, technology, intangible assets, and intellectual assets are used interchangeably and concentrate mainly on industrial design, product patents and technical know-how. The fundamental premise of valuation is that the value today is the present worth of expected future benefits. Nonetheless, the value implied by the amount of time and money that have been invested to bring a technology to a particular point are generally not accurate if the expected future returns from the business do not justify that value. The value that is determined corresponds to all the expected future benefits of ownership and is highly variable as the expected benefits increase or decrease with the passage of time or changing expectations. The value determined also depends on the degree of accessibility of the technology. The more difficult it is to replicate, the better one is positioned to earn profits.

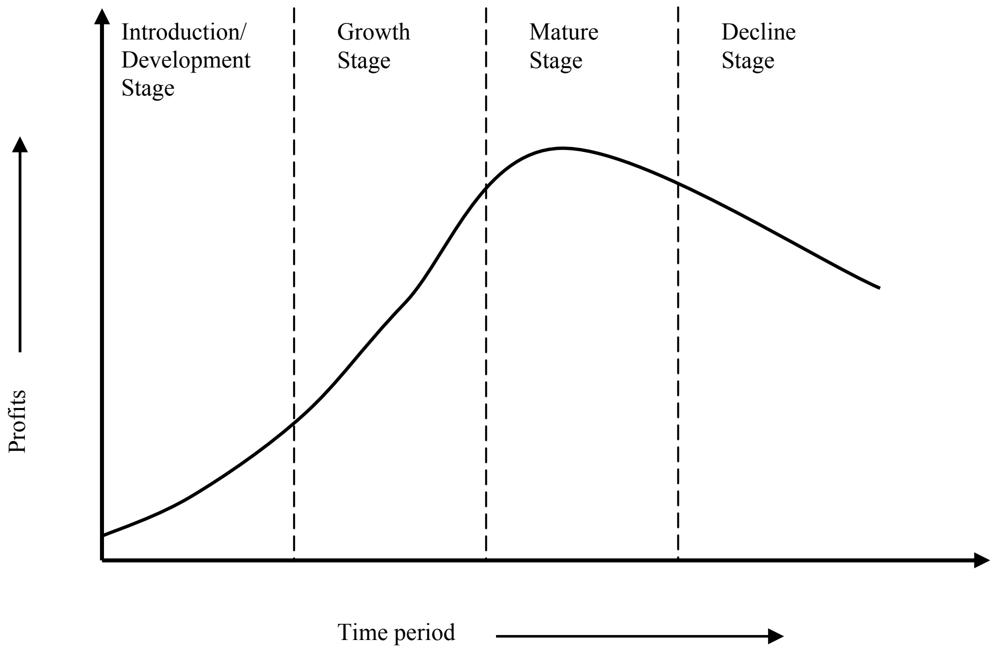
The value of the technology is also directly proportional to the level of legal protection to imitation it possesses (Matsuura, 2004). It must be realized that valuation of intellectual assets in their embryonic stage relies heavily on people's judgment. The value of an asset is based on what it can earn unless liquidation can result in higher value. There is an appreciable difference in the valuation of a general commodity or product and that of technology that has to be realized. In a technology market there is only a limited number of sellers and buyers and very little or no advertising of technologies, as compared to that of a general commercial market. The life and the value of the technology can be affected by the blistering rate of displacing technology innovation, hence pricing becomes difficult due to the short life cycle of the current technologies. The pricing issue also becomes increasingly difficult when the technology under consideration is at an early stage and largely unproven.

The value of the technology also depends on its position in the technology life cycle curve. The four stages of the curve include:

- Introduction /development stage
- Growth stage
- Mature stage
- Decline and decay stage

These four stages are depicted in Exhibit 1. The value of the technology will be at its peak during the growth phase where the intrinsic value of the technology value would include the R&D and development cost completely. If there is only one interested purchaser of the technology, then they will need to pay only a nominal price, but in cases where there two or more purchasers, they might bid competitively and might result in the price increasing above its nominal value. The licensors can extract the development costs incurred by selling the technology and may obtain profits from the sale. On the other hand, the licensees buying the developed technology can avoid the trial-and-error process that is a part of the course of technology development and hence will be able to save time and resources. It should be noted that the lower the investment required for implementing a technology, the more positive the effect on the value of the technology.

Exhibit 1. Various stages of technology.



