Real Options Valuation of eBusiness

by

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Abstract

Traditional funding criteria like return on investment (ROI) and net present value (NPV) do not work well with most eBusiness. These corporate budgeting techniques were designed for relatively slow progressing or well-established business models. The Internet marketplace is constantly being redefined and most of these projects have a high velocity of evolution and uncertainty. Firms and investors have yet to possess systematic and quantitative financial evaluation tools.

After studying the behavior of Internet firm valuations and exhaustively investigating the conventional ways of valuing an eBusiness, this paper finds that real options valuation is an extremely useful analytical tool for valuing eBusiness projects from the management’s perspective. It provides management a powerful extension of the traditional cash flow budgeting models, and a structure to attach and quantify strategies. Real options valuation in its current form, however, is not entirely suitable for the use as a valuation tool for traded stocks.

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T.E.E.
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Chapter 1 – Introduction

Traditional funding criteria like return on investment (ROI) and net present value (NPV) do not work well with most eBusiness. These corporate budgeting techniques were designed for relatively slow progressing or well-established business models. The Internet marketplace is constantly being redefined and most of these projects have a high velocity of evolution and uncertainty. Firms and investors have yet to possess systematic and quantitative financial evaluation tools.

After studying the behavior of Internet firm valuations and exhaustively investigating the conventional ways of valuing an eBusiness, this paper finds that real options valuation is an extremely useful analytical tool for valuing eBusiness projects from the management’s perspective. It provides management a powerful extension of the traditional cash flow budgeting models, and a structure to attach and quantify strategies. Real options, however, is not entirely suitable in the current form for the use as a valuation tool for traded stocks.

Over the last few years, the world has experienced a period of technological discontinuity like only a handful of others that have dotted human history. The result is a wave that has spread in phases with unprecedented speed from its seed of presence in the United States to quite literally every individual on earth. In the vortex of change during the three years from 1998 to first quarter 2000, it seems like the startup firms in the New Economy are momentarily defying the ‘natural law’ of business. Recognizing the possibilities of this
new mass interconnectivity, whole sectors of service industries sprouted with a simple registration of a ‘.com’ behind an idea. Armed with newly minted share certificates as currency, an infantile firm can suddenly acquire real assets and real businesses. For an investor or a firm, the inadequacy of existing valuation tools suddenly seems even more apparent. How should decisions be made in this time of great uncertainty and opportunity? And would valuation be done differently in the post-discontinuity equilibrium state or would previous doctrines hold true again?

This is a learning paper of my attempt to grapple with the current flux of the market and investment valuation. On April 14th, 2000, the court decision against Microsoft coupled with the release of unyielding inflation numbers triggered the most precipitous drop in the NASDAQ for a decade. This is the classical overshoot and collapse pattern or what is commonly termed ‘bursting of the bubble’. It is interesting to follow through the views of analysts about a year prior to this event (the justification phase) to the Monday after1:

“For months, small tech companies were able to begin trading publicly just months after their creation, often soaring to billions of dollars in value with only modest sales and no profit. Even big tech stocks like Cisco Systems Inc. and Oracle Corporation reached stock valuations rarely seen before. Investors bought them more for their momentum than their intrinsic value and that momentum fed on itself. Those stocks are still trading on momentum, but it’s a selling momentum.”

This paper will find it difficult and not very meaningful valuing eBusinesses in the midst of market exuberance. The reason is that many exogenous and investor psychological
elements have too strong a bearing on their valuation. It is difficult to value a firm driven by herd market forces. Many ‘soft’ parameters like network factors, management capability, capital market regulations, timing to market, and technological breakthroughs are involved. The high volatility, while helping to explain the high valuations, is a curse when trying to capture the true valuation of the firm.

Instead, I will attempt to use real option valuation to study the investment decision for setting up of a new eBusiness. High volatility, high potential growth and tremendous uncertainty characterize this form of project. Unlike other forms of risky projects (e.g. mining, pharmaceutical research and development) there are no scientific gauges or prior knowledge of market preference. There is also little salvage value. In short, it is a very immature business with little precedence.

Chapter 2 describes the brief history of e-business, the environment that created it and factors that propel this ‘new’ phenomenon. It also examines the likely post market exuberance landscape.

Chapter 3 describes the evolution of valuation. Real options valuation (ROV), with all its limitations, may be the most suitable technique available for projects with many uncertainties. It is not a panacea that provides a particular valuation number for a firm but it can help structure and quantify the strategy. Although it is not a predictive or a forecasting tool, and it cannot come up with a single number as a basis for investment

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1 Ip, G., Browning, E.S. (Apr 17, 2000) “What Are Tech Stocks Worth, Now That We Know It Isn’t Infinity?” The Wall Street Journal.
judgement, it provides a far more realistic framework for continual and sensitivity
analysis of alternatives. This chapter also demonstrates some current attempts to
rationalize valuation in the New Economy.

Chapter 4 looks at the development of real options valuation. It illustrates various types
of real options applied to real business situations. Project cash flows are not only
influenced by endogenous agents, but also by new information as it becomes available,
and by exogenous factors like competitors and suppliers. These external agents could in
turn be influenced by the firm’s actions. Therefore option interdependencies and game-
theory models are also useful for looking at project planning and risk mitigation.

Chapter 5 is a case study of a tire manufacturer in the People’s Republic of China and
their decision to start an eMarketplace aggregator portal for tires and rubber related
products. Real options are used to simulate the strategic structure of the project. While
the aim is not to come up with a concrete number to replace the net present value (NPV),
this model is a more powerful extension of the cash flow projections.

Mature firms are increasingly investing in growth business components related to
eBusiness. The final chapter suggests the application of asset allocation concepts used in
financial investment for capital investments and risk management. The questions are
whether and how should firms invest strategically in these new businesses, how does the
market perceive these investments, and how the value of a synergistic investments is
determined.
Chapter 2 - The Brief History of eBusiness

2.1 Critical Success Factors of the Internet

The systemic infrastructure and nurturing conditions that allow the seeding and soon after, the hypergrowth of the industry include the following:

a) Affordable and pervasive use of personal computers, telecommunication and browser software.

b) The demand for a lowering of intermediation cost.

c) United States has the necessary pre-requisites of service and technology based industries.

d) Stable legal system with enforcement of ownership and intellectual property rights.

e) The stability and strength of the United States economy.

United States prospered earlier and to a greater extent in eBusiness in comparison to Germany and Japan. Even though the latter countries are both wealthy and are technologically advanced nations, the 'regulation snow\(^2\)' and cultural impediments have slowed their progress in this sector. Indeed, according to Rudi Dornbusch, Capital markets and sheer greed are going to be the driving force for change\(^3\), not government legislation.

\(^2\) Professor Lester Thurow’s term for describing the analogy of the hibernating New England bear and the entrepreneur encumbered by regulation and social norms. (1999)

\(^3\) Professor Rudy Dornbusch has mentioned this at several MIT lectures in March - April 2000.
2.2 Value Added by the Internet

Economists at Warburg Dillon Read, an investment bank, suggest that the new economy should be called the "nude economy" because the Internet makes it more transparent and exposed. The Internet makes it easier for buyers and sellers to compare prices. It cuts out the middlemen between firms and customers. It reduces transaction costs. And it reduces barriers to entry. This last point may surprise ‘.com’ firms that reckon the huge marketing and technical costs of setting up a business, and the supposed advantage that comes with being a first mover, constitute big barriers to entry. In practice, it remains to be seen how big are such barriers. Some established ‘.com’ firms have lost market share. But the real point is that the Internet is reducing barriers to entry in other parts of the economy.

To understand this, go back to Ronald Coase, who argued in his 1937 undergraduate paper “Nature of the Firm” that the main reason why firms exist (as opposed to individuals acting as buyers and sellers at every stage of production) is to minimize transaction costs. In 1993, almost 2 million firms consisting of the retail, wholesale, finance, insurance, and other intermediation services added $1,687.6 billion, making up 25% of the US Gross Domestic Product (GDP). This is the space where the Internet is reducing costs. By doing so it also reduces the optimal size of firms.

In all these ways, then, the Internet cuts costs, increases competition and improves the functioning of the price mechanism. It thus moves the economy closer to the textbook

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model of perfect competition, which assumes abundant information, zero transaction costs and no barriers to entry. The Internet makes this assumption less far-fetched. By improving the flow of information between buyers and sellers, it makes markets more efficient, and so ensures that resources are allocated to their most productive use. The most important effect of the ‘new’ economy, indeed, may be to make the ‘old’ economy more efficient.

Economies will still be some way from the frictionless world of perfect competition. In some industries, low marginal costs (e.g. the marginal cost of selling software over the Internet is close to zero) and network effects (i.e. the more widely an operating system is used, the more people will want to use it) will result in increasing returns to scale, and thus the emergence of monopolies. However, as the Internet will in general reduce barriers to entry, making markets more contestable, competition and efficiency are still likely to increase across the economy as a whole.

It is hard to test this conclusion, but some studies seem to support it. Prices of goods bought online, such as books and compact discs, are, on average, about 10% cheaper (after including taxes and delivery) than in conventional shops, though the non-existent profits of many electronic retailers make this evidence inconclusive. Competition from the Internet is also forcing traditional retailers to reduce prices. The Internet offers even clearer savings in services such as banking. According to Lehman Brothers, a transfer between bank accounts costs $1.27 if done by a bank teller, 27 cents via a cash machine, and only one cent over the Internet.
Internet retailers and other business-to-consumer firms, such as Amazon or eBay, tend to hog the headlines, but the biggest economic impact of the Internet is likely to come from business-to-business (B2B) e-commerce. Gartner Group forecasts that global B2B turnover could reach $4 trillion in America in year 2003, compared with less than $400 billion of online sales to consumers. B2B e-commerce cuts companies’ costs in three ways. First, it reduces procurement costs, making it easier to find the cheapest supplier and cutting the cost of processing transactions. Second, it allows better supply-chain management. And third, it makes possible tighter inventory control, so firms can reduce their stocks or even eliminate them. Through these three channels B2B e-commerce reduces firms’ production costs, by increasing efficiency or by squeezing suppliers’ profit margins. In the economic jargon, the economy’s aggregate supply curve shifts to the right.

