Applications of ROA to Value a Dotcom Start-up and a Professional Basketball Player

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Wenqing Huang
Abstract

This paper attempts to evaluate a dotcom start-up company and a professional young basketball player using Real Option Analysis in the investors’ points of view. That is, we are standing in the financers’ shoes and valuing both cases if they are worth investing in. We believe that real option analysis is the most appropriate valuation method from our current knowledge compared to other traditional valuation methods notably like the Net Present Value (NPV), therefore we try to prove that using both qualitative and quantitative descriptions. The authors concentrate more on applying quantitative methods than giving detailed definitions of real options. Binomial Pricing Model and Monte Carlo simulation with the help of MS Excel and MATLAB were used in the evaluation. The paper consists of two case studies, each tackled differently but both summarized up all together. The paper concludes with a table exhibiting when real options are valuable and a belief that game theory is essential in ROA.

Key Words: Real Options, Project, Uncertainty and Flexibility, Traditional DCF or NPV Methods, Volatility, Present Value of Underlying Assets, Monte Carlo Simulation, Binomial Tree Model, Venture Business and Capitalist, Internet Start-up, Jeremy Lin
Acknowledgements

We would like to express our gratitude to Associate Professor Christos Papahristodoulou for the great guidance he rendered to us through his comments and thoughts. Not only did he help us in this thesis, he also gave us a good foundation through his lectures. A special appreciation to the other lecturers in the economic department of Mälardalen University, their lectures have been of great help in the realization of this thesis as well.
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1. Introduction

1.1. Problem Formulation

To invest or not is a puzzle reflected on by worldwide business investors on a daily basis. They are repeatedly in the dilemma of resolving whether to invest in developing a brand new product, introducing an updated technology, testing a new drug, or even sponsoring a sportsman, to name just a few cases (Prasad and Papudesu 2006). Owing to the ever-changing economic and competitive landscape, even seemingly bad ideas may turn out to be the next success story. With an eye to the opportunity of handsome investment returns, the money lost on bad ideas is unavoidable in not letting value stocks slip away.

As a rule, the traditional Discounted Cash Flow (DCF or NPV) approach, the Price Earning Ratio (PER) approach, or Internal Rate of Return (IRR), to value the business to be invested in, are available. Although discounted cash flow analysis accounts for the market uncertainty with a risk-adjusted discount rate, it often assumes a fixed path and gives managers a false sense of security. From a financer’s point of view, more importantly, a succession of latent options embedded in the investment opportunities (the option to expand, the option to abandon, and the option to defer the investment and so forth) are unfortunately overlooked by these traditional valuation methods like the discounted cash flow method. According to many researchers, this managerial flexibility in decision-making creates value to investments. This is mainly due to the uncertainties in the market and the new knowledge managers have learned in the process.

In recent years, Real Options Analysis (ROA) is increasingly arousing interest from the people involved, and has become a hot issue in the study of business valuation. By virtue of this approach, the value of uncertainty and flexibility of businesses can be highlighted and handled properly. Just as Cossin et al. indicates, to assess information technology businesses in their initial stages or venture businesses is a great challenge for traditional capital investment appraisal techniques and thus is likely to be one of the best candidates for real option. Other candidates are natural-resource investments (oil and gas), plus research and developments (R&D) in pharmaceuticals. As we can see, the above examples are obviously big companies with a huge amount of money put at stake. Meanwhile, we argue that the current professional sports market
can be one of the great users of real option as well.

This brings us to the problems of this paper: How is the ROA approach applied in an Internet startup venture business? Can ROA value a player? How are uncertainty or volatility and the expected values quantified? To what extent is the ROA approach superior to the DCF approach? Which factors are closely correlated with the option value for these two cases?

1.2. **Aim of the Thesis**

This paper aims to present the application of ROA in the venture business of an Internet startup and in professional sports world, by applying fundamental option pricing models to evaluate irreversible investments characterized by high uncertainty and flexibility.

1.3. **A Short Review of the Literature on the Topic**

1.3.1 Origin of Real Option

Despite of the fact that business managers have been making capital investment decisions for centuries, the term Real option is relatively young and was proposed by Professor Stewart Myers of the MIT Sloan School of Management in 1977. As a discipline, real options generally range from their application in corporate finance to decision making under uncertainty, adapting the techniques grown from financial options to "real-life" decisions. (Wikipedia.com 2012)

Before the introduction on real options, there were traditional valuation models like the discounted cash flow model, payback method and internal rate of return. Discounted cash flow model being the most preferred of the other models seemed ideal until the introduction of real option model, mostly termed ROA, the most favorable traditional method by then is seen to have shortcomings now. Take notice that this does not necessarily mean that the traditional method is no longer used. Real option incorporates these shortcomings and therefore is considered as the accurate method in projects with high uncertainties and risks.
1.3.2 Definition of Real Options

Real options are an extension of financial options in the financial market. A financial option is a call or a put option an investor can buy or sell on the underlying assets. Whichever option the investor buys, the option only gives him a right, not an obligation, to buy or to sell the underlying assets, thus leaving him with “freedom” of choice. The price and time at which the investor exercises his option is predetermined (Dixit and Pindyck 1995). In real options, the underlying asset is real and not marketed. The options are embedded in strategies, tactics and decisions. Real options exist if for example a firm has a right to take a decision at one or more stages in future, decisions like to invest or not to invest, to sell out or not to sell out. Due to consistently changing market conditions, each decision stage values differently and this enables the firm to make better decisions on which option to exercise (Mun 2002). The other difference between financial and real options is that the holder of a real option can influence the value of the underlying asset while the financial option holder cannot. Real option approach offers different types of options, the most commonly used are option to expand, option to defer or delay, option to switch and option to abandon. The names used to describe the options are self-explanatory.

Dynamic complexity is a focus of real options to find value of the complex factors that determine the value of the investment and cash flows. These factors help decisions to be made at any time over a period. However, a question stands: in what kind of situation should you use real options? Walters & Giles classify real options as proprietary or shared, simple or compounded (options on options) and options that expire or the ones that can be deferred. A given example of proprietary, simple, expiring options is routine maintenance of capital equipment and the shared, compounded, deferrable option is entering a new geographic market. In any case you use the option, the less your real option looks like a financial instrument, the harder it is to value, adds Walter and Giles.
1.3.3 Similarities between Financial Options and Real Options (Brach 2002)

Like we mentioned above, Real options derive from financial options, and there are striking similarities between them.

