Aligning Software Development Investment Decisions with the Markets

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ABSTRACT

Risk, or exposure to uncertainty, is an inherent part of software development. Therefore, risk is an important factor in making investment decisions about software development. This position paper illustrates a disciplined approach to treating risk, an approach that allows software development decisions to be aligned with the capital markets. We start from the premise that uncertainty creates value when managed properly. Then we show using a *real options* approach that if the markets contain traded assets whose values depend on the source of uncertainty to which the investment is subject, we can estimate the resulting risk, and then use this estimate to determine the value of the investment. The approach is applied to a familiar software development scenario involving technology risk, namely that of Java.

Keywords

Software development, decision-making, real options, uncertainty, investment analysis, economic valuation, risk, Java

1 INTRODUCTION

Software development is a highly uncertain activity. Large-scale software projects are notorious for completing with outrageous schedule and cost overruns, or not completing at all. And even when they are on schedule and within budget, failure in the market is not that uncommon. This situation can be attributed partly to corporate culture and to the effectiveness of the decision-making tools. It is possible that the current effort and cost estimation methods simply are not robust enough. It is also possible that champions consistently paint an overly optimistic picture in an attempt to have their projects approved by management. However, other, more fundamental, forces are in play here as well.

Private Risk

First, as with any technology-based investment, *private risk* is a fact of live. In a software project, private risk may be largely due to technical uncertainty that is project specific. But it may also stem from, for example, the interplay among an organization's skill set, knowledge base, development processes, management practices, compensation model, and information infrastructure. This kind of risk can theoretically be eliminated, at least by the investors. However, in practice, this is impossible to achieve by the management. Private risk gives rise to schedule uncertainty and affects the odds of failure. Since cost of labor dominates software development, schedule uncertainty inevitably gives rise to cost uncertainty.

Market Risk

The other, and more interesting, side of the medallion is the markets. Even with negligible private risk, a software development venture can fail. The market may turn out to be immature for the product. A competitor may have moved in to seize a good chunk of the market. The markets may have assigned a low value to the standard or technology on which the product is based. These examples constitute *market risk* – risk that will be decided and priced by factors external to the organization, essentially by the markets. This kind of risk can be managed to an extent, but not eliminated, neither by the investors nor by the management.

In this position paper, we will take a closer risk at market risk in the context of software development. Can we quantify it? Can we estimate it using publicly available data? How elusive is it?

The Upside

In the end, to the decision maker, the exact source of uncertainty does not matter so much as the fact that it exists. Fortunately, uncertainty is not necessarily such a bad thing. Risk comes with promise of reward.

Consider the private side first. Architects design a system to easily accept components. Midstream development, a commercial off-the-shelf product comes into the market. Suddenly arises the opportunity to use this component for a major subsystem at a fraction of the cost of developing that subsystem from scratch, and at the same time eliminate the technical risk of developing the subsystem. Management takes advantage of this opportunity, and reduces both development cost and private risk significantly.

Consider the market side now. A startup has bet on XML as the information interchange technology for its product, although XML was an evolving, unstable standard when development began. XML becomes an industry standard. The demand for the product not only exceeds the company's wildest expectations, buy it now gets a chance to be major player in the market for XML-based applications because of its experience and investment in the technology.

These examples demonstrate that if managed properly, uncertainty can be very valuable. The value results from the flexibility to adopt to changing conditions. Decision-making practices in software development should therefore recognize this value generating capacity of uncertainty—the ability to capitalize on the upside potential of unknown while limiting its downside risk.

2 REAL OPTIONS

A very active area of corporate finance research, known as *real options analysis*, is addressing the problem of how to appropriately value flexibility in the face of uncertainty [1, 6]. The real options research has its roots in the seminal work of three financial economists, Black, Sholes and Merton, on the pricing of derivative securities [2].

An *option* confers to its owner, the right, *without the obligation*, to exchange two risky assets at a future date. Thus an option is about a future decision whose direction is determined by the then-value of a set of underlying assets. An option is termed real when these underlying assets are real assets. For example, the development costs and future cash flows of a technology investment are real assets. A company undertaking such an investment and facing uncertainty may very well be acquiring a set of real options on these assets. Provided the management can exercise or forego them optimally, such options may significantly increase the value of the investment. Consider technology stocks. Their sometimes strikingly high market valuations are often explained by growth potential. Real options researchers maintain that a company creates this potential through the real options that it holds.