The biggest savings are likely to come in procurement. A report by Martin Brookes and Zaki Wahhaj, at Goldman Sachs, in the first quarter of 2000 estimated that firms’ possible savings from purchasing over the Internet vary from 2% in the coal industry to up to 40% in electronic components. British Telecom claimed that procuring goods and services online would reduce the average cost of processing a transaction by 90% and reduce the direct costs of goods and services it purchases by 11%. B2B exchanges can potentially offer big savings: Ford, GM and DaimlerChrysler have set up a joint exchange in 2000 to buy components from suppliers over the Internet, and other big firms in several industries (e.g. aerospace, pharmaceuticals and tires) have followed suit.
Messrs. Brookes and Wahhaj estimated that doing business with suppliers online could reduce the cost of making a car, for instance, by as much as 14%. Their 2000 report looked at industries that account for about one-quarter of America’s GDP, and uses input-output accounts to include second-round effects of cost savings—i.e. that lower costs in one industry will reduce the price of inputs for other industries. They conclude that, in the five big rich economies, B2B e-commerce could reduce average prices across the economy by almost 4%. And this probably understated likely cost savings because it was based on lower procurement costs alone.

What does all this mean for inflation and growth? As lower costs encourage firms to produce more at any given price (i.e. the supply curve shifts from S1 to S2 on Diagram 1.), the long-term equilibrium level of output will rise and the price level will fall. But note that it is the level of prices and not the level of inflation that falls. To the extent that this happens gradually over a period, inflation may be reduced, but only until prices reach their new, lower equilibrium level.
Diagram 1. Aggregate supply and demand of E-conomics.

The Internet cannot permanently reduce inflation, because this is a monetary phenomenon. If central banks continue to aim for the same inflation target as before, then, beyond the short term, inflation will stay unchanged. If inflation drops below target because the Internet pushes prices down, the central bank will reduce interest rates, allowing faster growth while leaving inflation unchanged. Prices of goods exposed to the Internet may fall, but prices of other goods and services will rise faster than before. By boosting productivity, the Internet can lift the economy’s safe speed limit before inflation starts to rise. But by how much? The Goldman Sachs study in 2000 estimated that B2B e-commerce would cause a permanent increase in the level of output by an average of 5% in the rich economies, with over half of this increase coming through within ten years. That implies an increase in GDP growth of 0.25% a year. If the benefits of Internet use spread to other industries not included in the study, the eventual gains would be larger. This growth in productivity (outstripping wage increase) only reflected
previous technological innovations, like the PC revolution, the impact of the Internet might still be in the pipeline\textsuperscript{6}.

In historical terms, an extra 0.25-0.5\% of annual growth would be hugely significant. Estimates suggest that the carriage of freight by rail over a couple of decades in the late 19th century added perhaps 10\% overall to American output. But if the Internet by itself seems unlikely to boost economic efficiency by as much as this, the productivity gains from information technology and the Internet together could easily come close. Computers, software and telecommunications accounted for about 12\% of America’s total capital stock in 2000, not far short of the share accounted for by railways at the peak of America’s railway age in the late 19th century.

Moreover, information technology has some advantages over previous technological revolutions. First, unlike the railways, which affected only the movement of goods, it can be applied across a broader section of the economy, including services. The Internet, for example, offers a new information system, a new marketplace, a new form of communication and a new means of distribution. The power of digital distribution may even lead to wholly new products and services that nobody has hitherto imagined, offering the hope of further increases in economic growth.

A second positive factor is that the prices of computers and telecommunications have fallen more rapidly than for any previous technology. This is encouraging firms to adopt the Internet more quickly. There is always a lag before new technology lifts productivity

\footnote{Professor Rudi Dornbusch at the MIT Sloan Fellow Luncheon, March 2000.}
growth, because it takes time for firms to reorganize their business to take advantage of new ways of doing things. The recent spurt in American productivity may be the productivity pay-off from the computer revolution, which started 50 years ago with the invention of the transistor. But because the Internet is now spreading extremely rapidly, productivity gains linked to it could arrive far more speedily.

2.2 ‘New Economics’ of the Internet

"Mathematics cannot outrun human judgements."

- Alan Greenspan, on the LTCM crisis.

In the initial years of proliferation, the Internet may have been over-hyped by the markets, but it also made most businesses more efficient. Its impact on economic growth was less obvious, but was possibly equally dramatic.

Information technology is supposed to reduce distances and bring people closer. Yet the Internet seems to have the opposite effect on economists. The profession is divided on the effects of the Internet. Some predict that it will hugely boost global growth and kill inflation—hence the boom in technology shares. Others retort that inflation is determined solely by the money supply, and that Internet share prices are overvalued. On this basis, when the bubble bursts, it will leave behind little more economic benefit than did the 17th century’s tulip bubble.
Gyrations in the stockmarket in early 2000 might seem to support this second view. Many ‘.com’ shares, particularly those of Internet retailers, have fallen off a cliff; some once-bright prospects are finding it hard to raise enough cash to stay in business. Yet the really big impact of the Internet is likely to be felt not among ‘.com’ firms, but in the wider economy. And in this area, the truth probably lies between the economists’ two extremes. The Internet will boost efficiency and growth, but not enough to justify lofty stockmarket valuations. Faster economic growth will not automatically mean faster profit growth, because margins may well be squeezed. As with most technological revolutions, the biggest benefits of the Internet will flow to consumers and not, in the end, to producers.

The economic impact of the Internet has often been described as an oil shock in reverse. The jump in the oil price in the 1970s increased inflation and pushed the world into recession. The Internet reduces the cost of another input, information, and so has positive economic effects.

The best way to look at this notion is to use a standard economic model of demand and supply. (See left chart on Diagram 1.) The economy is in equilibrium at the point where the aggregate demand curve D1 and the aggregate supply curve S1 intersect, at price P1 and real output Q1. The Internet pushes the aggregate supply curve (an economy’s productive potential) to the right, to S2. There is nothing new about this: innovations such as railways or electricity have always been the main source of long-term growth. If the demand curve remains fixed, the price level falls to P2 and output rises to Q2.
2.4 Inflation and Profits

So far, the argument has been that the Internet may push down inflation in the short run, and that in the longer run it will boost growth. However, this assumes that the Internet affects only aggregate supply. In reality, it could also boost demand. If equity investors expect faster growth in output and profits and so push up share prices, this will boost households’ wealth and encourage them to spend more, even before the increase in supply has materialized. Higher share prices, and hence a cheaper cost of capital, may also boost investment. As a result, the demand curve may shift to the right, to D2.

This may describe the situation in America in year 2000. Alan Greenspan, the Federal Reserve chairman, argued that an increase in productivity growth could indeed boost demand via share prices. The risk is that, if this increase in demand outstrips the productivity-led boost to supply, the equilibrium price level, and so inflationary pressure, could rise in the short term, and not fall. Some economists even argue that, following a technological shock, the previous inflation target is no longer appropriate. An essay in the 1999 annual report of the Federal Reserve Bank of Cleveland suggests that if rapid productivity gains pull down the costs of production, prices should also be allowed to fall, so workers can enjoy the benefits of higher productivity through increases in real wages. If central banks stop prices falling, and nominal wages, being stickier than prices, lag behind productivity gains, this will inflate profits and share prices will soar on the (false) expectation that profits will go on rising, spurring excessive investment. This
suggests that central banks should aim for lower inflation targets than before. The natural rate of unemployment (NAIRU) also seemed to have fallen to 4.1%.

Investors certainly seem to have inflated expectations about future profits. But faster growth and lower costs do not automatically justify a leap in share prices. History shows that, although the share of profits often rises during the early years of technology-led expansions, as it did in the 1990s, it then usually declines as a result of competition from new entrants attracted by the high returns.

Consider again the example of railways in the 19th century. Most schemes made little money and many went bust, largely because other investments had created excess capacity and fierce competition. Britain’s railway mania of the 1840s certainly had much in common with Internet fever. Share prices soared, then spectacularly tumbled as many lines failed to deliver expected profits.

There is big risk with the Internet, as boom will be followed by bust. But the good news is that, long after share prices crashed, railways continued to function, to the benefit of the economy, if not to the original investors. In all technological revolutions, from the railways to the Internet, the only sure long-term winners are consumers who gain from lower prices and hence higher real wages. There is no reason to expect the Internet to be any different.
Indeed, by reducing search costs and increasing the flow of information, the Internet explicitly shifts power from producers to consumers and so looks even more likely to squeeze profits. As with railways, stockmarkets currently seem to think that Internet firms will be the ones that reap the biggest rewards. But consumers and old-economy firms, from cars to chemicals, that use B2B e-commerce to reorganize themselves are likely to gain most. The overall rate of profits may be little changed, but profits will be redistributed.

2.5 Followers and Leaders

It is often argued that America’s lead in the Internet age will give it an economic edge for many years to come. After all, corporate spending on information technology is considerably higher as a share of GDP in America than in Japan or the European Union, and the proportion of households with Internet access is three times as high. Some economists also reckon that the success of America in exploiting information technology partly reflects its flexible, competitive markets. The Internet may yield smaller benefits in more tightly regulated economies with rigid labor and product markets and inefficient capital markets, which prevent labor and capital shifting in response to new opportunities.

To turn this argument around, however, the potential for cost savings and productivity gains from the Internet should be much bigger in the EU and Japan than in America. The impact of the Internet on growth could thus also be more powerful in Japan and Europe than in America. This is because the Internet, by increasing price transparency and competition, will directly attack the inefficiencies in their economies.
Countries with high distribution margins are likely to see the biggest price reductions and the biggest gains in efficiency. By exposing firms to more intense global competition, the Internet should force governments and businesses to rethink their old, inefficient habits and seek new ways to get around or eliminate market rigidities.

In Japan the Internet strikes right at the heart of many archaic business practices that hold prices high and hinder productivity. Take Japan’s famously inefficient and expensive distribution system. Suppliers and retailers tend to be tied to manufacturers, through cross-shareholdings. This allows manufacturers to control prices by restricting distribution to their own retailers. However, by increasing price transparency, the Internet will give more power to consumers. Japan often seems to be a nation of middlemen. The longer the supply chain, the bigger the potential gains from B2B e-commerce, since it allows firms to eliminate the many layers of middlemen that hamper economic efficiency. Structural failings in Japan may hinder productivity gains from the Internet at first—but they cannot block them. Similarly in the People Republic of China, where it is a supply (push) economy and not a demand (pull) economy, the Internet can provide industrial restructuring, further to information dissemination.

The Internet allows producers and consumers to seek the cheapest price in the global market. This will make it harder to maintain higher prices and higher taxes. In Europe especially, by facilitating cross-border purchases, the Internet will increase tax competition and so put pressure on governments to reduce taxes.
The Internet could also give a boost to growth in emerging economies. Echoing Ronald Coase's theory, Andy Xie, an economist with Morgan Stanley in Hong Kong, argues that because the Internet cuts transaction costs and reduces economies of scale from vertical integration, it reduces the economically optimal size of firms. For example, lower transaction costs will make it possible for small firms in Asia to work together to develop a global reach. In this way, the web could open up more opportunities for emerging economies to catch up with wealthier nations.