The ultimate price paid for the technology is dependent on a number of factors, including (Udell and Potter, 1989):

- Complexity of the technology
- Amount of patent protection and duration
- Number of licensors and licensees for the particular technology
- Prospective profit margin
- Extent to which the licensee is dependent on the technology
- Nature of the technology
- Stage of development
- Status of competing technologies
- Scope (patent vs. know-how)
- Relative bargaining power of the two parties
- Markets to be served
- Size of market
- Date of entry into market
- Expected market share
- Time to achieve ultimate market share
- Cost to finalize development
- Cost to bring to market
- Cost to maintain technology

The price of the technology largely depends on the incremental utility provided by the unique aspects of the new technology, over any comparable old technologies. This can be formalized as

$$T_{new} = T_{comp} + X_{new} \quad (1)$$

T_{comp} is the comparable price of the related old technology. X_{new} represents the incremental value offered by the new technology. While T_{comp} can be obtained through surveying the comparable old technology prices, the more challenging task has been in quantifying the incremental value of the technology (Bergstien and Estelami, 2002). The two primary factors that determine the value of any technology are its contribution and protection available for the particular technology through government regulation and systems. At any point of time, when a given technology is effective in both of the above factors, the licensor (transferor) of the technology has a commanding position. There are also numerous reasons for technology valuation, such as:

- Ranking of projects for the allocation of resources between them
- Determining whether to proceed to the next stage of development
- For disposal or sale
- For raising capital, lenders are increasingly accepting intellectual property as collateral to secured financing
- Evaluating potential merger or acquisition
- Evaluating the commercial prospects for early stage research & development

Some of the most commonly used valuation methods are discussed below.

Market Approach Method

The market approach depends on the market prices observed in actual transactions for the purchase of a similar technology. It measures the present value of future benefits by obtaining a consensus of what people in the marketplace have assumed. The two prerequisites needed while employing this method include a dynamic, public market, and an exchange of comparable properties. But these conditions do not exist for new technology. This model would be inappropriate for determining the exact value in the case of technologies in the embryonic stages. Under the market approach, the value of a technology would tend to be similar to prices being paid for similar technologies. For example, if comparable intangible asset have been selling for five times earnings, it is reasonable that a buyer of a particular asset might expect to pay a similar multiple.

The market approach establishes value based on recent sales or licensing of comparable assets. In the valuation of an intangible asset, similar assets recently sold or currently offered for sale are analyzed and compared with the intangible asset being valued. Since intangible assets are typically highly specialized, finding good market comparables is often difficult, particularly since financial details of sale or licensing transactions are rarely disclosed. Most often, the market approach has applications in other valuation methods that use comparable royalty rates. Thus, the market approach often can not be applied because of limitations in information. It is dependent on an active, verifiable market and does not generally apply to intangible assets. The notable exceptions are the pharmaceutical and software industries.

Income Approach Method

The income approach gives significant importance to the income producing potential of the technology under study. It determines the fair value of a specified asset or technology by calculating the present value of the cash or income stream over a specified future period, or in some cases, its life time. Value derived from future economic benefits, quantified in the form of expected future cash flows, involves two general steps. First, one has to establish a forecast of the estimated future net cash flows from the asset and then discount these estimated future net cash flows to their present values. These cash flows result from one of numerous reasons: incremental revenue, manufacturing cost savings, relief from royalty, and excess earnings. The three vital aspects of the income approach are: the amount of income to be generated and the pattern in which it will be received, duration of the income stream, and risk linked with the realization of the expected income. This particular method gives realistic values, but one faces difficulties while obtaining the inputs. For instance, it's relatively easy to predict the net cash flow of an established business, but in the case of a technology, especially in its initial stages, it's difficult to predict the net cash flow credited to it.

The income approach is impractical to implement for embryonic stage technology due to the extreme difficulty in forecasting the economic benefits, but as it passes though the various life stages, the uncertainties and risk involved will be reduced and the application of the income approach becomes more convincing (Dietrich, 2000). If the particular income yielded by the technology cannot be identified independently, this method might not be suitable. The following three methods are variations of the income method approach.