Table 1: Analogies: Financial Options—Real Options

<table>
<thead>
<tr>
<th>Financial Option</th>
<th>Variable</th>
<th>Investment Project &amp; Real Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise or Strike price</td>
<td>(K)</td>
<td>Costs to acquire the asset</td>
</tr>
<tr>
<td>Current Stock price</td>
<td>(S)</td>
<td>Present value of future cash flows from the asset</td>
</tr>
<tr>
<td>Time to expiration</td>
<td>(T)</td>
<td>Length of time investment opportunity is valid</td>
</tr>
<tr>
<td>Volatility of stock price</td>
<td>(\sigma)</td>
<td>Fluctuation of anticipant cash flow</td>
</tr>
<tr>
<td>Risk-free rate of interest</td>
<td>(R_f)</td>
<td>Risk-free rate of return</td>
</tr>
</tbody>
</table>

In terms of financial options, the value of the call option \(C\) is the difference between current value of the asset acquired by exercising the option and the exercise costs \(K\) at maturity. A call option is in the money if \(S-K>0\), at the money if \(S-K=0\), and out of the money if \(S-K<0\). Equation 1 exhibits the mathematical formula for the value of a call (\(C\)).

\[ C = \text{Max} \ [0, S - K] \quad (1) \]

The key value to invest is achieved when the exercise price \(K\) of the option approaches the asset value \(S\) at the time of exercise. For a call option, if the asset value \(S\) goes down below \(K\), the option owner would rather not exercise. Likewise, there is a critical cost to invest for real options. It indicates the threshold, or maximum amount of money, beyond which investment should be abandoned. Given the working assumptions on future payoffs, any further commitment of resources would drive the option out of the money. The expected payoff and volatility relevant to the project play dominant roles in the investment decision. The expected return is denoted by the net payoff from that project, normally in today's currency as a present value, and the volatility is the uncertainty with that payoff (Prasad and Papudesu 2006).
1.3.4 Why Are Real Options Important?

The ROA considers multiple decision routes since there is high uncertainty coupled with management’s flexibility in adapting the optimal strategies or options along the way when new information becomes available. The management can make strategy corrections along the way when there is uncertainty in the future as new information is gathered and uncertainty resolved, therefore is able to implement the best strategies. The traditional discounted cash flow approach only assumes a single decision route with fixed outcomes and all decisions made in the beginning without a possibility of making changes and developments over time. Proceed as you began in other words. In simple terms, real options assumes a multidimensional dynamic series of future decisions where management has the flexibility to adapt given changes in the business environment, while traditional approaches assume a static decision–making ability (Mun 2002).

Real options offer decision – makers an opportunity to learn. Firstly, it allows them for an initial phase where they get to observe the cash flows on the first and comparatively small try at the project. Bad outcomes in the first phase will indicate that the overall project is more likely to bring losses than profits. Secondly, decision - makers act on the learning by abandoning the project if the outcome is negative. In other words, decision – makers learn from observing what happens in the real world and adapt the behavior to increase the potential upside of the investment and decrease its possible downside (Damodaran 2002). For instance, given a chance to invest $10 in a project, the payoff is expected to be between $6 and $16 with an average of $11. The DCF without the uncertainty finds the net present value of the investment at or less than $10. This return does not meet the satisfaction and the decision will be not to invest. However, what if a starting tiny investment of $1 will help clear the uncertainty and give an option to invest fully $9 later as long as the return is favorable otherwise abandon it (Prasad and Papudesu 2006)?

Real options emphasize strategic opportunism. It compels managers to compare every supplementary opportunity arising from the existing investment with the full range of opportunities that open to them in the course of time. (Mun 2002)

1.3.5 Why Real Options Are Not Widely Used?

Despite of the opportunities and the flexibility real options offer to management, not all the
companies embrace the real option approach in their decision making. Adding to that, there has been a growing support for the approach in the academia, to mention a few authors; Smith and Trigeorgis (1993, 2005), Copeland and Antikarov (2001), Paxon (2003), Schwartz (2002) and Howell et al. (2001). With this support, one would expect real options to be broadly used in companies characterized by high levels of R&D, marketing investments and manufacturing but this is not the case.

According to a survey conducted in 2000 by Bain & Co. of 451 senior executives across more than 30 countries examining their use of 25 management tools, only 9 percent used real options. This ranked next to last on the list. The survey showed that in 2000, 32 percent of the real option appliers abandoned the technique (Teach 2003).

Teach continues to say that the 2003 survey Bain conducted, real option valuation was not included. He adds that discouraging news came from a 2002 survey by Colorado state University professor Patricia A. Ryan who found Real options trailing a field of 13 “supplementary” capital–budgeting tools. Out of 205 Fortune 1,000 CFOs, Ryan found that only 11.4 percent used ROA, compared to 85.1 percent for sensitivity analysis and 66.8 percent for scenario analysis. The survey found net NPV to be the top “basic” capital-budgeting tool by 96 percent (Teach 2003; Stanley 2007).

The reasons to why real options were less used according to the survey were: a) the approach lacked support from the management: Some managers were hesitant to embrace a methodology they cannot follow up at each step. Since real option, approach offers systematic decision-making and since the methods used are mathematical, mathematicians and decision scientists did much of the work. This made executive managers feel less participating, and that their jobs were being taken away from them. b) Discounted cash flow was a preferred method and was seen to be a proven method. c) The third reason for not using ROA was that it tends to promote excessive risk-taking (Teach 2003; Stanley 2007). The CFOs believe that real options overestimate the value of uncertain projects, which encourages companies to over-invest in them. Real options strongest link (incorporation of uncertainties) seemed to be its weakest link at the same time to some executives (Stanley 2007).
1.3. The Limitations

Following our intention of using ROA as a valuation method, we are more interested to find out why ROA is the appropriate method by drawing up its advantages than giving a detailed definition of it and the types of the options that exist. We are also bearing in mind pitfalls of ROA, as we have mentioned above, ROA is still not a preferable method despite its advantages. According to Teach (2003), recent evidence suggests that the ROA valuation techniques may be losing traction. Therefore, some limitations will be made accordingly.

For the limitation of our paper, when critical model inputs are estimated, data difficulties come up. The present value of the underlying assets in real option cannot straightly be observed, and meanwhile uncertainty of its present value and volatility incorporated by managerial strategy abound. In the paper, the volatility and the risk-free interest rate are assumed to be simply constant over time. It is also assumed that exercise costs remain fixed in present value during the option life. The probabilities of binary tree model are determined under the assumption of risk neutral pricing.

In the first case study, due to the confidentiality agreements signed within the venture capital market, it is rather unlikely to have an access to real data, and renders it necessary to make use of a fictive case regarding the evaluation of an Internet startup. The growth rates of the company of interest presumably follow normal distribution. In addition, there is no dividend payout and taxes.

In the second example, for classical real options, the underlying asset tends to make no decisions. Here the player is assumed to be dominated by the team and the sponsors and could possess limited freedom. We center on a team option according to National Basketball Association (NBA) in America, where a team has a right to call on the option. In addition, due to the lockout in the beginning of NBA 2011-12 Season, the data for the players is somewhat less adequate than last few years. A typically completed NBA season between the October and the June consists of preseason, 82-games regular season, and playoffs. The details of contract between the player and the team or the sponsors are not revealed to the public thoroughly, which makes it hard to capture the entirely consequent steps the holders are about to take. Unlike corporations, it seems
that the present value of players could scarcely be expressed fully in monetary units. The efficiency is instead used to evaluate a basketball player’s game performance. For financial options, the strike price has been determined much earlier the expiration date. The strike price of an option contract does not vary since every stock has a wide range of options trading with different strike prices. For a player to buy, unless there is a tight contract signed before, it is determined rather late and is not always a parameter, but a positive function of the present value of the underlying assets (S). If “the market” values the player high, he is going to cost high (high K). In that case, neither the binomial tree pricing model nor Black-Scholes model is valid any more.