Applications of the real options approach to software development decisions have been studied by a few researchers [3, 4, 5, 8]. Examples include:

- pioneering internet security project with a follow-on opportunity in the growing e-business market;
- up-front investment in software architecture to better accommodate future changes;
- development of a software prototype to resolve technical uncertainty;
- aborting development midstream to cut losses or when software artifacts can be reused in future projects; and
- delaying a restructuring project or a COTS product upgrade until uncertainty about the target platform or product is resolved.

Real options recognize the value of risk. The more uncertain the world is, the more potential there is for reward. Since an option does not constitute an obligation, it is exercised only when it is beneficial to do so. Therefore, the value of an option is always positive.

3 A SOFTWARE PLATFORM INVESTMENT WITH TECHNOLOGY RISK

As an example, consider the investment decision faced by a fictitious Java™[1] start-up based on a realistic scenario. For the purposes of illustration, we limit the problem to a single source of uncertainty, one that gives rise to technology risk. The focus of this example will be on pricing this risk. Is it possible to find a market asset whose historical performance will help estimate it? Favaro et al. [5] suggest similar software investment scenarios can be formulated as option pricing problems, however does not address how to price the underlying risk.

Context

- JSystems, a Java start-up, is considering to develop a new software development tool, Enterprise JFrame or EJF in short, and a suite of e-business applications based on this tool.
- EJF will consist of an application framework and component repository to complement the framework.
- Once developed, EJF will enable JSystems to efficiently produce new, customized e-business applications.

Forces

- JSystems is taking a risk by investing in a still evolving, unstable technology such as Java.
- The return from the project depends on how the market in Java e-business applications pans out.
- The future of the e-business market looks good.

[1] Java is a trademark of Sun Microsystems, Inc.

Investment Problem
What should be the value of the target market to make this project worthwhile?

Development Strategy
JSystems will first develop the framework and a core component repository at an estimated cost of $0.5M. This first-stage development will take one year. At the end of the first year, JSystems will make a decision depending on how the market looks. If the market in Java-based e-business applications is unfavorable, it will abandon the project and its first-stage costs will be sunk. However, if the market is favorable, it will follow on with a more substantial, second-stage investment of $1.2M that involves extending the component repository and developing an initial product line. Actual market entry will take place at the end of year two.

Formulation
This strategy can be formulated as a European call option on the market value of the complete project [5, 8]. The option can be exercised at the end of year 1, upon completion of the first-stage investment. The cost of exercise is the cost of the second-stage investment. The exercise of the option is conditional on the then market value of the investment (conditional on having completed both stages) exceeding the second-stage cost. The market value is uncertain because the success of the technology (Java) on which the final product depends is uncertain.

Pricing the Underlying Risk
At fist sight, the risk taken by JFrame seems private, and intangible. How is it possible to assign value to the risk of an evolving software technology in a given application domain? A closer look at the capital markets and an appeal to accepted economic theory reveal a different picture, and provides an elegant way out.

Software ventures are special. It requires relatively small capital and overhead to start and run a small software company. Virtually no regularity or other barriers exist. These characteristics are conducive of an economic environment with many specialized innovative companies free to explore specific, promising technologies. Having demonstrated their potential, some of these startups will seek to raise capital by going public. Once in the market, their stock price will reflect the value assigned by investors to their future growth potential. If this value is based on an a specific technology, then its dynamics will at least partly reflect the underlying risk of that technology.

The Case of Java
Such is the case for Java. Indeed, Java is even more special. In 1996, having realized the potential of Java as a "de facto standard for open, multi-platform, secure networked computing", the Silicon Valley venture capital firm Kleiner Perkins Caufield & Byers has created a $100 million fund to invest in startup companies working with Java. Technology companies that have invested in the KPCB Java Fund include Sun Microsystems Inc., Cisco Systems Inc., IBM Corp., Netscape Communications Corp. and Oracle Corp. The mission of the fund, which continues to be in existence, is "to encourage and invest in new ventures using Java technology to develop tools and applications." The establishment of the KPCB fund fuelled the interest in Java. In 1997, more than a dozen Java startups were in existence.

Some of the companies that got funded by the KPCB fund held public offerings since their inception. Some others that did not get funded remained in existence, and a few of those eventually went public as well. Of those public companies, a significant number have since been acquired by Sun. Thus their stock value got absorbed within that of a much larger entity.