Smaller firms in emerging economies can now sell into a global market. It is now easier, for instance, for a tailor in Shanghai to make a suit by hand for a lawyer in Boston, or a software designer in India to write a program for a firm in California. One big advantage rich economies have, is their closeness to wealthy consumers, barriers will be eroded as transaction costs fall. Mr Xie argues that this will help emerging Asia to catch up. The Internet could also accelerate the process of economic catch-up by speeding up the diffusion of information, which will help new technologies reach emerging economies. The Internet is spreading rapidly throughout Asia, Latin America and Eastern Europe. In contrast, it took decades before many developing countries benefited from railways, telephones or electricity. And unlike any other technology revolution before, this is based on knowledge and software, not capital intensive assets. The real time nature of information flow and transfer, together with conditions of idea rather than capital shortage, means that virtually anyone can become a big player in a very short time. Billy Tam of Hong Kong brought an idea to Richard Li of Pacific Century Cyber Works

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(PCCW). Within a few minutes, he received $12.8 million to start iIink.net.\textsuperscript{8} Thus, if America can look forward to significant gains from IT and the Internet, then the rewards to other economies could be even greater.

\textbf{2.6 Drivers of Internet Bubble}

The cycle time for eBusiness is much faster than previous innovations from its start to the hypergrowth phase\textsuperscript{9}. Combinations of enabling technologies, market demand for products and investor exuberance drive the value of internet initial public offerings (IPO’s) in the initial phase. The demand and supply imbalance of available stock, and narrow floats also add to the steep run-up. This high stock value is used to fund acquisition and hiring. A ‘better’ portfolio of companies (CMGI, Softbank) presumably creates higher expectations for the future cash flows and therefore stock price. This is a self-reinforcing loop. (See Diagram 2.)

\textit{“A trend that cannot continue, must stop.”}

Even though Alan Greenspan could not reign in the upward spiral with a staged interest rate hikes in early 2000, a combination of inflation indicators, industry consolidation and rationalization by investors finally did. Also significant was the explosion of the number of IPOs driving up supply of stocks in the industry. These factors now dominate, propelling the model into a vicious (downward) cycle. In a relatively short amount of

\textsuperscript{8} Wonacott, P. (Apr 3, 2000) “How Hong Kong’s Li the Younger Made His Own Name.” The Wall Street Journal.

time, several sectors, first business to consumer (B2C) then the business to business (B2B) sectors, have made significant corrections.

The central loop is a reinforcing loop (R), which drives a steep ascend can also quickly turn into a vicious cycle. The forces of ‘consolidation’ and market ‘rationalization’ overpower the feeding variables of ‘narrow float’ and ‘market demand’.

While most Internet firms will eventually crash, some will maintain their value, others will decline and act more like the ‘old’ economy companies. (See Diagram 3.)
Diagram 2. **Drivers for the "Internet Bubble"**.

Diagram 3. **Behavior of Internet firm valuation**
Chapter 3 - The Formation of Thought

3.1 Evolution of Project Valuation

The payback method of valuation was dominant before the 1960’s when John Hicks and Irving Fisher developed the discounted cash flow techniques. The proportion of Fortune 500 corporations using discounted cash flow for investment appraisal has risen from 38% in 1962, to 64% in 1977, to 90% in 1990-93\textsuperscript{10}. Currently, few corporations are employing real options model that is derived from the classic financial option-pricing paradigm of Black-Scholes and Merton\textsuperscript{11}.

The evolution of the valuation models used in project analysis can be distinguished into three stages\textsuperscript{12}. The first stage is the discounted cash flow approach. It is a static, or mechanistic model that produces specified streams of cash flows over time whose joint probability distribution is given exogenously. The analyst must value these projects by discounting the exogenously given cash flows at an appropriately determined but exogenous discount rate.

The second stage of development in the theory of project valuation recognizes that the cash flows are, at least partially, controllable. That is the agent making the investment decision may be able to act in the future to influence the probability distribution of cash


\textsuperscript{11}“To Wait or Not to Wait.” CFO Magazine, 13 (May 1997), 91-94.

flows generated by the project and will generally wish to do so as more information becomes available. The contingent future actions of the decision-maker must be taken into account when the project is initially analyzed, since these will affect the expected value and risk of the future cash flows. This controllable cash flow model of project valuation parallels the agency theory of corporate financial policy. Stemming from the insights of Jensen and Meckling\textsuperscript{13} that financial structure serves to divide up the given stream of cash flows. It also affects the size of cash flows available for distribution through the incentives it creates for the agents who now have control over the probability distribution of those cash flows. In this stage, project cash flows are treated as endogenous because they are under the control of the decision-maker. Thus, it is appropriate to label it the 'controllable cash-flow' stage of project analysis development.

While Monte Carlo simulations and decision tree analysis are useful techniques for estimating the probability distribution of future project cash flows, they offer little guidance as to how future decision possibilities or contingencies affect project risk and therefore project risk and therefore project discount rates. Thus, so long as the problem of risk, and therefore the appropriate discount rate, remained unsolved the second stage of theory development remained stagnant and incomplete. It follows that Monte Carlo analysis and decision trees cannot be integrated into the value maximization framework of neoclassical corporate finance.

Black, Scholes and Merton eventually solved the discount rate problem in the context of claims on financial assets\textsuperscript{14}. In showing how to value a claim whose payoff is contingent on the value of another asset, they developed the technique of risk neutral, or equivalent martingale, pricing. The far-reaching implications for project analysis is that the expected rate of change in the underlying cash flow drivers or stochastic state variables are risk adjusted, the resulting 'expected' (risk-adjusted) cash flows can be discounted at the risk-free interest rate.

The Basic Risk Neutral (Certainty Equivalent) Pricing Principle\textsuperscript{15}:

$$PV_0[P_t] = \frac{P_0e^{gt}}{e^{(r+RP)t}} = e^{-rt} P_0 e^{(g-RP)t}$$

PV: Present value.
P: Price.
r: Risk free rate.
(g-RP): Risk-adjusted growth rate.
RP: The risk premium associated with P (at time t).

This is regardless of the types of future decision contingencies inherent in the project or of the nature of the relation between the stochastic state variables and the cash flows of the project\textsuperscript{16}.


\textsuperscript{15} Brennan, M.J. "The Real Options Paradigm: Preview and Prospects" Lecture during the "Real Options Valuation in the New Economy," Conference. Real Options Group. (March 2000)

\textsuperscript{16} In particular, whether the relation is linear or not. The simplest type of nonlinearity arises from the tax code that taxes positive profit but does not allow tax rebates for losses.
Stewart Myers coined the term ‘real options’ to address the gap between strategic planning and finance:

*Strategic planning needs finance. Present value calculations are needed as a check on strategic analysis and vice versa. However, standard discounted cash flow will tend to understate the option value attached to growing profitable lines of business. Corporate finance theory requires extension to deal with real options.*

Brennan and Schwartz, and McDonald and Siegel were the first to employ these insights in the valuation of real assets, thus helping to complete this second stage in the development of project valuation, which has become known as ‘real options’ analysis.

The term ‘real options’ recognizes both the similarities and the differences between the valuation of rights to controllable cash flows and the valuation of financial options. The similarities arise not only because the ability to control a cash flow stream represents an option, but, more importantly, because equivalent martingale pricing techniques are appropriate to both real and financial options. The major difference is that although financial options are almost always options on traded assets, the rights to controllable cash flows typically cannot be reduced to claims on traded assets. This often makes the determination of equivalent martingale measure of risk adjustment more problematic than is the case of financial options. The real options approach has the ability to capture risk-

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reducing effects of cash flow controllability, through the equivalent martingale risk adjustment. This technique can be thought of as bringing discipline and analytical rigor to the older techniques of Monte Carlo simulation and decision tree analysis for valuing claims to controllable cash flows, by correctly adjusting for risk.

The third stage in the development of theory of project analysis takes account of the fact that the cash flows from an investment project are influenced not only by agents within the firm who can react as new information becomes available, but also by agents outside the firm such as competitors and suppliers. And that these actions can in turn be influenced by, as well as influence the agents within the firm. From this perspective, the cash flows from a project (and therefore the value of the project) can be seen as an outcome of a game among endogenous agents, exogenous agents and stochastic forces. These are referred as game-theoretic models, although not all take an explicit game-theoretic perspective. A. Dixit and J. Williams are among the first to consider real options within the equilibrium context. In these models, the firm’s financial structure affects the payoff to equity holders who control the firm’s decisions, and thereby affects their incentives. This allows them to use financial structure to make credible pre-commitments about their output policy.

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3.2 Applications of Real Options\textsuperscript{20}

Realization of cash flow often differs from what managers expect due to uncertainty and competitive interactions. These uncertain issues can be resolved with the unveiling of new information. Managers with the ability to alter course midway of the project can steer it to a more favorable outcome. Options to defer, expand, contract, or abandon can be very valuable. This flexibility which allows management to adapt to future actions depending on the environment introduces an asymmetry or skewness in the probability distribution of the NPV. That expands the true value of the investment opportunity by improving the upside potential while limiting the downside losses relative to the management’s expectations without in-built flexibility (Static NPV). (See Diagram 4.)

\[
\text{Expanded NPV} = \text{Static NPV} + \text{“Option Premium”}
\]

The “Option Premium” can manifest as deferrable, abandonment, or expansion value.

Diagram 4. Managerial flexibility introduces an asymmetry in the probability distribution of NPV.\textsuperscript{21}

\textsuperscript{21} Trigeorgis L. (1998) Real Options – Managerial Flexibility and Strategy in Resource Allocation. MIT Press. Chapter 4. (Figure 4.1)
3.3 The Modified Discounted Cash Flow\textsuperscript{22}

With the rise of start-up firms and the venture capital industry, various new modifications of the DCF model are employed. Below are some examples of these\textsuperscript{23}:

a) DCF with Weighted Cost of Capital (WACC)

- Step 1 – Calculate Free Cash Flows (FCFs) to an ‘all equity’ firm for a period of years until the company has reached a ‘steady state’ of cash flows.
- Step 2 – Discount these FCFs at the WACC.
- Step 3 – Calculate the Terminal Value as the present value of a growing perpetuity of FCFs assuming some growth rate in FCFs and discounting by WACC.
- Note - WACC incorporates debt shields of debt financing and is typically assumed constant throughout. Also assumes constant debt ratio through time.

b) DCF with Adjusted Present Value (APV)

- Step 1 – Calculate Free Cash Flows (FCFs) to an ‘all equity’ firm for a period of years until the company has reached a ‘steady state’ of cash flows.
- Step 2 – Discount FCFs at the discount rate of an all equity firm \(k = \text{Risk Free Rate} + \beta * \text{Market Risk Premium}\).