1.4. The Methodology

In finance, a number of methodologies and approaches are accessible to evaluate a real option’s value. These range from employing closed-form equations like the Black-Scholes model and its modifications, Monte Carlo path dependent simulation methods, binomial and multinomial trees, partial-differential equations and other numerical techniques. However, the mainstream methods are the closed-form solutions, partial-differential equations, and the binomial lattice trees.¹

Monte Carlo simulation is one of the methodologies used in real options to value an option. The simulation is carried out in steps; Firstly, the expected payoffs from the underlying asset are calculated using a sampling procedure, then the payoff are discounted back to the risk–free rate of interest and finally, the average of all the discounted payoffs is calculated which is equal to the value of the project or investment. Secondly, a sensitivity analysis is carried out on each variable, by changing the value of the variables recursively and noting the changes they have on the net present value respectively. The sensitivity analysis gives you knowledge on which variables are highly uncertain and deterministic in future. The more simulations carried out, the more accurate are the results (Damodaran 2002).

The binomial options pricing model (BOPM), which initialized by Cox, Ross and Rubinstein in

¹ See more: Mun, J. (2002), Real Option Analysis - Tools and Techniques for Valuing Strategic Investments and Decisions, Wiley ,chapter 6,p139-168
1979, provides a generalized numerical method for the valuation of options. Essentially, whereas a Brownian motion stochastic process is a continuous simulation, the model uses a discrete-time lattice based model of the varying price over time of the underlying financial instrument. The model assumes that the price can go either up or down with certain respective probabilities in each period.

Closed-form solutions are models such as the Black-Scholes model, which can be solved under a set of input assumptions. They are accurate, quick and easy to implement with the aid of some basic programming knowledge but are difficult to explain because they tend to apply highly technical stochastic calculus mathematics. In addition, they have limited modeling flexibility and are very specific in nature. By contrast, binomial lattices are easy to implement and explain. They are also highly flexible but require significant computing power and time-steps to obtain good approximations (Mun 2002). Besides, the more the number of the subintervals divided per year in the BOPM is, the closer the result of the BOPM is to that of the Black-Scholes model.

The authors have relied on secondary data. Relevant journals, books and websites have been used. By investigating the literature, authors tried to be acquainted with relevant factors to help them in their analysis. Time was put on doing simulations and sensitivity analysis with Excel and MATLAB software. The aim was to quantify the parameters as accurate as possible. Most of the articles were found using Google scholar, Google search and through older thesis. Sometimes when relevant articles were found they led the authors to other articles that were useful which gave us more information at hand.

II. Cases Analysis

**Case 1: Real Option with Dot-com Start-up Business** (Anett and Ahnefeld 2002; Wang 2006)

Today’s financial market offers a variety of instruments for corporate financing. Besides the ability to take advantage of internal sources such as earnings, reserves, depreciation or corporate restructuring, most companies use such external finance as debt, private equity or venture capital. By comparison, against mature businesses, venture businesses refer to enterprises in its infancy.
Typically, many such businesses can scarcely thrive without the support of venture capital. In order to earn the aid of venture capital, the venture investors must confirm the investment value.

Venture capitalists dealing with seed and start-up companies on their daily basis make their assessment of the value of a venture business either by intuition or with the aid of quantitative methods. To make wise investment decisions, the latter is increasingly preferred by venture investors. The qualitative judgment may be valid, but the question is what next? How should large corporate investment decisions with high levels of uncertainty be identified, valued, selected, justified, optimized, timed, and managed such that when a decision is made and the investment becomes irreversible (Brach 2002)?

2.1.1. Background
In this section, we will study the case of Amigos Company\(^2\), an enterprise that was founded with the support of venture capital at the end of 2011 in Beijing. It is an Internet business that provides services like online social networking and micro-blogging that enables its users to send and read text-based posts of up to 120 characters. At that time, the company had developed its service, and launched in December 2011.

The company’s latest strategic objective is to attain 2% market share in 2012. In addition, the main revenue comes from the advertisements and online games. To start with, Amigos was seeking a partner that provides relevant technology, consultation and integrated services to get leverage support for its services. In order to make the company run, the company must find an appropriate venture investment period for the financiers. Finally, the company decided to select the venture investors, because they are able to offer capital needed at the follow-up financing stage in the next two years and, with their social networks, assistance with locating partners and important clients for the company.

At the first stage, in order to secure the enough start-up financing, Amigos was looking for venture investors. According to the business plan, Amigos Company would claim two more rounds of investment, i.e. the second round at the beginning of 2013 and the third at the

\(^2\) Note that Amigos Company does not exist in the real world.
beginning of 2014. The company negotiated with the venture investors concerning the start-up investment problem. The financiers analyzed the investment opportunity and found it acceptable to invest. They had one week to decide whether to invest in this business. During that week, the investment opportunity would be reserved for the related investors. If an investor gave up this opportunity, he was not allowed to participate in the next round investment. If merely one single investor made investment in the company at its foundation period, he would become the exclusive investor at the follow-up investment stages. To put it in another way, unless there was more than one investor, his share at the early stage would by no means be diluted at the later financing rounds. As required in the business plan, the total of investment capital should be ¥240million. The investment costs are required to be ¥75 million (call premium) at the first round, ¥99 million at the second round and ¥66 million at the third round.

2.1.2. Real Options Scenario Analysis

Real options analysis is carried out from the standpoint of venture investors with the overview of venture businesses considered, instead of a specific equity stake owned by a venture capitalist.

Suppose venture investors decided to invest in the Amigos at the launch stage, they have to consider whether to continue the investment or not once more when the second round investment at the start of 2013 is coming. Obviously, the capitalists will make their decisions based on the company’s value, while this value depends on the future development of the company. If the company develops as expected, the venture investors will hold on their investment; otherwise if the company does not promise a positive future, they can get rid of the investment and suffer from little loss.

The same case holds for the third financing round. After these three rounds of investment, Amigos Company will not demand financing assistance any more. If the business model turned out to be successful, the company would come to the full operation phase and then probably make positive profit. This will boost the rise in the company’s value, and its value can be finally realized with the venture investors withdrawing successfully (e.g., by way of IPO or trade sale). Figure 1 depicts the overall situation of the investment opportunities.

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3 1 Yuan≈1.14SEK  （Forex Bank，April 25, 2012）
To put it in technical terms of option theory terminology, the investment made at the beginning in Amigos Company can be seen as a purchase of two-stage compound call options (indicated by option A). Different investment stages have different options, and options at the second and third stages are indicated by option B and option C respectively. It is not allowed to jump in from the second or the third round without involvement in the previous rounds.

2.1.3. Choosing the Option Pricing Model

Amigos Company acts as the sequential compound call options, which are compounded by other call options, and all these are European options since they can merely be exercised at the maturity date. The binomial tree pricing model is preferred in this particular instance. On one hand, this model can offer more flexibility and the calculation of option value is much more apparent and simpler to accommodate jumps together with leakage, even though the Black-Scholes pricing model might be applied to price these options. On the other hand, this model gives a lively illustration of investment decision-making under updated circumstance. When the number of periods in a year of options is divided by quarters instead of by one whole year, the accuracy error of the binary tree model can lessen. With the aid of sensitivity analysis, the impact of input parameters on option value can be quantified significantly.