Super/ Premium Profits Method

The super/premium profits method involves determining the level of expected cash flow that might otherwise be generated in excess of the cash flow if not for the utilization of that technology. Care has to be taken to attribute the exact economic benefits to that technology. These excess profits are then discounted to the effective quantification date by then applying a discount rate that takes into consideration the weighted cost of capital and several risk factors. The first step is to project the total cash flows of the firm which uses the technology that is to be valued. The return on the net tangible assets are then deducted, resulting in the 'super profits' due to the intangible assets (this includes the technology whose value is to be determined). The risk attached to the tangible assets are typically lower than the intangible assets, hence they have a lower rate of return. The income generated by each intangible asset is identified individually and the other intangibles are valued. A suitable return on these is deducted from the super profits to value the intellectual property (technology) under study. The method becomes complicated when a large number of intangible assets are involved.

Discounted Cash Flow Method

The Discounted Cash Flow (DCF) approach attempts to determine the value of the technology by computing the present value of cash flows, attributable to that piece of technology, over its useful life. Since 1995, patents have a life of 20 years from the date of filing the application. Once the patent has expired it is likely others will enter the market using the technology and will lead to increased price competition. In these cases valuation will vary based on the degree of post patent expiration cash flows that are assumed. The discounted cash flow approach is well established, but is known to systematically undervalue R&D projects and other intangible assets (technology) due to the long life times. This method is short sighted in nature and could end in poor decisions being made, giving more importance to the early cash flow rather than its value for future development. The cash flow is discounted to the present by applying a rate of return which takes into account the time value of money and the investment risk involved in the commercialization of the technology. The value of the asset at the end of the cash flow period is taken into consideration, since it's assumed that the asset will be disposed of for a price that would either form a part or all of the return of the initial purchase price. This would be considered like the other cash in-flows received during the period.

Discounted cash flow analysis has been the dominant valuation method for decades. Its strength is that it approximates the real cash value of a company at any given time. For a company that is in a rapidly evolving business and depends on its capital and intellectual property, however, this may not be appropriate. For most companies, knowing what any of these numbers are even for the next year is hard enough, let alone calculating them five years from now. An additional disadvantage of the DCF method is that it does not account for managerial flexibility, and it assumes that once a project is launched it is passively managed. In DCF it is also assumed that all risks are completely accounted for by the discount rate, but in reality the firm and project risk can change during the course of the project (Damodaran, 2004). Based on the business plan realized by the licensee, cash flow is decided during the term of validity of the technology. Since the cash flow is affected by the discount rate, the level of discount rate matters. It is because of the lack of clarity in the DCF method that real option theory has recently come in to the picture (discussed later).

Relief from Royalty Method

The relief from royalty method is based on the amount of income that a company would be deprived of if it did not own the intellectual property in question but was required to rent it from a third party instead. The relief from royalty method generally assumes that the asset owner licenses the protected technology for use to a user and receives a fair royalty return based on his applicable revenues. The technique is a permutation of the income approach in which a royalty rate (multiplied by the forecasted royalty base) is used to calculate an income stream attributable to the subject asset (Roos, 2003). Thus, the income stream calculated using the royalty becomes a surrogate for the economic benefit attributable to the intangible. A capitalization of that income stream becomes an indication of value. The disadvantage of this method is that it fails to represent the entire economic benefit attributable to the asset being appraised. The royalty given for the technology depends on factors such as the industry, nature of the intangible asset, amount of rights granted, legal protection, uniqueness and change in profits, and costs reduction. This method only indicates the value gained by the licensor and the present value of the royalties saved is relatively low when compared to its true value (Pavri, 1999). The benefits retained by the licensee are not reflected in the calculation and a significant portion of the assets value is not represented in the valuation process and hence understates the value of the asset. In most cases a relatively low discount rate is used as the only risks associated with the commercialization process in consideration.

Cost Approach Method

The cost approach is determined by estimating the current replacement or reproduction cost of a similar technology or asset. This method contemplates the cost to purchase or develop a similar technology in proportion to the economic benefits that the technology can provide during its life. In this method it should be assumed that the economic benefits exists and are of sufficient amount and duration to validate the expenses. Under certain situations this method is efficient for intellectual property valuation when economic benefits associated with the technology cannot be determined precisely and in situations where the particular technology is useful only when it is used along with other technologies. This particular method is appropriate for newly developed technologies, as its future earning capacity tends to be speculative.