\textsuperscript{22} These methods are used prior to the sharp stock price depreciation of many internet firms in April 2000.  
- Step 3 - Calculate the Terminal Value as the present value of a growing perpetuity of FCFs assuming some growth rate in FCFs and discounting by k.

- Step 4 – Value the tax shield of debt financing separately (trD) and discount by a rate that reflects the riskiness of those cash flows.

c) The Comparables Method

- Values companies by looking at similar companies.

- Take multiples of EBITDA, sales, customers, ‘eyeballs’ etc

- Strength – Tells you what market thinks about discount rates and growth rates.

- Weaknesses – Market may not be driven by fundamentals. May be difficult to find a comparable firm with a known beta if the business model is new.

d) The Venture Capital Method

- Step 1 – Calculate the FCFs to equity for a period of years (often zero or negative).

- Step 2 – Estimate the time at which the VC will exit the investment (Typically through Initial Public Offering (IPO) of an acquisition).

- Step 3 – Value an exit price based on an assumed multiple of sales or customers etc. The multiple is based on comparable public companies or comparable transactions.

- Step 4 – Discount interim cash flows at rates ranging from 25% - 80%.
3.4 More Art than Science

"It is better to have the approximately optimal solution to the right problem then the exact solution to the wrong problem." – Everyone.

Asking the question whether any kind of sophisticated valuation models are used to value new ventures and startups usually draw a blank or ridicule from seasoned venture capitalists\(^{24}\). In fact, there is no way of accurately valuing a business with just a founding team and a good idea. The Entrepreneurial Finance class at the MIT Sloan School of Management attempted to value Chemdex.com\(^{25}\). Even with hindsight, the class could not get anywhere close to the market value of $20 billion in early 2000.

A New York University professor\(^{26}\) has also collected a detailed list of valuation methods on his website. Tzachi Zach also published a working list (Appendix 1). Others are valuing firms by “Eyeballs”. Placing a value on a website’s customers may be the best way to judge a net stock. If the internet market were rational, the market capitalization per eyeball would represent the total profit that you could reasonably expect a company to get from its average customer, adjusted for risk and length of time before those profits are realized\(^{27}\). The Xerox Palo Alto Research Center (PARC) has found a “power-law”

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\(^{24}\) Based on posing the question to Bob Greene, Managing General Partner, Flatiion Partners; and Michael Feinstein, Founder and Partner, Atlas Venture.

\(^{25}\) Based on work on Course 15.397 (MIT Sloan). (Spring 2000)

\(^{26}\) http://www.stern.nyu.edu/~adamodar/New_Home_Page/

\(^{27}\) Schonfeld, E. “How Much Are Your Eyeballs worth?” (Feb 21, 2000)

http://www.pathfinder.com/fortune/2000/02/21/eye.html
relationship between website usage and market capitalization ranking. It found the top 0.1% of sites got 32% of usage, the top 1% got 56%, the top 10% got 82%.

Shaun G. Andrikopoulos of BT Alex Brown Inc. came up with a method to justify the 320 times projected 1999 earnings for Yahoo!. It is called Theoretical Earnings Multiple Analysis (TEMA). By that measure, which projects the future earnings by estimating revenue growth and the operating margins that the company would hope to achieve when it has matured, the price-earning ratio in year 2000 is just 192. But factor in a revenue growth that is 55% higher, which is possibly consistent with a history of higher than expected sales growth of Yahoo!, the TEMA p-e drops to 124.

Veteran securities analyst Charles R. Wolf of Warburg Dillon Read used a method built on Economic Value Added (EVA). Simply put, this means that a company earns an economic profit only if it has earned more than its cost of capital, which is not found on an income statement. In EVA analysis, the market value of the firm has two components. One is the Current Operations Value (COV), which measures the worth of a company as it now operates. The second is Future Growth Value (FGV), which measures the company's expected growth. Once the COV is determined, which is the easier of the two, the implied FGV can be derived. With the FGV the implied revenue growth rate can be determined. Then a judgement can be made whether that growth rate is achievable. The cost of capital can be derived from the Capital Asset Pricing Model (CAPM), with the

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beta derived from a comparable security. Instead of forecasting all the inputs to come up with a number for what the stock should be worth, this method starts with the stock price and works backwards to answer the question: What kind of growth does this company have to deliver to justify this price? This method is a way to perform a reality check. If Amazon.com is priced at $214 per share, the market is implying that Amazon’s revenue will increase 59.6% a year over the next 10 years. Assuming the cost of capital to be 15%, Amazon.com should reach sales of $63 billion in 10 years. (The estimated US retail book sales in 10 years is $16 billion.) Of course, they may have expanded into many other sectors of the market. With that amount of sales, they would also need a correspondingly large amount of fixed asset and support. The question is whether they will behave more similar to Wal-Mart, Sears or Barnes and Noble than an internet firm.

Based on a similar theory, Tzachi Zach of the Simon Graduate School of Business describes a method that decomposes the value the firm into two parts. One is the Current Operating Value (COV), which is the value of the firm’s current operations assuming no growth in its cash flows. The other is Value of Growth Opportunities (GR), which is calculated by subtracting COV from the firm’s market value. Accordingly, calculate the growth rates that are implied by GR and see if they make any business sense. The following equation to solve for the average implied growth rate (g) over 10 years.

\[ GR = \frac{NOPAT_0(1 + g)}{(1 + r)} + \frac{NOPAT_0(1 + g)^2}{(1 + r)^2} + \ldots + \frac{NOPAT_0(1 + g)^{10}}{(1 + r)^{10}} + \frac{NOPAT_0(1 + g)^{10} \cdot 1.05}{(1 + r) \cdot r} - COV \]

GR: Value of growth opportunities.
NOPAT: Net income after tax. (Assume a tax rate of 40% and operating margin of 10%.)
COV: Current operating value.
g: Implied growth rate over 10 years.
r: Discount rate.

20 sample internet firms were studied based on certain assumptions. (See Appendix 2.) The results clearly illustrate the volatility and high risk of Internet stocks. Most of the value of the firms comes from future growth potential. On average, approximately 98% of the market value can be associated with future growth (FGV or PVGO). It also demonstrates how sensitive are the market values to different growth rates. On average, market value declines by one third if the growth rate is 10% lower than those implied by the current valuation. By this fact alone, we can conclude that most Internet stocks are overvalued because only one or two firms will be successful in each category of firms, and furthermore not all categories of businesses will be sustainable.

In valuing an internet company or eBusiness we need to take into account the landscape, the characteristics of the firm and other issues like potential of the firm to be a large player\textsuperscript{31}. During the late 1990’s, there was a typical ‘gold-rush’ scenario of internet initial public offerings (IPO’s). Between January 1995 and November 1998, there were 172 IPO’s. This frenzy also attracted many firms within the same industry. They account for about 10% of all IPO’s and increasing. Compared to others, these IPO’s are characterized

by greater under-pricing, smaller issues (about 70% as large as others), and much smaller annualized revenues ($38 million versus $232 for others). These firms typically have extremely uncertain revenue growth and profitability (see Appendix 3.4d), and large disagreements on forecast assumptions.

In my interview with Professor S. P. Kothari, he reiterated that strategy and framework of the firm must take precedent to worrying about valuation. On the valuation of eBusinesses, there is a need to get an idea of the market size and the market-share the firm can hope to achieve. All current valuation techniques can be easily defeated. He comments that the option pricing approach is intuitively appealing, but is difficult to implement because variances of cash flows are not easy to estimate. The numbers in real options pricing are less important than its usefulness for conceptualizing structure of the business, strategy and ranking of priorities.

Michael Mauboussin of Credit Swiss First Boston (CSFB) comments that when it comes to valuing Internet firms, the management quality is more important. Where value was previously largely derived from capital, it is now increasingly derived from knowledge. Companies like Microsoft with a New Economy price-earning ratio of nearly 80 have a lower physical capital needs, their real value is in intellectual capital. Traditional accounting method for the most part does not take into account of intellectual capital. One indirect measure of how much intellectual capital a company has is how much value is tied up in its employee stock options. In September 1999, Microsoft employee stock

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options are worth $68 billion. However, the potential of a company for creating new value still cannot be quantified.

3.5 Quantitative Models

In September 1999, Eduardo Schwartz and Mark Moon published an article on the valuation model for Internet companies using Amazon.com as a case. They applied real options theory and modern capital budgeting to formulate the model in continuous time by forming a discrete time approximation. They estimated the model parameters with industrial and company data, solve the model by simulation, and finally performed a sensitivity analysis. Depending on the parameters chosen and high enough growth rates, the seemingly high Internet stock price can be justified. The high volatility of the growth rate and stock price is consistent with the large sensitivity of the valuation to initial conditions and exact specification of the parameters.

In this relatively simple model, more than 20 parameters were required (Appendix 3). While some were easily observable or estimated with the quarterly data, others needed the use of judgement that can only come from deep knowledge of the specific situation. I spoke to Mark Moon, the co-author, briefly about this. He said this was done by conducting detailed interviews with people in the industry. Estimating the parameters is probably the most critical step in the analysis. Using the base parameters (Appendix 4) and putting the model through 100,000 simulations, a valuation of $21,038 million was obtained. If, for example, the variable cost is increased by 1%, thereby decreasing the

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profit margin to 2% of sales from 3%, the value of the Amazon.com will decrease from
$21 billion to $14 billion. Other examples are the parameters for the stochastic process of
the changes in the growth rates in revenues. An increase in the initial volatility of the
growth rate by 10% almost doubles the value of the firm, and vice versa (Appendix 5).

The paper also looks into other pertinent facts like the probability of bankruptcy, the debt
and equity structure of the firm.

3.6 Cash Flow – Old versus New Economy

A February 1999 Credit Suisse First Boston paper argues that seemingly incredible
valuations on internet companies and their discrepancies with traditional ‘profitable’
firms can be explained by the cash flows\textsuperscript{34}. The investment goal, however, has not
changed. That is to buy into a stream of cash flows with greater current value than the
price they paid for the investment. Instead of looking at the income statement and using
price-earning ratios to judge the worth of a firm, there should be a focus on the balance
– follow a distinct trend. (See Diagram 5.)

of Finance. (Vol. 9) Credit Suisse First Boston Corporation.
Diagram 5. **Cash Economics Matrix: Old Economy Company**

After a period in the *Startup* quadrant, most successful Old Economy companies become cash earning positive. After making increasing cash investments, diminishing marginal returns eventually forces the company to lower its investments until its annual investment near its economic depreciation, resulting in a net investment of approximately zero and a stable cash earnings base.
In contrast, the New Economy companies follow different pattern. After originating in the *Startup* quadrant, a favorable cash conversion cycle often translates into a cash inflow from investment, even in the face of mounting losses. This moves them into the *Emerging Capital Efficient Company* quadrant. As their business model scales and begin to report earnings, both cash earnings and investments generate cash inflows. This moves them into the *Super Cash Flow* quadrant.