2.1.4. Parameters Estimation

After selecting the option pricing model, it is necessary to determine the input parameters to be used in the model. To start with, the estimation of volatility \( \sigma \), measured as the standard deviation of the natural logarithm of cash flow returns in the real options models, is a little trickier because there is no historical information on the Amigos Company. Instead, the average
annual standard deviation of the returns on publicly traded Internet corporations can be considered as proxy. Table 2 below displays 8 Chinese listed Internet corporations in American stocks market. These leading companies in China specialize in diverse fields so that have different volatilities except those two online game developers. Accordingly, the volatility of Renren Incorporation, the social networking service provider, shall be the proxy. The current implied volatility of Renren is 80.8% for 20 days. Thus, the volatility should be converted into 345.178% of the annualized one using $\sigma^* \sqrt{T} = (80.8\% \times \frac{\sqrt{365}}{20})$, where T is the number of periods in a year. Because the Amigos is a new venture to compete in the market, the risk here would be somewhat greater (350%).

Table 2: Descriptions and Volatilities of 8 Chinese Listed Internet Corporations in US Stocks

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QIHOO 360 TECHNOLOGY CO LTD(QIHU)</td>
<td>Internet security products provider</td>
</tr>
<tr>
<td>RENNEN INC (RENN)</td>
<td>Social networking web similar to Facebook</td>
</tr>
<tr>
<td>YOUKU INC(YOKU)</td>
<td>Internet television</td>
</tr>
<tr>
<td>DANGDANG INC(DANG)</td>
<td>Business-to-consumer e-commerce company</td>
</tr>
<tr>
<td>SINA CORP(SINA)</td>
<td>Online media and Chinese communities</td>
</tr>
<tr>
<td>SOHU COM INC(SOHU)</td>
<td>A search engine company</td>
</tr>
<tr>
<td>CHANGYOU COM LTD(CYOU)</td>
<td>Developer and operator of online games</td>
</tr>
<tr>
<td>SHANDA GAMES LTD(GAME)</td>
<td>Online game developer, operator and publisher</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symbol of Company</th>
<th>Implied Volatility (%)</th>
<th>Historical Volatility(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>current</td>
<td>2-day Change</td>
</tr>
<tr>
<td>QIHU</td>
<td>98.7</td>
<td>-4.51</td>
</tr>
<tr>
<td>RENN</td>
<td>80.8</td>
<td>0.12</td>
</tr>
<tr>
<td>YOKU</td>
<td>71</td>
<td>-0.08</td>
</tr>
<tr>
<td>DANG</td>
<td>70.47</td>
<td>-5.14</td>
</tr>
<tr>
<td>SINA</td>
<td>67.69</td>
<td>1.28</td>
</tr>
<tr>
<td>SOHU</td>
<td>54.5</td>
<td>1.48</td>
</tr>
<tr>
<td>CYOU</td>
<td>45.7</td>
<td>2.84</td>
</tr>
<tr>
<td>GAME</td>
<td>43.86</td>
<td>0.18</td>
</tr>
</tbody>
</table>

The one-year risk free saving interest rate in China is used as the estimate of the annual interest rate ($r$). The 3.5% of annual interest rate is equivalent to the 0.88% of quarterly compounding one.
The current asset value \( S \) is the present value of the business itself, excluding the up-front investment cost, which is usually prepared for standard capital budgeting analysis. The asset value is estimated from the cash flows created over the investment phase, and is forecast based on the market share. Even if a lot of noise or uncertainty in this estimate exists, this should not be seen as a barrier, but rather is as the reason for performing the option pricing analysis at the beginning.

To predict the company value each year, the Monte Carlo simulation, a method to generate samples of random variables, will be utilized. The idea is to let Excel draw randomly value for the annual growth rates and evaluate the corresponding present values. Suppose that the growth rate \( g \) is a normally distributed random variable with a 50% of mean \( \mu \) and an 350% of standard deviation \( \sigma \) identical to the volatility stated previously, that is \( g \sim N(0.5,3.5) \). Consider a standard normal variable \( Z \sim N(0,1) \), then the cumulative normal probability distribution \( F(z) = P(Z \leq z) = n(0 < n < 1) \), which in turn \( z = F^{-1}(n) \). If the underlying random variable \( X \) is \( N(\mu, \sigma) \), it is calculated by \( X = \mu + \sigma Z \). In this way, the growth rate is denoted by \( g = \mu + \sigma \times \text{NORMSINV(RAND())} \) in Excel. In addition, the first year cash flow is assumed to be ¥100m. To make the estimated present value of the underlying asset to be as accurate as possible, 40,000 simulations are completed. Thus, the expected value of present value \( S \) is ¥432,132 million. (Farber 2005)

Figure 2: Outcomes of the Present Value of Amigos for 40,000 Iterations (million Yuan (¥))

\[
PV = \frac{\text{Cash Flow}, Y_1}{1 + r} + \frac{\text{Cash Flow}, Y_2 \times (1 + g_1)}{(1 + r)^2} + \frac{\text{Cash Flow}, Y_3 \times (1 + g_2)}{(1 + r)^3}, \text{where } g_1 \text{ and } g_2 \text{ are usually unequal.}
\]
On top of those parameters, the exercise price of the option (K) is the investment cost for the option. In the real options world, exercising an option takes a long time, while exercising financial options is in an instant. It is assumed that these costs remain fixed in present value during the option life. The investment costs are required to be ¥75 million (call premium) at the first round, ¥99 million at the second round and ¥66 million at the third round.

Finally yet importantly, although the above parameters capture a number of aspects of the real world, it has one shortage. The realism increases with the number of intervals (Δt), because the restriction of only two possible outcomes is more plausible over a short interval than over a long one. Thus, the value of the call when the number of subintervals is 4 or even infinity is likely to be more realistic than this value when the number of intervals is one or two.

2.1.5. Options Computation

In this case, the input parameters required in the option pricing process are shown in Table 3.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Calculated Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Annual risk free rate, R_f</td>
<td>3.50%</td>
</tr>
<tr>
<td>2. Present value of the underlying, S_0</td>
<td>432.13</td>
</tr>
<tr>
<td>3. Life of the options (year), T</td>
<td>2</td>
</tr>
<tr>
<td>4. Annualized standard deviation, σ</td>
<td>350%</td>
</tr>
<tr>
<td>5. Number of subintervals per year, n</td>
<td>4</td>
</tr>
<tr>
<td>6. Exercise price, K1, Call (million Yuan)</td>
<td>75</td>
</tr>
<tr>
<td>7. K2, Call</td>
<td>99</td>
</tr>
<tr>
<td>8. K3, Call</td>
<td>66</td>
</tr>
</tbody>
</table>

The rest of the parameters are calculated as follows:

Coefficient for upward increase (u) = $e^{\frac{R_f \Delta t}{\Delta t}} = e^{\frac{3.5\% \times 2}{1}} = 5.755$

Coefficient for downward reduction (d) = $\frac{1}{u} = 0.174$

Determine the upward risk-neutral probabilities: $p = \frac{e^{R_f \Delta t} - d}{u - d} = 0.15$
The step length of an up movement \((u)\) is calculated to be 5.755, implying that the down movement \((d)\) is 0.174. The probability of a rise and fall here are 15\% and 85\% respectively. These probabilities are dependent of the assumption of risk neutral pricing. That is to say, under the risk neutrality, the expected return on any asset would be identical to the risk-free interest rate. None would desire for an expected return beyond this riskless rate, because risk-neutral individuals do not bother to be compensated for risk suffered.