The cost approach method includes the reproduction cost method and the replacement cost method. The reproduction cost method determines the costs that would be incurred to replicate the specific technology, while the replacement method will try to establish the cost to replace the technology with a different technology having the same functionality. In both these methods the complete cost incurred to develop the technology, like labor, equipment etc., will be taken in to consideration. Intangible assets like brand name, franchise, and trademark would be difficult to valuate using this method as this would require the collection of the historical advertising and promotional costs needed to develop its value. Once the cost of reproduction is established, the three types of depreciation, physical depreciation, functional obsolescence, and economic obsolescence are to be deducted to obtain the value. The cost approach method would fail to justify technologies that have the potential of being economically successful since there could be some buyers willing to a pay an extra premium for the costs they would otherwise incur in attempting to develop the technology. In most cases it doesn't represent the technology's future potential. This method can be implemented in initial research stages where there is a lack of economic activity, the reason being that it doesn't recognize the economic benefits received by the owner through its use.

Real Options Method

Traditional valuation techniques do not take into account the flexibility available, and as a result often underestimate the value of an asset (Jeffery et al., 2003). The real option based method of intangible asset (technology) valuation is promising in highly uncertain environments. The primary advantage of the real options method is that it accounts for the value associated with the uncertainty of cash flows and risks that may be captured in the option element of the asset. The real option valuation methodology encompasses the value of future growth opportunities. The options approach to valuation helps a great deal in developing firm technical strategies. Real option analysis is an extension of the financial option theory, where similar to financial options, there exists the right, but the not the obligation to make a potential decision or investment. The similarities between financial options and real options are shown in the table below.

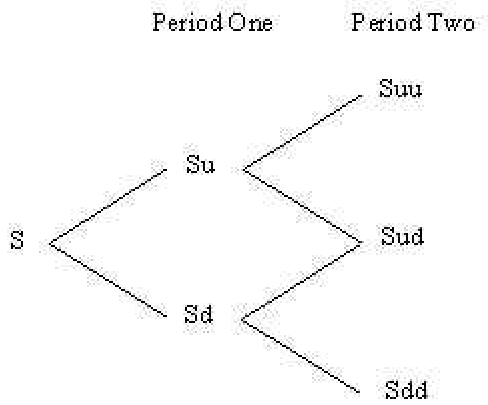
Exhibit 2. Analogy between real options and financial options.

Financial options	**Real options**
S , Stock price	Present values of the assets expected cash flow
X , Exercise price	Potential investment to be made
T , Time to expiration	Length of time period available for the decision to be deferred
R_f, Risk-free rate	Time value of money
σ^2, Variation of returns	Risk related to the asset

The value of assets determined using the real option method is similar to the value of the call option (Breadley and Myers, 1988). Technology seems be an ideal candidate for real options. The key is defining the future events that would be analogous to hitting the strike price (think of buying an oil field as the purchase of the real option, and striking oil as being the event). When taking into consideration an intangible asset (technology) that is to be valued, a wide range of degrees of success or failure plays a vital role in the option value.

The binomial option pricing model is used to determine the real option value. The binomial model depicts price movements across a specific period of time, such that the asset value can move to either of two possible prices with associated values (u – up and d – down in Exhibit 3). The binomial option pricing model has proved over time to be the most flexible, intuitive and popular approach to option pricing. It is based on the simplification that over a single period (of possibly very short duration), the underlying asset can move from its current price to only two possible levels. The advantage the binomial model has over the Black-Scholes model is that it can be used to accurately price American options, which can be exercised at any time. This is because with the binomial model it is possible to place a value at every stage in an option's life for the possibility of early exercise. The limitation of the binomial model is that it requires more computational work. It should be noted that options are worthless in a world of certainty, where you have perfect insight into what the future brings.

Exhibit 3. Formulation for binomial option price path.



Researchers and practitioners face problems while using this method since some parameters needed for estimating the real option value are at times arbitrary. At times the difficulty in determining the future returns from the asset and integrating it into the option model is a core challenge to the option modeling. Also, the risk associated with the asset is highly fluctuating over time and for better results the discount factor should be adjusted as the risk varies, further complicating the process. While dealing with the real option method, one should take into consideration the unique or internal risk, as well as the market or systematic risk. The internal risk is usually expressed in terms of probability, for instance - there is 62% probability that the new processor will pass the R&D stage. The market risk is attributable to macroeconomic factors and cannot be eliminated. In the case of options, higher market risks increases the option value. For example take a situation where a utility company has plans for developing and manufacturing solar cells as an alternate source for electricity when the cost of the traditional source increases. These solar cells are subject to internal risks such as technical risks and market risks, such as the fluctuating prices. When the technical risks are overcome, two options exist: either to invest in production facilities in a favorable market or defer the investment in the case of an unfavorable condition. The stock price or underlying security for the option is the present value of the business plan for the solar cells under prevalent market conditions. The strike price is the investment needed to start production. The Black Scholes formula is used to calculate the value of the call option, as given in Equation 2.