Diagram 6. *Cash Economics Matrix: Average New Economy Company*\(^{36}\).


\(^{36}\) (As in foot note 35.)
Chapter 4 – Implementation of Real Options Valuation

4.1 Value Flexibility – Examples of Real Options

Apart from hedging against market and institutional risks, specific project implementation risks can also be mitigated. If flexibility can be built into a project, it is possible decrease or control the risks. Real options can be used to value real assets. They are also useful for devising and quantifying strategy. This approach provides a much more satisfactory method of taking account of the effects of project risks caused by the controllability of project cash flow than does the mechanical discounted cash flow approach, which essentially ignores future decision contingencies.

Below are examples of common real options:

a) Option to Defer: If a firm hold a lease on (or an option to buy) valuable land or resources, it can wait a period of time to see if the output prices justifies constructing a building or a plant or mine the resource. This applies for natural resource extraction industries, real estate development, farming or paper products.  

b) Time-to-Build Option (Staged Investment): Staging investments as a series of outlays creates the option to abandon the enterprise in midstream if new information is unfavorable. Each stage can be viewed as an option on the value of subsequent stages and valued as a compound option. This can be applied to research and development

intensive industries like pharmaceuticals; long-development capital-intensive projects
like large scale construction, energy-generating plants, or startup ventures.\textsuperscript{38}

c) Option to Alter Operating Scale: If the market conditions are more favorable than
expected, the firm can expand the scale of production or accelerate resource
utilization. However, if conditions are less favorable than expected, it can reduce the
scale of operations. In extreme cases, the projects can be stopped and later restarted.
Natural-resource industries, facilities planning and construction in cyclical industries,
fashion apparel and consumer goods industries may apply this option.\textsuperscript{39}

d) Option to Abandon: If market conditions decline severely, management can abandon
operations permanently and realize the salvage value of the capital equipment, other
tangible and intangible assets (e.g. rights, licenses, and intellectual property). This may
be used in capital intensive industries (e.g. airlines, railroad), financial services, and
new product introduction in uncertain markets.\textsuperscript{40}

d) Option to Switch: If prices or demand change, management can change the output mix
of the facility (product flexibility). Alternatively, the same output can be produced
using different types of input (process flexibility). Goods sought in small batches or

\textsuperscript{38} Majd, S., R. Pindyck. (1987) "Time to Build, Option Value, and Investment Decisions." Journal of
\textsuperscript{39} Trigeorgis, L., S.P. Mason. (1987) "Valuing Managerial Flexibility." Midland Corporate Finance Journal
5, No.1:14-21
\textsuperscript{40} Myers, S.C., S. Majd. (1990) "Abandonment Value and Project Life." Advances in Futures and Options
subject to volatile demand (e.g. consumer electronics, toys) cause output shifts. Feedstock-dependent, electric power, chemicals, crop-switching cause input shifts.  

e) Growth Options: An early investment (e.g. R&D, lease on undeveloped land, strategic acquisition, information network) is a prerequisite or a link in a chain of interrelated projects, opening up to future growth opportunities.

f) Multiple Interacting Options: Real-life projects often involve a collection of various options. Upward-potential-enhancing and downward-protection options may be present in combination. Their combined value may be different from their separate value. They may also interact with financial flexibility options.

4.2 Real Options Valuation Method

The basic methodology for real option valuation is a four-step process described below.

Step 1 – Compute Base Case

- Compute the base case present value without flexibility using the DCF valuation model.

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Step 2 – Model the Uncertainty

- Model the uncertainty using event trees.
- Understand how the present value develops over time with respect to the changing uncertainty.
- Choose multiplicative or additive stochastic process.
- Still no flexibility here; This value should equal to the value in Step 1.
- Explicitly estimate uncertainty.

Step 3 – Identify and Incorporate Managerial Flexibilities

- Analyzing the event tree, identify and incorporate managerial flexibility to respond to new information.
- Flexibility is incorporated into event trees, which transform them into decision trees.
- The flexibility has altered the risk characteristics of the project and therefore changing the cost of capital.

Step 4 – Calculate the Real Option Value (ROV)

- Value the total project using simple algebraic methodology.
- ROV will include the base case present value without flexibility plus the option (flexibility) value – under high uncertainty and managerial flexibility option value will be substantial.
- There are six variables or levers which determine the uncertainty and managerial flexibility:
(a) Time To Expire – A longer time to expiration will allow managers to learn more about new information before taking a decision, therefore increasing ROV.

(b) Investment Cost – A higher investment cost will reduce NPV (without flexibility) and therefore reduce ROV.

(c) Risk-Free Interest Rate – An increase in the risk-free rate will increase ROV since it will increase the time value of money advantage in deferring the investment cost.

(d) Uncertainty (volatility) about the Present Value – In an environment with managerial flexibility, an increase uncertainty will increase ROV.

(e) Expected Present Value (PV) of Cash Flows from Investment – An increase in PV will increase the NPV (without flexibility) and therefore the ROV will also increase.

(f) Cash Flows Lost to Competitors – Increasing cash flows lost to competitors will clearly decrease ROV.

4.3 Interdependencies

It is possible to value investment opportunities with a collection of embedded real options and quantify their interactions. While the additivity of individual option values may be trivial when options are written on distinct assets, it can become significant if however the options are written on the same unique underlying asset. Examples of interacting financial options include putable convertible bonds, callable extendable bonds and securities callable by issuer at two distinct times. Real options more often come as an
inseparable package with a single underlying asset (i.e. the gross project value).
Interaction occurs when multiple options are embedded in the same underlying asset.

The mere presence of subsequent options increases the value of the effective underlying asset for earlier options. Prior real options have as their underlying asset the whole portfolio of gross project value plus the value of any future options at that time. In the extreme case, the inseparability of real options from their underlying asset allows also the possibility that exercise of a prior put option on the asset, such as the option to abandon early, may eliminate the asset.

In general, exercising a prior real option may alter the underlying asset itself and hence the value of subsequent options on it, causing a second-order interaction. For example, the option to contract will decrease, while the option to expand will increase the project scale, affecting the value of other options on it. Furthermore, the (conditional) probability of exercising a later option, in the presence of an earlier option, will be higher or lower than the (marginal) probability of its exercise as a separate option, depending on whether the prior option is of the same or the opposite type, respectively. Real options may thus interact for various reasons and to varying degrees, depending on the probability of their joint exercise during the investment’s life.45

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4.4 Competition

Project cash flows are not only influenced by endogenous agents but by new information as it becomes available and to exogenous factors like competitors and suppliers. These external agents could in turn be influenced by the firm’s actions. Therefore game theory models are also useful for looking at project planning and risk mitigation.
Chapter 5 – Case Study: Gefei Tire Company

5.1 The Company and Industry Background

Gefei is one of the top ten largest tire manufacturer in the People’s Republic of China (PRC). It currently produces about 10,000 tires a day in two plants. Although it mainly sells to the domestic market, the export segment of the business is growing. Its procurement sources include mainly domestic and imported rubber, nylon cords and coal. Gefei has a network of 25 distribution centers across PRC selling to local wholesalers or retail stores.

There is a need to make marketing, sales and inventory control more efficient. They are planning to introduce an enterprise resource planning (ERP) system in mid-2000 to manage its supply chain and financial systems. With the popular rise in electronic marketplaces (e.g. industry aggregators, exchanges and auction networks), the principals of Gefei are deciding whether to invest in a new eMarketplace company. This can potentially merge seamlessly with the back-end systems. The end result would hopefully provide better customer service, lower transaction costs and increase access to a larger range of goods. A bigger and more efficient customer network can also add a premium to the value of the firm.

In February 1999 a Forrester Research report “Anatomy of New Market Models” predicted a multibillion-dollar market for these online exchanges. The main rationales for the rapid adoption of these new trading arenas are:
a) **Industry inefficiencies run rampant:** In today's business environment, comparing offerings across suppliers requires multiple phone calls to various suppliers or enlisting the costly support of a broker. Time-consuming practices like these are easy targets for the Internet, where purchasing agents can gain instant access to comparisons of many different products.

b) **eMarketplace vendors lower technology barriers:** Early online market makers had no option except to build their sites from scratch. But the technology landscape is maturing. B2B entrepreneurs can presently acquire sophisticated marketplace software from firms like Tradex, Ariba and Commerce One or entirely offload the building of their Websites to a lengthening list of experienced eCommerce integrators like Scient, Viant and CSC.

c) **Venture funding shifts to business trade:** High-profile B-to-B players like VerticalNet, whose market cap currently exceeds $4 billion, have caught the investor community's attention. The result is that many venture capitalists are placing bigger bets on their business trade portfolio. CMGI, for instance, just announced its plans to raise $1 billion to invest in B-to-B firms.

Net marketplaces like MetalSite and AltraNet are taking over the B-to-B eCommerce headlines. To gain a better understanding of these new players, Forrester interviewed executives from 50 online vertical eMarketplaces – sites that provide specialized products and services tailored to specific industries. Interviewees, who transacted
a minimum of $250,000 over the last 12 months, have ambitious plans, expecting their transaction volumes to mushroom by more than seventy-fivefold in two years.\(^{46}\)

The formation of Rubbernetworks.com by the top six largest tire manufacturers in the world has just been announced. They plan to be up and operational by the end of 2000. The PRC market is moving toward a free market style economy. There are lots of opportunities to increase efficiency in sales, marketing and fulfillment.

So far we have seen very good reasons for Gefei’s principals to invest in this new venture. However, by April 2000 ZD net publish an article, which questioned the viability of eMarketplace \(^{47}\). The promise of these so-called super exchanges is quickly beginning to fade as key players balk at having to pay transaction fees to do business with existing partners and at the prospect of having to share key business data with competitors. A growing number of companies are resisting the call to join public exchanges and are instead deciding to go the private exchange route. The question is if the exchanges could help them streamline their supply chain and add to their earnings. Also the big three automotive exchange is doomed to fail because it does not address the supply chain integration issue.