Now there are sufficient data to evaluate this compound option. The calculation starts with the construction of the event tree. Beginning from the first subinterval, the event tree can be constructed. That is, to create a binomial lattice, multiply the present value of the underlying asset \((S_0)\) by the up \((u)\) and down factors \((d)\). Based on the event tree, option values at the final nodes are determined with equation (1) and discounted backward. Then the values of options C, B and A are calculated in sequence. In this case, additional options B and A have to be considered at time 2012Q4 and at the beginning \((T=0)\) respectively. Figure 3 below shows calculations done in Excel.

Reading from fig. 3, the net payoff of ¥340.330m represents the final value of the real options. Within this analysis, it can be realized that in several nodes options should by no means be exercised. The calculated option value \((C)\) of ¥340.330m represents the investment value of Amigos, with the total costs \((K)\) of ¥240m for three rounds.

### 2.1.6. Numerical Comparison between DCF and ROA

The company value generated from the DCF analysis is ¥192.132m at the beginning of 2012, which is ¥148.198m lower than the value of the real option analysis.

In order to value start-up companies, the applied model can be used other than other valuation techniques, such as DCF or multiplies. They are not able to value the flexibility of the investment decisions, which depend significantly on the development of the company and the environmental changes within this industry. In this case, the value of the company evaluated with the ROA approach yields higher by 77.13\% than that obtained with the DCF approach.
Figure 3: Binomial Tree Model

<table>
<thead>
<tr>
<th>Event Tree</th>
<th>2012 Q1</th>
<th>2012 Q2</th>
<th>2012 Q3</th>
<th>2013 Q4</th>
<th>2013 Q1</th>
<th>2013 Q2</th>
<th>2013 Q3</th>
<th>2013 Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>432.132</td>
<td>2486.748</td>
<td>14310.246</td>
<td>473890.280</td>
<td>272050.274</td>
<td>15693090.802</td>
<td>90307500.322</td>
<td>519683794.525</td>
</tr>
<tr>
<td></td>
<td>75.099</td>
<td>432.132</td>
<td>2486.748</td>
<td>14310.246</td>
<td>473890.280</td>
<td>272050.274</td>
<td>15693090.802</td>
<td>90307500.322</td>
</tr>
<tr>
<td></td>
<td>13.049</td>
<td>75.099</td>
<td>432.132</td>
<td>2486.748</td>
<td>14310.246</td>
<td>473890.280</td>
<td>272050.274</td>
<td>15693090.802</td>
</tr>
<tr>
<td></td>
<td>2.268</td>
<td>13.049</td>
<td>75.099</td>
<td>432.132</td>
<td>2486.748</td>
<td>14310.246</td>
<td>473890.280</td>
<td>272050.274</td>
</tr>
<tr>
<td></td>
<td>0.394</td>
<td>2.268</td>
<td>13.049</td>
<td>75.099</td>
<td>432.132</td>
<td>2486.748</td>
<td>14310.246</td>
<td>473890.280</td>
</tr>
<tr>
<td></td>
<td>0.068</td>
<td>0.394</td>
<td>2.268</td>
<td>13.049</td>
<td>75.099</td>
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<td>13.049</td>
<td>75.099</td>
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<td>2486.748</td>
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<tr>
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<td>0.002</td>
<td>0.012</td>
<td>0.394</td>
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<td>75.099</td>
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</tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 4: DCF Analysis

Discounted company value until 2014 (PV): ¥432.132m

Discounted investment costs each year:
- ¥75m
- ¥99m
- ¥66m

Value of investment based on DCF or NPV: ¥192.132m

2.1.7. Sensitivity Analysis and Break Even Analysis

After analysis in the Excel, it is founded that the final option value of the underlying asset is positively correlated with three parameters (present value of the assets, riskless interest rate and volatility), but negatively correlated with those three exercise costs. Besides, the present value of
the company, ceteris paribus, is found to be primary factor in reality that drives this investment out of money, at the threshold of approximately ¥85.49m compared with ¥240m with DCF.

Case 2: Real Option with Professional Sportsmen

2.2.1. The Story of Lin-derella (Wikipedia 2012)

Jeremy Shu-How Lin, an American professional basketball player with the New York Knicks of the National Basketball Association (NBA), has become an overnight legend in the sports world. He is called Lin-derella, like the Cinderella in the fairy tales. Not only did he rocket meteorically to sports stardom, but also influenced company stocks substantially, through either direct or indirect endorsements.

In fact, before joining the Knicks early in the 2011–12 NBA season, Lin, as an undrafted player, seldom played in his rookie season and was waived by Golden State Warriors and the Houston Rockets in a row. Even before the early February 2012, he was signed by New York Knicks only with an non-guaranteed one year contract of minimum salary of $613,000 prorated for the shorten reason and was generally considered to be the one competing for a backup spot as the 12th to 15th player on the roster. However, since the Feb 4th, Lin seized the chance and became a starter for the Knicks to help the team lead serials of turnaround performances. It is what happens when there is unscripted drama. His great popularity and success is regarded as the most amazing story in the NBA.

2.2.2. The Economical Influences of Lin-dex

To define how 'Lin-sanity' has affected companies, Minyanville Media invented a Jeremy Lin-dex which is made up of a basket of stocks created to keep track of the ongoing success of Jeremy Lin. Every stock in the index was equally-weighted so that no one stock has priority over another. Strikingly, as of February 15th, the Lin-dex exceeded by 2.5% the S&P 500 - a market-cap weighted basket of large cap stocks. (Western Libraries 2012)

Here is what the Lin-dex includes (Rohrlich 2012):

1. The Madison Square Garden Company (MSG), which hosts the Knicks' home games and
whose shares have risen 9.2% from Feb. 5-10

2. Nike (NKE), which signed Lin to a three-year contract in 2010

3. Adidas (ADDYY.PK), which makes replica No. 17 Lin jerseys sold hotly on NBA.com

4. Dick's Sporting Goods (DKS), which sells Nike & Lin apparel

5. Berkshire Hathaway (BRK-A), which owns Spalding that makes the official NBA basketball

   J-Lin uses

6. Disney (DIS), which owns both ESPN and ABC, the dominant channels that air NBA games

7. Verizon (VZ), which carries the Knicks's games in Hi-Def

8. Ethan Allan (ETH), as Lin has slept on a sofa-bed

When it comes to the question if Lin lives up to such reputation, there is no apparently correct
answer to that because he is an unknown who has done what none has ever done. Even so, an
intuitive assessment is made by looking at what we know and what do not know about him yet.

With 1.91m, 90.7kg and 23 years old, Lin is strong agile and vigorous enough to handle himself
against most NBA point guards at both ends of the court. He played national college basketball
league for the Harvard University from 2006 to 2010 after a successful high school career in
California. That implies that he is definitely smart, motivated enough, and capable of making
good decisions on the court and following his coach’s tactics.

Despite of the fact that Lin did not strike the right people in NBA as impressive and that he was
unable to earn a role with the Golden State Warriors as a rookie and with the Houston Rockets in
December of 2011, he was given minutes at the point when the coach was trying to find someone
to lead the team out of desperation for the Knicks. Furthermore, he was historically brilliant as
the starter, hitting more points than anybody in the NBA did in his first four starts. As an Asian
American player, he has also brought about worldwide frenzy and interest especially in America
as well as East Asia and is considered to be the world's fastest-rising athlete brand.