$$c = s\phi(d_1) - xe^{-rt}\phi(d_2)$$

(2)

$$d_1 = \frac{\ln(s/x) + (r + \sigma^2/2)t}{\sigma\sqrt{t}}$$

(3)

$$d_2 = d_1 - \sigma\sqrt{t}$$

(4)

where, s = the price of the underlying stock, x = the strike price, r = the risk free rate, t = the time in years until the expiration of the option, σ = the implied volatility for the underlying stock, and Φ = the standard normal cumulative distribution function.

Using the Black-Scholes formula, the value of the option is determined. This value represents the flexibility available to the management to make decisions depending on the market environment. An example is provided in the appendix. Here the volatility rate is given by the sector's stock volatility. The real option value moves in the same direction as changes in the parameters time (t) and variance (σ^2).

The real option valuation method is appropriate when applied and compared with the other traditional methods, depending on the situation, and cannot single handedly replace the other valuation methods. Problems arise in determining the various terms needed for the Black Scholes formula. The main advantage of the Black-Scholes model is speed – it lets you calculate a very large number of option prices in a very short time. The various options that are embedded with technology are the option to defer, option to abandon, and the growth option to invest in production. Some of the disadvantages of the Black Scholes formula are that it assumes a single exercise date and all certainties are resolved when the decision is made, which is not the case in a real option situation. It is also often assumed that the risk-free rate is constant.

Conclusions

From a review of the literature, it becomes apparent that technology valuation is not a single step formula application process but requires a detailed study of a number of related aspects. More importance is given towards historical data to value an intangible asset, but in the current scenario of technology intensive companies, where such assets play a vital role, there is a need to value technology based on its future earning capabilities, which are measured in terms of cost reduction, product differentiation, and increased profits, among others. Technology should be valued using the knowledge of the prospective gains and use the historical data as a starting point. In the case of an existing technology where the future prospects or capabilities are clearly defined and well known, it would be unproductive to use a real options method. In a scenario where there is a large amount of information pertaining to its transactions and sales available, the market approach would be best suited. The market approach is also appropriate for technology which has reached the mature stage with little expected change.

For technology which has left the R&D lab and crossed the transition point of satisfying the basic needs, the income approach method is appropriate. In this stage the majority of the technical uncertainties are resolved and it is uncomplicated to determine the anticipated income stream. Here the life span of the technology and the cash attributed to the particular asset should be identified to get more accurate results. While valuating technology which is still in the R&D phase, the real options method is most suitable as technical and commercial uncertainties still exist. There are several options available at this stage, such as the option to wait and commercialize during a favorable market environment, the option to defer, the option to abandon, etc. Every technology in its embryonic stage is essentially embedded with an option to seek profits at a particular point of time, or abandon it. As the number of likely potential scenarios increases, the option value becomes more expensive since the volatility increases. The cost approach is also applicable to an emerging technology since it has no active market and since there is negligible information available regarding earlier transactions. It is purely based on the costs incurred during its development and does not need to be proportional to future potential. As the success of firms depend more on intangible assets, valuating them accurately has gained importance.

There is no clear cut approach as each method has its own strengths and weakness. Valuation of technology should be performed to include its economic and strategic value depending on its life cycle stage. As previously mentioned, traditional methods are often not applicable to new technology, while the real options method is a better alternative. Another factor which should be taken into consideration while performing technology valuation is the amount of legal protection from imitation or infringement (these aspects were not considered in this review).

Appendix

An example case of which real option to applied is explained below. Consider a firm specializing in microprocessors has received a patent for a next-generation, high performance device that boasts on-chip parallel processing with power dissipation that is only one-fifth that of contemporary chips. In terms of real options, this gives them the right, but not the obligation to undertake manufacturing and marketing of the patented processor. For illustration purposes, assume a company called Nu-Tech has a patent on the microprocessor chip that provides the company legal monopoly for nine years. The patent for this microprocessor is bought from Nu-Tech by a firm named D-Powergate USA INC.