5.2 Choices for the Gefei

Gefei could maintain the current way of sales and procurement, wait for technology and 'revenue model' for eMarketplace to mature. Perhaps even wait for other networks to establish in the PRC and join them.

- Buy a low-end generic software package and implement front end to interact with existing customers. ($150,000 to implement.)
- Buy brand name software, training and support. ($2 mil to start project.)
- Introduce an independent company to host the service. Advantage of attracting a larger pool of firms, creating economies of scale. It could be a bridge to other strategic partnerships. Disadvantages are immature business and unproved revenue model. It could disrupt current market equilibrium, potential lose customers by disintermediating personal service. Customer poaching and price war may occur. Although rapidly improving, the PRC has relatively poor telecommunication infrastructure and low levels of PC usage.

The real option analysis and valuation can be used here to evaluate the alternatives.

5.3 Real Options Analysis\(^{48}\)

The aim is to build a Multiplicative Tree without dividends with the following parameters:

\(^{48}\) Based on Professor Thomas E. Copeland's course 15.964 Analysis of Corporate Finance (MIT Sloan).
- PV of assets without flexibility = \( V_a = \$ 585,422 \) (The present value of asset without flexibility is calculated using the Adjusted Present Value (APV) method. (Appendix 6 and 7.)
- Annual volatility (continuous) = 50%
- Risk-free rate = \( r_f = 6\% \)
- Periods per year = \( T = 1 \)
- Objective probabilities: \( \text{up} = U = e^{\sigma \sqrt{T}} \), \( \text{down} = 1/U = e^{-\sigma \sqrt{T}} \)
- Discount rate (required rate of return)(continuous) = 20% /year = \( k \)
- Note: The discount rate and the objective probabilities are jointly determined.

To construct the event tree, we need to determine:

\[
\begin{align*}
u &= e^{\sigma \sqrt{T}} = 1.6487 \\
d &= e^{-\sigma \sqrt{T}} = 0.6065
\end{align*}
\]

Below are the results for nodes A, B and C for the event tree (Let value at node A=\( V_a \), value at node B = \( V_b \) and so on). Nodes D to J are expanded similarly. (Appendix 8.) The first column, node A, represents Year 1 (2000), the second column, nodes B and C represents Year 2 (2001), and so on.
(Numbers in the tree are expressed in $ '000.)

\[ B : uV_a = e^{\sigma \sqrt{T}} V_a = 965 \]

A: \[ V_a = 585 \]

(1-p)

\[ C : dV_a = e^{-\sigma \sqrt{T}} V_a = 355 \]

To calculate p:

\[ V_0 = puV_0 e^{-k/4} + (1 - p)dV_0 e^{-k/4} \]

585 = \[ puV_0 e^{-k/4} + (1 - p)dV_0 e^{-k/4} \]

1 = \[ p(1.6487)e^{-20/4} + (1 - p)(0.6065)e^{-20/4} \]

\[ p = 0.4267 \]
To construct decision tree based on 3 simple options:

1. Maintain operations

2. Expand operations – American call option. To expand revenue by 30% requires $1 million investment. Entering another aggregator vertical like retail industry, which the principals of Gefei Tire Company are also involved in. This decision would only be made if indicators show that eMarketplaces have gain acceptance by the industry.

3. Abandon operations – American put option. This decision is made if indicators show that eMarketplaces in general have not taken off or that Gefei’s aggregator has not been widely adopted. The alternatives would be to return to the old ways of transaction or join other more successful aggregators. The salvage value of equipment and expertise would be only $300,000.

On the Decision Tree, calculations for each option are made for nodes G to J respectively. To value the options further back in the tree, either the replicating portfolio approach or the risk neutral probabilities approach can be used. (The former approach is used here.) The latter approach could uses $p$ and the Risk Adjusted Discount Rate (RAR) to calculate the Present Value.

The replicated value for node D consists of m units of the underlying risky asset, and a short position in default free bonds, B.
This is designed to pay out exactly the same state contingent claims as the option and is therefore perfectly correlated with the option (a perfect substitute) and will have the same value.

The replicating portfolio has the following payout at the end of the period:

State G  \[ m(V_g) - (1 + r_f)B = V_G = 2,624 \]

State H  \[ -[m(V_h) - (1 + r_f)B = V_H = 965] \]

\[ m(2,624) - m(965) = 1559 \]

\[ m = 1, B = 0 \]

\[ (u^2V_0 = V_d) \]

\[ V_D = m(u^2V_0) - B \]

\[ V_D = 1,591 \]

Since at Decision node G and H, the value for ‘Maintain’ is chosen, \( V_D = V_d \). Since the option to expand is an American option, the value of ‘Maintain’ is always higher than the value to ‘Expand’. The management should look at the industry (or comparable) volatility, market conditions and competition factors before exercising the option.

The rest of the nodes are replicated the same way and the Decision Tree is constructed from right to left. \( V_A - V_a = 622 - 585 = $37,000 \) represents the option value to expand or to abandon for the next four years. It is also known as the value of the Expanded NPV.
A sensitivity analysis was done with volatility ranging from 40% - 80%. It clearly shows increasing Expanded NPV values with increasing volatility. (See Diagram 7.)

![Graph showing Sensitivity Analysis: Volatility with Expanded NPV values increasing with volatility.](image)

**Diagram 7. Sensitivity Analysis**

While the above method provides a more powerful way of assessing a project, and while it incorporates certain categories of risks within the volatility, the management should consider other factors related to the investments. Non-market forces may have significant impact when operating in the emerging market. The decision tree should be updated as soon as new information arises to maximize its effectiveness.
Corporate investment projects often contain ‘embedded options’. The valuation of such options is difficult to accommodate within the DCF framework. It would be interesting to draw on the concept of asset allocation in investment portfolios and apply it to capital allocation for corporations. Consider the established mature firm as the bond component, and a growth subsidiary (e.g. eBusiness) as a stock component of the firm’s ‘portfolio’. It would be useful if we can use this method to decide how to allocate capital investments in each subsidiary, to decide what kinds of businesses to acquire depending on the risk-return utility (i.e. Value-At-Risk level) of a firm. The component and composite worth of the corporation can also be formulated. A premium on the value would perhaps signal that there is a synergistic mix of components. Real options can be applied to provide ‘partial perfect foresight’ to increase the valuation of the firm. The following is a description of the asset allocation procedure of investment portfolios. I would continue to describe its application to firm capital allocation.

If you invested in either the stock market of the bond market, allocating your asset back and forth with perfect foresight every month, a $1 investment in January 1926 would produce a return of $5,546,854,626 in December 1998.

---


50 Based on notes by Prof. Andrew Lo’s 15.433 Investment Course, Class 17. (Spring 2000)
\[ R_{pt} = \text{Max}[R_{mt}, R_{ft}] \]

\[ W_t = (1 + R_{p1})(1 + R_{p2})...(1 + R_{pT})W_0 \]

Perfect foresight is of course impossible. However, a varying range of 'partial perfect foresight' is possible and is equivalent to a higher performing portfolio. The asset classes for the allocations of capital can be defined based on the Mutual Fund Separation theorem. These asset classes are typically stock, bond, real estate, or foreign exchange indices. We need to also specify goals, constraints, select 'optimal' asset mix based on investor utility, and monitor performance. Asset allocation can also be functionally classified as Strategic (Long-run policies), Tactical (Short-run predictions) and Insured (Portfolio insurance).

A method of asset allocation is by Dynamic Optimization. A discrete time utility model is not suitable. Rather a stochastic calculus model with continuous time is used:

\[ \text{Max}_E_0 \int_0^\infty e^{-\rho} U(C_t)dt \]
\[ \{C_t, \omega_t\} \]

\[ dP_t = \alpha \cdot P_t dt + \sigma \cdot P_t dZ_t \]
\[ dW_t = (\omega_t(\alpha - r) + r)W_t + C_t)dt + \omega_t\sigma Z_t \]
Assume constant Relative Risk Aversion:

\[ U(C_t) = \frac{C_t^\gamma - 1}{\gamma} \]

\[ \gamma < 1 \]

\[ RRA = 1 - \gamma \]

Optimal Policies:

\[ C_t^* = c_0 W_t \]

\[ \omega_t^* = -\frac{\alpha - r}{\sigma^2 (1 - \gamma)} \]

\[ dW_t^* = \mu W_t^* dt + \delta W_t^* dZ_t \]

\( \omega \) is the fraction of the total wealth invested in risky assets. This could be more than 100% of total wealth with leverage. Plotting out positions on the Capital Allocation Line (CAL) allows the accommodation of changing preferences, changing economic conditions (e.g. Business cycle, exchange rate, political, legal and model risks) and predictable components (e.g. Econometric models, market timing skills, multi-factor linear models, non-linear models, neural networks and chaos etc.).

While it is said that in an efficient market, firms should concentrate on their core competency and let the portfolio allocation be done by investors, there may be merit to the above concepts if the return on investments can be enhanced by more optimal allocation of capital. An example is the merger between AOL and Time Warner. The
potential benefits of such a 'portfolio' are the abilities to cross sell, save costs and expand services and products. Theoretically, the value of the combined firm should rise if the growth is maintained and the future cash flow increases.
Appendices