However, we are not sure about Lin if he is just fortunate. A number of players have turned hot
for one or two weeks into the one that had never been heard of any longer. From the knowledge
about him, he can play well in particular once he can have consistent connections with
teammates. The second doubt is that if he could maintain this tempo. He is unlikely to take too
much shoots any more when his new coach finds a way to constraint the production of the player who is not among the elite level yet. Meanwhile, injuries often could slow him down. In this case, one thing that could be almost for sure is that his trade value will not be higher than now, so trade him quickly before his value depreciates.

Let alone the external factors, if the team is unsure if he should be held or dealt, gauge the place in the standings and the statistical demands of the team. How much risk is required to be taken to strike a fruitful deal? More importantly, how much is another team owner willing to pay for Lin? Trading or acquiring Lin is optimally done through a multiplayer deal. In this way, risk involved for both teams is diversified away among two or three players. (Carpenter 2012)

2.2.3. Scenario Analysis

This scenario analysis is performed from the standpoint of team owners and sponsors, with the overview of opportunity considered. Figure below displays the overall situation of the opportunities in the professional sports industry.

**Figure 5: Options in the Professional Sports World for Teams or Sponsors**

At the first stage, players are looking for teams and endorsements in order to earn their bread and butter. The players take part in numerous games to attract the attention of scouts and then are invited to attend training sessions. The team or sponsors, like Nike or Adidas, analyze their potential and have some time to decide whether to sign and endorse one of them or more. During that period, the opportunity would be reserved for the team and sponsors of interest.

If merely one single player was selected, he would become the exclusive player at the follow-up stages. Suppose the team decides to offer him a short run contract at the launch stage and the
contract is about to expire, the team has to consider whether to continue to offer or not. As required in the regulation of sports league, the contract should be no shorter than at least the end of this season. Obviously, the team will make decisions based on player’s performance and popularity. If the player developed as expected, the team will hold on their investment; otherwise get rid of the contract. The same case holds for the sponsors. Suppose the player becomes superstar, they would take advantage of his appeal and give more publicity to him. If the model turned out to be successful, the company would come to make huge profit and enhance the market value.

From the perspective of the real option analysis, coupled with the American type call option, the teams in NBA or other sport leagues have the right to offer the partly guaranteed contract at the beginning and then provide a long term contract if the player does do outstanding jobs, otherwise waives him in the middle of the regular season. The team manager would rather turn to look for another option in the same way afterwards until he finds the one who has desirable chemistry with the team. To reach the contract with the young players, like Jeremy Lin, for the teams and corporations is an extraordinary uncertain and risky venture business, since it is well acknowledged that the chance for a sportsman to be a superstar is rather slim in the contemporary era.

2.2.4. The Statistical Performance and Volatility of Linsanity

First, we can explore how volatile his performance has been on the court. Normally, for a professional basketball point guard, given the more minutes played each game, the more points are scored the more rebounds are grabbed and the more assists are delivered while the more turnovers are inevitably committed and the more shots are missed. Thus, the efficiency can evaluate his overall performance fairly. As we can see from the table 4 below, the efficiency of Jeremy Lin climbed abruptly to the peak on the February of 2012.
The formula is officially denoted as the equation 2;

\[ \text{Efficiency}^5 = \text{Points} + \text{Rebounds}^6 + \text{Assists}^7 + \text{Steals}^8 + \text{Blocks}^9 - (\text{Field Goals Attempted} - \text{Field Goals Made}) - (\text{Free Throws Attempted} - \text{Free Throws Made}) - \text{Turnovers}^{12, 13} \]  

(2)

Since Lin is just a sophomore now and he missed all the rest of games starting from March 24 of 2012 because of the knee surgery, the stats are somehow inadequate. However, we can still focus on his 2011-2012 regular season performance to look at how volatile he is. In finance and economics, the growth rate of cash flows, or stock prices, can be derived by the equation, such as

\[ g = \ln\left(\frac{S_1}{S_0}\right) \]

for the continuous time case. Then the standard deviation of these rates will result in their volatility \( \sigma \). By analogy, here the growth rate of Lin’s efficiency, in New York, approaches 97.6% between the January and February, and -32.88% from the February to March afterwards. It can be concluded that his volatility is 92.26% for these three months. From the perspective of his NBA career with 3 different teams, his average efficiency in Houston was worse than that in Golden State by nearly 20.58%, on the condition that he played 29 games for Golden State while only 2 games for Houston in the preseason before he was waived. However, in New York, he has been outperforming by 124.27% compared against that in the Houston. Therefore, the volatility reached 102.43% throughout these two years with three teams.

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5 http://www.nba.com/statistics/efficiency.html
6 A rebound refers to the act of successfully gaining possession of the ball after a missed shoot.
7 An assist is attributed to a player who passed the ball to a teammate in a way that leads to score.
8 A steal takes place when a defensive player legally regains the ball by his aggressive action.
9 A block occurs when a defensive player legally deflects a shoot from an offensive player.
10 Filed goals is a basket scored on any shots other than free throw, worth 2 or 3 points dependent of the distance of the attempt from the basket.
11 Free throws are undefended attempts to score one point from the free throw line after being fouled.
12 A turnover happens when a player loses possession to the opponent.
13 For more basketball terminologies, visit http://en.wikipedia.org
<table>
<thead>
<tr>
<th></th>
<th>GP</th>
<th>MPG</th>
<th>EFF</th>
<th>EFF48M</th>
<th>Pts/Reb/Asts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preseason</td>
<td>2</td>
<td>4</td>
<td>3.5</td>
<td>29.12</td>
<td>4</td>
</tr>
<tr>
<td>Dec.</td>
<td>3</td>
<td>2.3</td>
<td>0</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>Jan.</td>
<td>5</td>
<td>8.2</td>
<td>7.8</td>
<td>45.81</td>
<td>10</td>
</tr>
<tr>
<td>Feb.</td>
<td>14</td>
<td>35.1</td>
<td>20.7</td>
<td>28.32</td>
<td>33.3</td>
</tr>
<tr>
<td>Mar.</td>
<td>13</td>
<td>31</td>
<td>14.9</td>
<td>23.22</td>
<td>24.2</td>
</tr>
<tr>
<td>2011-2012</td>
<td>35</td>
<td>26.9</td>
<td>15.2</td>
<td>26.75</td>
<td>23.8</td>
</tr>
<tr>
<td>2010-2011</td>
<td>29</td>
<td>9.8</td>
<td>4.3</td>
<td>21.26</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Notes: 1. GP: Games played; MPG: Minutes Per Game; EFF: Efficiency; EFF48M: Efficiency within 48 minutes; Pts/Reb/Asts: Points, Rebounds and Assists per game; 2. First row: when Lin played for Houston Rockets on the December of 2011; 3. From 2nd to 5th rows: regular season of 2011-12 in New York Knicks; 4. The last row: he played for the Golden State Warriors in 2010-11 Season; 5. He missed all the rest games from the 1st April of 2012 because of injury.

Let us look at one current top NBA player, LeBron James, who is playing for the Miami Heat and is considered to be the most efficient player over the last 10 years. For his last 8 seasons, the growth rate of the efficiency fluctuates slightly, thus the volatility amounts to 10.76% only. And through this season this figure accounts for 12.51% which is much lower than 92.26% of Lin.