Before getting into the deal, D-Powergate USA INC analyzes the deal and intends to determine the proper value by utilizing real options analysis. The patent for the processor would give the company D-Powergate USA INC the exclusive right to manufacture and market the processor if suitable market conditions prevail in the next nine years, during which the patent is valid. The investment costs for commercialization is $46 million (E). The present value of cash flows from the project is $78 million (S). DCF analysis shows that for immediate investment, a positive $32 million NPV results. D-Powergate USA INC considers if the option of waiting and introducing the product at a later time when the market is ready for a next-generation, high performance processor. There exists the risk that other players in this segment might come up with a similar product that does not infringe the patent and reduce D-Powergate USA INC market share, and in turn its profits. The risk-free nine year treasury bond rate is 4.69%. Time for the option to expire is nine years (t). The variability of the expected returns is assumed to be 97.49% (σ) - this value is usually taken from the volatility of the stock of the company. After applying these values in the Black-Scholes model, the value of the patent is found to be $71.24 million using the real option model. While using the above data, the NPV of the patent is $78M - $46M = $32M. The additional $39.24M ($71.24M-$32M) in value is due to the managerial flexibility available to take decisions during the given time period of the commercialization process, making the purchase valuable.

References

Bergstien, H., and, H. Estelami, "A Survey of emerging technologies for pricing new-to-the world products," *The Journal of Product and Brand Management*, Volume 11, No 5, 2002.

Breadley, R., and S. Myers, *Principles of Corporate Finance*, 3rd edition, New York: McGraw Hill, 1988.

Damodaran, Aswath, "Discount Cash Flow Valuation: Basics," http://pages.stern.nyu.edu / ~adamodar/pdfiles / basics . pdf, (cited May 2004).

Dietrich, P., "Determining the Value of New Technology," *Seminar Study in Strategy and International Business in the Institute of Strategy and International Business*, 2000, http://www.tuta.hut.fi/studies/Courses_and_schedules/Isib/TU-91.167/ Old_seminar_papers/ dietrich_perttu.pdf, (cited May 2004).

Jeffery, Mark, Sandeep Shah, and Robert J. Sweeney, "Real Options and Enterprise Technology Project Selection and Deployment Strategies," Submitted to *MIS Quarterly*, 2003, http://www.realoptions.org/papers2003/JefferyShahROConference.pdf, (cited May 2004).

Matsuura, H., "An Overview of Intellectual Property and Intangible Asset Valuation Models," *Research Management Review*, Volume 14, Number 1, 2004.

Pavri, Zareer, "Valuation of Intellectual Property Assets: The Foundation of Risk Management and Financing," Paper presented at the INSIGHT Conference: "Negotiating License Agreements: Maximize the Value of Your Intellectual Property Assets," Toronto, April 29-30, 1999.

Roos, Göran, An Intellectual Capital Primer, 2003, http://www.euintangibles.net/library/ localfiles/Roos_AnIntellectualCapitalPrimer.PDF .

Udell, G., and T. Potter, "Pricing New Technology," *Research Technology Management*, Volume 32, No. 4, 1989.

Bibliography

Amram, M., and N. Kulatilaka, 1991. *Real Options: Managing Strategic Investments in an Uncertain World*, Harvard Business School Press, Boston, Massachusetts.

Boer, F. P., "Financial Management of R&D 2002," http://www.boer.org/files/2002.pdf, (cited May 2004).

Boer, F. P. "Traps, Pitfalls and Snares in the Valuation of Technology," *Research Technology Management,* Vol. 41, No. 5, 1998, pp. 45–54.

Dixit, A., and R. S. Pindyck, 1994. *Investment under Uncertainty*, Princeton University Press, Princeton, New Jersey.

Merton, R.C., "Application of Option-Pricing Theory: Twenty-Five Years Later." *The American Economic Review*, 1998; Vol. 88, No. 3.

Mun, J., "Real Options and Monte Carlo Simulation Versus Traditional DCF Valuation in Layman's Terms," http://www.crystalball.com/articles/download/ro-vs-dcf.pdf .

Neil, D.J., "Realistic Valuation of Your IP," *Les Nouvelles- Journal of the Licensing Executive Society*, 1997, pp 183.

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