Appendix 1. Multiples used by practitioners to value Internet stocks

<table>
<thead>
<tr>
<th><strong>RATIO</strong></th>
<th><strong>DESCRIPTION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Capitalization/User</td>
<td>A reference for comparables and peers, an indicator of overall value per reach.</td>
</tr>
<tr>
<td>Market Capitalization/Page View</td>
<td>Indicates what a basic page view is valued at by investors.</td>
</tr>
<tr>
<td>Market Capitalization/Ad View</td>
<td>Page views generating revenue rather than sitting blank.</td>
</tr>
<tr>
<td>Private Market Value</td>
<td>What private deals go for either in merger or in bidding situation.</td>
</tr>
<tr>
<td>Customer Acquisition Cost</td>
<td>What it costs to gain a new subscriber or buyer; valuable in evaluating ISPs,etailers, auctioneers, wholesalers, manufacturers that sell on the Web.</td>
</tr>
<tr>
<td>Valuation/Customer Acquisition Cost</td>
<td>Useful when comparing peers to see which may be valued at a relative discount based on customer growth efficiencies.</td>
</tr>
<tr>
<td>EBITDA Cash flow Multiple</td>
<td>The way mature media companies are valued such as Time Warner, Disney or TCI.</td>
</tr>
<tr>
<td>Revenue per Subscriber</td>
<td>Primary way to value ISPs such as PSINet, Earthlink, Mindspring or AOL.</td>
</tr>
<tr>
<td>Lifetime Value of an e-Buyer</td>
<td>This is the metric we think will be key very soon in valuing Internet companies, especially Amazon.com, C&amp;lno, Egghead, ONSALE and eTailers.</td>
</tr>
<tr>
<td>Effective Deal Value</td>
<td>What a deal went for after factoring cash and debt or other considerations that affect the outcome of the offer.</td>
</tr>
<tr>
<td>Market Capitalization/POP</td>
<td>A ratio for comparing ISPs that have points of presence.</td>
</tr>
<tr>
<td>Market Capitalization or PMV to Potential Market Share</td>
<td>Helpful in determining future revenue, cash flow and earnings to see if the firm is under or overvalued to its potential.</td>
</tr>
<tr>
<td>Market Capitalization/Total Internet Users</td>
<td>The value of a firm’s reach globally per user.</td>
</tr>
<tr>
<td>Revenue / Direct e-Marketing</td>
<td>Shows yield of campaign efficiency, useful for direct sellers such as Xoom.com.</td>
</tr>
<tr>
<td>Market Capitalization/Websteader</td>
<td>Measures yield on community sites, how effective Websteads generate revenue for community firms.</td>
</tr>
<tr>
<td>Price/Discounted Earnings</td>
<td>Project earnings and discount back to current stock price; especially useful for firms with losses today; Netscape’s IPO was priced this way at 50x projected EPS two years ahead.</td>
</tr>
<tr>
<td>Sales/Employee</td>
<td>How lean and mean a company operates; 1 engineer to 10 lightbulbs or 10 engineers and 1 lightbulb.</td>
</tr>
<tr>
<td>Revenue/Bandwidth Cost</td>
<td>Useful to determine how effectively management deploys its bandwidth to generate revenue; applies to all Web firms but especially those involved in selling.</td>
</tr>
</tbody>
</table>

---

## Appendix 2. Market Valuation of Internet Stocks

<table>
<thead>
<tr>
<th>Company</th>
<th>Ticker</th>
<th>COV (% of Value)</th>
<th>GR (% of Value)</th>
<th>Implied Growth (g)</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>AXENT Technologies</td>
<td>AXNT</td>
<td>0.2</td>
<td>98.0</td>
<td>68.5</td>
<td>-31.7</td>
<td>-62.2</td>
<td>-86.4</td>
</tr>
<tr>
<td>Network-1 Security Solutions</td>
<td>NSSI</td>
<td>0.4</td>
<td>99.6</td>
<td>102.9</td>
<td>-39.2</td>
<td>-72.4</td>
<td>-93.4</td>
</tr>
<tr>
<td>Open Market</td>
<td>OMKT</td>
<td>4.0</td>
<td>96.0</td>
<td>56.5</td>
<td>-28.0</td>
<td>-56.4</td>
<td>-81.5</td>
</tr>
<tr>
<td>ISS Group Inc</td>
<td>ISSX</td>
<td>1.0</td>
<td>99.0</td>
<td>81.6</td>
<td>-35.0</td>
<td>-66.9</td>
<td>-89.9</td>
</tr>
<tr>
<td>Verisign</td>
<td>VRSN</td>
<td>0.7</td>
<td>99.3</td>
<td>90.3</td>
<td>-36.8</td>
<td>-69.4</td>
<td>-91.6</td>
</tr>
<tr>
<td>America Online Inc</td>
<td>AOL</td>
<td>1.8</td>
<td>98.2</td>
<td>71.0</td>
<td>-32.4</td>
<td>-63.2</td>
<td>-87.2</td>
</tr>
<tr>
<td>At Home</td>
<td>ATHM</td>
<td>0.1</td>
<td>99.9</td>
<td>146.3</td>
<td>-44.9</td>
<td>-79.0</td>
<td>-96.6</td>
</tr>
<tr>
<td>Concentric Network</td>
<td>CNCX</td>
<td>5.0</td>
<td>95.0</td>
<td>52.9</td>
<td>-26.7</td>
<td>-54.4</td>
<td>-79.5</td>
</tr>
<tr>
<td>EarthLink Network</td>
<td>ELNK</td>
<td>2.8</td>
<td>97.2</td>
<td>62.9</td>
<td>-30.0</td>
<td>-59.7</td>
<td>-84.4</td>
</tr>
<tr>
<td>Frontline Communication Corp</td>
<td>FCCN</td>
<td>0.7</td>
<td>99.3</td>
<td>89.1</td>
<td>-36.6</td>
<td>-69.1</td>
<td>-91.4</td>
</tr>
<tr>
<td>Infoseek</td>
<td>SEEK</td>
<td>1.8</td>
<td>98.2</td>
<td>70.8</td>
<td>-32.3</td>
<td>-63.1</td>
<td>-87.1</td>
</tr>
<tr>
<td>Theglobe.com</td>
<td>TGLQ</td>
<td>0.4</td>
<td>99.6</td>
<td>98.5</td>
<td>-38.4</td>
<td>-71.4</td>
<td>-92.9</td>
</tr>
<tr>
<td>Excite Inc</td>
<td>SCIT</td>
<td>1.0</td>
<td>99.0</td>
<td>82.3</td>
<td>-35.1</td>
<td>-67.1</td>
<td>-90.1</td>
</tr>
<tr>
<td>Yahoo!</td>
<td>YHOO</td>
<td>0.2</td>
<td>99.8</td>
<td>113.7</td>
<td>-40.9</td>
<td>-74.4</td>
<td>-94.5</td>
</tr>
<tr>
<td>Lycos</td>
<td>LCOS</td>
<td>0.6</td>
<td>99.4</td>
<td>90.9</td>
<td>-37.0</td>
<td>-69.6</td>
<td>-91.7</td>
</tr>
<tr>
<td>Preview Travel</td>
<td>PTVL</td>
<td>2.3</td>
<td>97.7</td>
<td>66.4</td>
<td>-31.1</td>
<td>-61.2</td>
<td>-85.7</td>
</tr>
<tr>
<td>Amazon.com</td>
<td>AMZN</td>
<td>1.0</td>
<td>99.0</td>
<td>81.9</td>
<td>-35.1</td>
<td>-67.0</td>
<td>-90.0</td>
</tr>
<tr>
<td>Beyond.com</td>
<td>BYND</td>
<td>1.8</td>
<td>98.2</td>
<td>71.2</td>
<td>-32.4</td>
<td>-63.2</td>
<td>-87.3</td>
</tr>
<tr>
<td>CD Now</td>
<td>CDNW</td>
<td>4.3</td>
<td>95.7</td>
<td>55.5</td>
<td>-27.6</td>
<td>-55.9</td>
<td>-81.0</td>
</tr>
<tr>
<td>Egghead.com</td>
<td>EGGS</td>
<td>10.3</td>
<td>89.7</td>
<td>40.6</td>
<td>-21.8</td>
<td>-45.9</td>
<td>-70.7</td>
</tr>
</tbody>
</table>

**Average**

- $r = 20\%$: 2.1, 97.9, 79.7, -33.6, -64.6, -87.6
- $r = 15\%$: 2.8, 97.2, 68.8
- $r = 25\%$: 1.7, 98.3, 89.9

---

Appendix 3. Key parameters of the Model\textsuperscript{53}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Proposed Estimation Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Revenue</td>
<td>$R_0$ Observable from the current quarterly income statement</td>
</tr>
<tr>
<td>Initial loss-carry forward</td>
<td>$L_0$ Observable from the current quarterly balance sheet</td>
</tr>
<tr>
<td>Initial cash balance available</td>
<td>$X_0$ Observable from the current quarterly balance sheet</td>
</tr>
<tr>
<td>Initial volatility of expected rates of growth</td>
<td>$\mu_0$ From the last 2 quarterly income statement and projections of future growth</td>
</tr>
<tr>
<td>Initial volatility of revenues</td>
<td>$\sigma_0$ Standard deviation of percentage change in revenues over the recent past</td>
</tr>
<tr>
<td>Initial volatility of expected rates of growth</td>
<td>$\eta_0$ Standard deviation of change in the rate of growth in revenues over the recent past</td>
</tr>
<tr>
<td>Correlation between changes in revenue (%) and change in expected rate of growth</td>
<td>$\rho$ Estimated from quarterly data available over the recent past or form similar firms</td>
</tr>
<tr>
<td>Long-term rate of growth in revenues</td>
<td>$\overline{\mu}$ Quarterly rate of growth in revenues for a stable firm in the same industry as the firm</td>
</tr>
<tr>
<td>Long-term volatility of the rate of growth</td>
<td>$\sigma$ Quarterly volatility of percentage change in revenues for a stable firm in the same industry as the firm</td>
</tr>
<tr>
<td>Corporate tax rate for the firm</td>
<td>$\tau_c$ Observable from tax code</td>
</tr>
<tr>
<td>Risk free interest rate</td>
<td>$r$ One year Treasury-bill rate</td>
</tr>
<tr>
<td>Speed of adjustment for the rate of growth process</td>
<td>$k$ Estimated from the assumption about the 'half-life' of the process to the long-term rate of growth in revenues</td>
</tr>
<tr>
<td>Speed of adjustment for the volatility of revenue process</td>
<td>$k_1$ Estimated from the assumption about the 'half-life' of the process to the long-term volatility of the rate of growth in revenues</td>
</tr>
<tr>
<td>Speed of adjustment for the volatility of the rate of growth process</td>
<td>$k_2$ Estimated from the assumption about the 'half-life' of the process to zero</td>
</tr>
<tr>
<td>Cost of goods sold as a percentage of revenues</td>
<td>$\alpha$ Estimated from the quarterly data available and predictions about the future</td>
</tr>
<tr>
<td>Fixed component of other expenses</td>
<td>$F$ Estimated from the quarterly data available and projection of future activities</td>
</tr>
<tr>
<td>Variable component of other expenses</td>
<td>$\beta$ Estimated from the quarterly data available and projection of future activities</td>
</tr>
<tr>
<td>Market price of risk for the revenue factor</td>
<td>$\lambda_1$ Obtained from the product of the correlation between % changes in revenues and return on aggregate wealth, and the standard deviation of aggregate wealth</td>
</tr>
<tr>
<td>Market price of risk for the expected rate of growth in revenue factor</td>
<td>$\lambda_2$ Obtained from the product of the correlation between changes in growth rates in revenues and return on aggregate wealth, and the standard deviation of aggregate wealth</td>
</tr>
<tr>
<td>Horizon for the estimation</td>
<td>$T$ An arbitrary long-term horizon at which the firm is deemed to become a 'normal' firm</td>
</tr>
<tr>
<td>Time increment for the discrete version of the model</td>
<td>$\Delta t$ Chosen according to the data availability, which is usually quarterly.</td>
</tr>
</tbody>
</table>