<table>
<thead>
<tr>
<th></th>
<th>GP</th>
<th>MPG</th>
<th>EFF</th>
<th>EFF48M</th>
<th>Pts/Reb/Asts</th>
<th>Growth rate of EFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preseason</td>
<td>2</td>
<td>28</td>
<td>20</td>
<td>34.1</td>
<td>28</td>
<td>66.27%</td>
</tr>
<tr>
<td>Dec.</td>
<td>4</td>
<td>37</td>
<td>38.8</td>
<td>50.17</td>
<td>47.5</td>
<td>-24.73%</td>
</tr>
<tr>
<td>Jan.</td>
<td>16</td>
<td>37.5</td>
<td>30.3</td>
<td>38.79</td>
<td>43.7</td>
<td>-3.02%</td>
</tr>
<tr>
<td>Feb.</td>
<td>13</td>
<td>35.6</td>
<td>29.4</td>
<td>39.47</td>
<td>38.9</td>
<td>-3.11%</td>
</tr>
<tr>
<td>Mar.</td>
<td>16</td>
<td>39.8</td>
<td>28.5</td>
<td>34.38</td>
<td>39.4</td>
<td>-12.48%</td>
</tr>
<tr>
<td>2004-2005</td>
<td>80</td>
<td>42.4</td>
<td>28.2</td>
<td>41.7</td>
<td></td>
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<tr>
<td>2005-2006</td>
<td>79</td>
<td>43.9</td>
<td>29.4</td>
<td>33.19</td>
<td>45</td>
<td>4.17%</td>
</tr>
<tr>
<td>2006-2007</td>
<td>78</td>
<td>40.9</td>
<td>25.6</td>
<td>30.05</td>
<td>40.1</td>
<td>-13.84%</td>
</tr>
<tr>
<td>2007-2008</td>
<td>75</td>
<td>40.4</td>
<td>30.3</td>
<td>36.08</td>
<td>45.1</td>
<td>16.86%</td>
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<tr>
<td>2008-2009</td>
<td>81</td>
<td>37.7</td>
<td>30.9</td>
<td>39.31</td>
<td>43.3</td>
<td>1.96%</td>
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<td>2009-2010</td>
<td>76</td>
<td>39.1</td>
<td>32.4</td>
<td>39.88</td>
<td>45.6</td>
<td>4.74%</td>
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<tr>
<td>2010-2011</td>
<td>79</td>
<td>38.8</td>
<td>28.6</td>
<td>35.39</td>
<td>41.2</td>
<td>-12.48%</td>
</tr>
<tr>
<td>2011-2012</td>
<td>49</td>
<td>37.7</td>
<td>30.1</td>
<td>38.36</td>
<td>41.3</td>
<td>5.11%</td>
</tr>
</tbody>
</table>

Notes: 1. Data from 2002-2004 are not included. 2. Before 2010-2011 NBA seasons, he played for Cleveland.
Whether it is a blessing or curse for the team to have such a volatile player as Jeremy Lin is hard to answer. In the short run, he can at least be of help to motivate the teammates feeling an intense competition, so as to push up the competitiveness of the whole team. That is so called ‘catfish effect’ in the human resource management. Besides, more positive externalities can be discovered in the previous section.

2.2.5. Valuation of Jeremy Lin

To estimate the present value of a player is supposed to be much trickier than that of a corporation. To simplify, assume that the PV of a player for the team depends on his weighted contribution to team’s value, and his contribution is directly observed by his efficiency per games, then the formula 3 is artificially constructed.

A player’s weighted contribution to the team (%) = 

\[
\frac{\text{Number of Games Played} \times \text{Average Efficiency of the Player}}{\text{Total Number of Games} \times \text{Average Efficiency of the Team When the Player Played}}
\]

According to Forbes prediction by the January of 2012, the value of New York Knicks in 2012 in sport sector reaches $131 million, excluding the segments, like brand stadium and market. Suppose that this value is attributable to all the team players on the court instead of managerial staffs, the monetary contribution each player makes to the team personally is expressed as the product of weighted contribution and the value of the team in sport sector. Therefore the present value \(S_0\) of Jeremy Lin this regular season in New York is \[\frac{35 \times 15.2}{66} \times$131m = $9.733m\] almost when he played 35 (Number of subintervals per year, n) games out of the total 66 games in the regular season and contributed individually 15.2 of efficiency on average over 108.5 of the team when he served, as showed table 6.

<table>
<thead>
<tr>
<th></th>
<th>Pts</th>
<th>Reb</th>
<th>Asts</th>
<th>Stl</th>
<th>Blk</th>
<th>FG Att. (Made)</th>
<th>FT Att. (Made)</th>
<th>Turnovers</th>
<th>EFF.</th>
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</thead>
<tbody>
<tr>
<td>Knicks</td>
<td>98.7</td>
<td>42.2</td>
<td>20.9</td>
<td>9.7</td>
<td>4.5</td>
<td>80.9 (36.2)</td>
<td>26.5 (19.6)</td>
<td>15.9</td>
<td>108.5</td>
</tr>
<tr>
<td>Lin</td>
<td>14.6</td>
<td>3.1</td>
<td>6.2</td>
<td>1.6</td>
<td>0.3</td>
<td>10.9 (4.9)</td>
<td>5.2 (4.2)</td>
<td>3.6</td>
<td>15.2</td>
</tr>
</tbody>
</table>
As calculated previously, the volatility (\( \sigma \)) of a professional player is represented by his efficiency volatility. The annualized volatility of Lin is 1.8452, multiplying his quarterly volatility (0.9226) by square root of 4. The length of his contract (T) is assumed to be as long as six months and the strike price, namely his salary, is $0.613m as promised in the contract.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Calculated Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual risk free rate, ( r_f )</td>
<td>3.50%</td>
</tr>
<tr>
<td>Current value of the underlying, ( S_0 )</td>
<td>$9.733m</td>
</tr>
<tr>
<td>Maturity time of the options, ( t )</td>
<td>0.5 year</td>
</tr>
<tr>
<td>Annual standard deviation</td>
<td>1.8452</td>
</tr>
<tr>
<td>Number of subintervals per year, ( n )</td>
<td>35</td>
</tr>
<tr>
<td>Exercise price, ( K ), call</td>
<td>$0.613m</td>
</tr>
<tr>
<td>Length of subinterval, ( \Delta t )</td>
<td>0.029</td>
</tr>
<tr>
<td>Up movement per step, ( u )</td>
<td>1.366</td>
</tr>
<tr>
<td>Down movement per step, ( d )</td>
<td>0.732</td>
</tr>
<tr>
<td>Risk neutral prob.(up), ( p )</td>
<td>0.424</td>
</tr>
<tr>
<td>Risk neutral prob.(down),( 1 - p )</td>
<td>0.576</td>
</tr>
</tbody>
</table>

Table 7: Estimation of Parameters for Jeremy Lin

After all estimations of those parameters(Table 7), binomial tree pricing model should be readily used to evaluate the payoff of Jeremy Lin’s American call option (C) for the New York Knicks, whereas the B-S model is valid only for the European options. The calculation begins with the build-up of the event tree. Starting from the first subinterval, the event tree can be constructed. A binomial lattice is the product of the present value of the underlying asset (\( S_0 \)) and the up (\( u \)) and down factors (\( d \)). Based on the event tree, option values at the final nodes are determined with equation (1) and discounted backward. Eventually, the value of the option is computed. The final net payoff is approximately $9,228,300 calculated via MATLAB (see Appendix). However, with the traditional DCF, the result is nearly $9,120,000 (=\$9.733m-$0.613m) and therefore less by $108,300(1.19%). This means that the team can enjoy higher payoff form such an uncertain player through ROA, while by intuition two methods are quite likely to make less difference in valuing those stable players, like LeBron James.

To be more specific, New York Knicks and those eight companies are undoubtedly the luckiest venture capitalists who bought the ‘Lin’ call option, expanded it further with quite low strike price, benefited from his high volatility and thus enjoyed financial returns beyond precise measurements. On the contrary, the Golden State Warriors and the Houston Rockets are financiers who did abandon this option and therefore failed to gain from the incredibly potential payoff of Lin’s option with both excellent team records and huge economics revenue such as tickets selling and TV transmission fee. The reason for these two teams probably because they
took too much Lin's past and current achievement into consideration while underestimated his future development, just as simply discount his future growth with his historical rate ignoring the volatility. Alternatively, although they might evaluate him by ROA, hardly did they predict that his volatility could be so high.

As a whole, this is a win-win game for Lin himself and New York Knicks as well as the 8 companies. Next season, his salary is predicted to be no less than $5 million\(^\text{14}\) by virtue of his sky high market value. Either New York or other teams will bid for this real option again.

2.2.6. Sensitivity Analysis

Although the correlations between the call option value and those four model parameters are already explored as the first case, other objective X factors in this case could also exert some effects on the payoff of call option.

The first common one is the injury. It usually takes some time for injured player to recover their athletic level, and this could bring about adverse effects on his contribution to the team and thus his payoff for the team.

The second X factor is the age. As the players, like LeBron James, grow older, higher salary often is offered, particularly from around 27 to 32-year-old, than their early years while their average efficiency tend to be less volatile. Thus, either the volatility or the option value is negatively affected by the age for that reason. Their accumulated experience would be intangibly invaluable to the team though.

The third factor may be the importance of game played. One who is able to control the tough game against the favorite or hit the big shot, should deserve higher value than against the underdogs. For the Jeremy Lin, his turning points are those games in the middle of February when he beat the buzzer winning shot against the Toronto Raptors and led the team to win over two championship teams like Los Angle Lakes, and Dallas Mavericks. All of these games give much credit to him and appreciate his value. Additionally, the contribution of home games are

\(^\text{14}\) According to the regulations of NBA, the salary cap of the third year players is $5 million.
usually attached more value than that of road games for players in an effort to win the support of the home audiences.

Ultimately, it is worth noting that a player with high efficiency unnecessarily means high payoff (C) for the team monetarily. Instead, it tends to lead to high strike price (K) for the team and thus low call option value (C), since those star players demand higher wages to serve the team.

III. Results and Conclusions

The purpose of this paper has been to employ and test the application of real option analysis in the venture investments of the dotcom start-up together with the professional basketball player. To carry out the computation of their values, multiple parameters have been estimated in different manners. According to the analysis of both cases, either the risky Internet business or some professional young sportsmen can be preferably valued with the help of ROA, while neither ROA nor NPV makes difference for the business and players with low volatility or considerable certainty. Figure 6 illustrates when real options are valuable (Prasad and Papudesu 2006).

![Figure 6: Correlations among Managerial Flexibility, Uncertainty and Option Values](image)

<table>
<thead>
<tr>
<th>Managerial Flexibility</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>V3</td>
<td>V1</td>
</tr>
<tr>
<td>V4</td>
<td>V2</td>
</tr>
</tbody>
</table>

Note: \( V(n) \) is denoted as the option value and \( V4 > V3 > V2 > V1 \approx 0 \)

From the procedures of real options analysis, the value of uncertainty with respect to the underlying asset, as well as managerial flexibility to stay in a favorable path, has been acknowledged. For the Internet business, two primary drivers of the uncertainty are market variability and technology novelty. More exactly, no one is certain regarding the service demands of the Internet users and the arrival of superior technologies. Speaking of the
professional players, such X factors as age and injury are always sources of the uncertainty. As a result, these outcomes are comparatively rational.

Admittedly, there are limitations if the financial option pricing is adapted literally to price real options. What is more, it should be realized that in determining the required input parameters, this approach also makes use of traditional valuation models. Thus, the selected approach is built on conventional static valuation models, but provides the advantage of evaluating flexibility and uncertainty in the decision-making process as well.

Nevertheless, the assessment of investment including interactions among several investors typically necessitates the adjustment of game theory. For instance, a number of teams may compete with each other to sign one excellent player. Therefore, it is indispensable to couple ROA with game theory in our future study.
IV. References

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Electronic Sources


<http://en.wikipedia.org/wiki/Real_options_valuation>

<http://en.wikipedia.org/wiki/Jeremy_Lin>
function value = BinomialTree(putcall,exerciseType,S0,K,sigma,r,T,n)
% This function calculates the American or European option value by a binomial tree model.
% Input: putcall: indicates the option type
% putcall = 'Call' for a call option
% putcall = 'Put' for a put option
% exerciseType: European ('E') or American ('A') exercise type
% S0: Stock price
% K: Strike price
% sigma: Volatility
% r: Risk-free rate
% T: Time to maturity
% n: Number of steps in the tree
% OUTPUT: value: option value
% EXAMPLE:value=BinomialTree('call','A',9733000,613000,1.8452,0.35,0.5,35)
% Parameters for binomial tree
dt = T/n;
u = exp(sigma*sqrt(dt));
d = 1/u;
p = (exp((r)*dt)-d)/(u-d);
q = 1-p;
disc = exp(-r*dt);
% Initialize matrices
stockM = zeros(n+1,n+1);
optionM = zeros(n+1,n+1);
% Create stock tree
stockM(1,1) = S0;
for j = 2:n+1
for i = 1:j-1
stockM(i,j) = stockM(i,j-1)*u;
end
stockM(i+1,j) = stockM(i,j-1)*d;
end
switch putcall
% Set z parameter to calculate the option payoff depending on the selected option type (Call, Put)
case 'call'
z = 1;
case 'put'
z = -1;
otherwise

Source: Adapted from Axel K,(2011),Quantitative Security Analysis, Solution Exercise Set 3:Binomial-tree Option Pricing, University of Basel
error('Check option type!');
end
optionM(:,end) = max(z*(stockM(:,end)-K),0); % Insert terminal values

% Value call by working backward from time n-1 to time 0
switch exerciseType
    case 'E'  % European option
        for j=n:-1:1;
            for i=j:-1:1;
                optionM(i,j) = disc*(p*optionM(i,j+1)+q*optionM(i+1,j+1));
            end
        end
    case 'A' % American option
        for j=n:-1:1;
            for i=j:-1:1;
                optionM(i,j) = max(z*(stockM(i,j)-K),disc*(p*optionM(i,j+1)+q*optionM(i+1,j+1)));
            end
        end
    otherwise
        error('Check exercise type!');
    end
value = optionM(1,1);