\textsuperscript{53} Schwartz, E.S., M. Moon. (1999) "Rational Pricing of Internet Companies." Anderson School UCLA and Fuller & Thaler Asset Management.
Appendix 4. Parameter Used in the Base Valuation of Amazon

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Revenue</td>
<td>$R_0$ $314$ mil/quarter</td>
</tr>
<tr>
<td>Initial loss-carry forward</td>
<td>$L_0$ $361$ mil</td>
</tr>
<tr>
<td>Initial cash balance available</td>
<td>$X_0$ $1142$ mil</td>
</tr>
<tr>
<td>Initial volatility of expected rates of growth of revenues</td>
<td>$\mu_0$ 0.11 per quarter</td>
</tr>
<tr>
<td>Initial volatility of revenues</td>
<td>$\sigma_0$ 0.10 per quarter</td>
</tr>
<tr>
<td>Initial volatility of expected rates of growth in revenues</td>
<td>$\eta_0$ 0.07 per quarter</td>
</tr>
<tr>
<td>Correlation between changes in revenue (%) and change in expected rate of growth</td>
<td>$\rho$ 0.0</td>
</tr>
<tr>
<td>Long-term rate of growth in revenues</td>
<td>$\bar{\mu}$ 0.015 per quarter</td>
</tr>
<tr>
<td>Long-term volatility of the rate of growth of revenues</td>
<td>$\bar{\sigma}$ 0.05 per quarter</td>
</tr>
<tr>
<td>Corporate tax rate for the firm</td>
<td>$\tau_c$ 0.32</td>
</tr>
<tr>
<td>Risk free interest rate</td>
<td>$r$ 0.05</td>
</tr>
<tr>
<td>Speed of adjustment for the rate of growth process</td>
<td>$k$ 0.07 per quarter</td>
</tr>
<tr>
<td>Speed of adjustment for the volatility of revenue process</td>
<td>$k_1$ 0.07 per quarter</td>
</tr>
<tr>
<td>Speed of adjustment for the volatility of the rate of growth process</td>
<td>$k_2$ 0.07 per quarter</td>
</tr>
<tr>
<td>Cost of goods sold as a percentage of revenues</td>
<td>$\alpha$ 0.75</td>
</tr>
<tr>
<td>Fixed component of other expenses</td>
<td>$F$ $50$ mil per quarter</td>
</tr>
<tr>
<td>Variable component of other expenses</td>
<td>$\beta$ 0.22</td>
</tr>
<tr>
<td>Market price of risk for the revenue factor</td>
<td>$\lambda_1$ 0.01 per quarter</td>
</tr>
<tr>
<td>Market price of risk for the expected rate of growth in revenue factor</td>
<td>$\lambda_2$ 0.0 per quarter</td>
</tr>
<tr>
<td>Horizon for the estimation</td>
<td>$T$ 25 years</td>
</tr>
<tr>
<td>Time increment for the discrete version of the model</td>
<td>$\Delta t$ 1 quarter</td>
</tr>
</tbody>
</table>

54 Schwartz, E.S., M. Moon. (1999) "Rational Pricing of Internet Companies." Anderson School UCLA and Fuller & Thaler Asset Management.
Appendix 5. Sensitivity of Firm Value to Different Parameters

<table>
<thead>
<tr>
<th>Valuation</th>
<th>Perturbed Parameter</th>
<th>Total Firm Value (Million Dollars)</th>
<th>Standard Deviation</th>
<th>Probability of Bankruptcy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Valuation</td>
<td></td>
<td>21,038</td>
<td>949</td>
<td></td>
</tr>
<tr>
<td>$\mu_0$</td>
<td>0.121 per quarter</td>
<td>24,734</td>
<td>1115</td>
<td>40.6</td>
</tr>
<tr>
<td>$\sigma_0$</td>
<td>0.11 per quarter</td>
<td>20,948</td>
<td>945</td>
<td>43.6</td>
</tr>
<tr>
<td>$\eta_0$</td>
<td>0.077 per quarter</td>
<td>40,038</td>
<td>2575</td>
<td>44.0</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.01</td>
<td>21,221</td>
<td>956</td>
<td>43.4</td>
</tr>
<tr>
<td>$\bar{\mu}$</td>
<td>0.0165 per quarter</td>
<td>23,046</td>
<td>1043</td>
<td>42.6</td>
</tr>
<tr>
<td>$\bar{\sigma}$</td>
<td>0.055 per quarter</td>
<td>20,950</td>
<td>945</td>
<td>43.6</td>
</tr>
<tr>
<td>$k$</td>
<td>0.077 per quarter</td>
<td>11,278</td>
<td>367</td>
<td>44.5</td>
</tr>
<tr>
<td>$k_1$</td>
<td>0.077 per quarter</td>
<td>21,057</td>
<td>949</td>
<td>43.3</td>
</tr>
<tr>
<td>$k_2$</td>
<td>0.077 per quarter</td>
<td>15,895</td>
<td>620</td>
<td>42.9</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.76</td>
<td>13,946</td>
<td>633</td>
<td>51.6</td>
</tr>
<tr>
<td>$F$</td>
<td>$55$mil per quarter</td>
<td>20,984</td>
<td>949</td>
<td>46.7</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.23</td>
<td>13,946</td>
<td>633</td>
<td>51.6</td>
</tr>
<tr>
<td>$\lambda_1$</td>
<td>0.011 per quarter</td>
<td>20,945</td>
<td>945</td>
<td>43.4</td>
</tr>
<tr>
<td>$\lambda_2$</td>
<td>0.001 per quarter</td>
<td>20,766</td>
<td>937</td>
<td>43.5</td>
</tr>
<tr>
<td>$T$</td>
<td>26 years</td>
<td>21,987</td>
<td>1850</td>
<td>43.5</td>
</tr>
</tbody>
</table>

### Appendix 6. Gefei Tire Company

<table>
<thead>
<tr>
<th></th>
<th>Q3</th>
<th>Q4</th>
<th>Year 2</th>
<th>Q3</th>
<th>Q4</th>
<th>Year 3</th>
<th>Q3</th>
<th>Q4</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Japan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average sales per manufacturer</td>
<td>15,000,000</td>
<td>15,000,000</td>
<td>15,000,000</td>
<td>15,000,000</td>
<td>88,000,000</td>
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<td>2</td>
<td>3</td>
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<td>30%</td>
<td>30%</td>
<td>30%</td>
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<td>30%</td>
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<td><strong>Total quarterly revenue</strong></td>
<td>125,000.00</td>
<td>380,000.00</td>
<td>380,000.00</td>
<td>507,500.00</td>
<td>537,500.00</td>
<td>866,500.00</td>
<td>954,000.00</td>
<td>986,500.00</td>
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<tr>
<td>Total annual revenue</td>
<td>125,000.00</td>
<td>380,000.00</td>
<td>380,000.00</td>
<td>507,500.00</td>
<td>537,500.00</td>
<td>866,500.00</td>
<td>954,000.00</td>
<td>986,500.00</td>
<td>1,513,750.00</td>
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<td>13</td>
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Appendix 7. Gefei Tire Company Cash Flow Statement

For the financial years ending 2000 - 2003

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<th>2000</th>
<th>%</th>
<th>2001</th>
<th>%</th>
<th>2002</th>
<th>%</th>
<th>2003</th>
<th>%</th>
<th>2004</th>
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<td></td>
<td>USD</td>
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<td>USD</td>
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<td>USD</td>
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<td>USD</td>
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<tr>
<td></td>
<td>112,500</td>
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<td>5,327,100</td>
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</tr>
<tr>
<td>R&amp;D, Technical support, content mgmt</td>
<td>(1,000,000)</td>
<td>889%</td>
<td>(2,000,000)</td>
<td>123%</td>
<td>(2,500,000)</td>
<td>73%</td>
<td>(3,000,000)</td>
<td>56%</td>
<td>(1,000,000)</td>
<td>29%</td>
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<tr>
<td>Sales and marketing</td>
<td>(250,000)</td>
<td>222%</td>
<td>(2,000,000)</td>
<td>123%</td>
<td>(2,500,000)</td>
<td>73%</td>
<td>(2,500,000)</td>
<td>47%</td>
<td>(250,000)</td>
<td>7%</td>
</tr>
<tr>
<td>General and Administration</td>
<td>(30,000)</td>
<td>27%</td>
<td>(120,000)</td>
<td>7%</td>
<td>(300,000)</td>
<td>9%</td>
<td>(500,000)</td>
<td>9%</td>
<td>(30,000)</td>
<td>1%</td>
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<td>(117,000)</td>
<td>7%</td>
<td>(131,000)</td>
<td>4%</td>
<td>(139,000)</td>
<td>3%</td>
<td>-</td>
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<td>Depreciation</td>
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<td>(200,000)</td>
<td>12%</td>
<td>(200,000)</td>
<td>6%</td>
<td>(200,000)</td>
<td>4%</td>
<td>(49,999)</td>
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<tr>
<td></td>
<td>(1,383,000)</td>
<td>1238%</td>
<td>(4,237,000)</td>
<td>261%</td>
<td>(5,431,000)</td>
<td>159%</td>
<td>(6,139,000)</td>
<td>115%</td>
<td>(1,329,999)</td>
<td>39%</td>
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<tr>
<td>Net (Loss)/Profit</td>
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<td></td>
<td>(1,280,500)</td>
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<td>(2,612,500)</td>
<td>161%</td>
<td>(2,016,850)</td>
<td>-59%</td>
<td>(811,900)</td>
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<td>Perpetuity (2004)</td>
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<td>Adjusted PV</td>
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Assumptions
A) Net revenue
Revenue share percentage
90%

Assuming on % of transaction volume, other revenue streams such as subscriptions, market intelligence, marketing etc not included

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<th>Year</th>
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<th>Nontional value of Transaction (USD)</th>
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Appendix 8. Real Options Valuation

Event Tree

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<th>d</th>
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<td>e</td>
<td>585</td>
<td>h</td>
<td>965</td>
<td>f</td>
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<td>i</td>
<td>355</td>
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<td>131</td>
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</table>

Combination of Simple Options
1. Maintain operations
2. Expand: American call, to expand revenue scale by 30%, cost $1mil.
3. Abandon: American put, salvage value (expertise and assets use in other departments) = $300k

At each node of the decision tree contains all 3 possible options.
Assume all 3 options are mutually exclusive, and exercising them does not make the tree path dependent

Decision Tree

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<tr>
<td>B</td>
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<td>B 1.00</td>
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<td>Max 965</td>
<td>Max 1,591</td>
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