A Custom Index
A recent study by the author has identified 17 publicly-traded companies with significant investments in Java in the e-business sector. Two blue-chip companies, IBM and Sun, are included in this list. The rest of the list largely consists of Java startups and former startups, including two that originally got funded by KPCB[2]. The companies are diversified within the target sector in that their products and services span a wide spectrum including core technology, web servers, network security, integration, business-to-business applications.

We can use this information to estimate the market risk of Java in the targeted sector. For this to work, we need to accept that the market valuation of these companies are, to varying extents, attributed to Java—the technology on which their software products and services are largely based.

Think of this list as a stock portfolio that tracks the risk we are trying to quantify or estimate. First form a custom stock index based on this portfolio. The index value at any given point in time is calculated as a weighted average using two different weights. The first weight determines the business value attributed to Java. It should equal unity for Java startups. For larger and diversified companies, this metric is elusive. Annual reports, past acquisitions, product line information, sales figures, and other publicly available information can be used to arrive at an educated guess. The second weight is common practice, and is based on the market capitalization: each stock contributes to the index in the same proportion as it contributes to the total market capitalization of the portfolio.

[2] Since the study, a third KPCB-funded Java startup has undergone an IPO. This company is not included in the list.

The Volatility of the Index

Let us examine the historical performance of this index. During the 12-month period beginning February 1999, it exhibited a mean (continuously-compounded) growth of 158%. The standard deviation of its continuous returns was 43%. It is this latter figure, the standard deviation of returns, that is of particular interest here. It tells us in a compact way how the capital markets have priced in the past the common surprise element of the underlying risk that systematically applied to all the assets in the portfolio as the technology in question (Java) and the target sector (e-business), collectively the source of that risk, evolved. We will use this figure as a proxy for the volatility measure needed for option valuation.

A Note on the Soundness of the Approach

The reasoned used in the previous subsection derives its soundness from a well-accepted economic theory, the Capital Asset Pricing Model. A discussion of this model is unfortunately well beyond the scope of this paper, and an overview can be found in any introductory corporate finance text [7]. At the heart of CAPM is the diversification principle: In a sufficiently diversified portfolio, risk that is unique to individual assets (or private risk) will be negligible. Simply put, fluctuations caused by such unique risk will appear to be random and tend to cancel each other out. What is left is the risk that applies to all the assets in the portfolio—the risk that is unavoidable. The same argument applies here. The selection criteria for the stocks in the portfolio defines the common element in terms of (1) the underlying software technology, or Java and (2) the target sector, or e-business. Of course, the stock prices are inevitably affected by several other factors. The net effect of those factors will theoretically be small in a diversified portfolio—a condition we hope to have satisfied by including a significant number of stocks in the portfolio. It is of course entirely possible to incidentally capture some common factor other than the one originally intended. This may imply a different, hidden source of uncertainty that we have failed to identify. In this case, we hope that this incidental risk also applies to the situation at hand.

Valuation Method

The historical values of the custom index seem to exhibit random fluctuations around an exponential trend, strong indication that the index follows a geometric Brownian motion (random walk). This kind of diffusion process is an assumption of the popular Black-Scholes option valuation model [2], and is often tested first. A closer investigation of the continuous returns confirms this suspicion—we cannot reject the random walk hypothesis here with any reasonable statistical significance. Therefore, we can use the Black-Scholes formula for the price of a call option to estimate the value of the second-stage investment. The formula requires five inputs:

- *The Present Value of the underlying asset*: given by the present market value of the complete project. This amount is unknown, and will be treated as a sensitivity variable.
- *The exercise price of the option*: given by the cost of the second-stage investment, or $1.2M.
- *Time to expiration*: equals the time to develop the core EJF, or one year.
- *Risk-free interest rate*: determined bv the market, taken as 8%.
- *Volatility of the underlying asset*: estimated by the standard deviation of the continuous returns of the custom index, or 43%.

Note that here we are using the custom index as a proxy for the underlying asset. In other words, we assume that the index formed approximately tracks the risk of the project's returns, risk that results from exposure to the uncertainty of Java in the e-business sector.

Analysis

To acquire the option to make the second-stage investment (extend repository and develop the initial product line), JSystems must first complete the first-stage investment (development of the framework and the core repository). Hence, the net value of the project is given by the option value of the second-stage investment minus the first-stage investment cost ($0.5M). This value turns out to be positive when the present market value of the complete project is above $2.5M. Therefore, JSystems should not consider this project unless it is able to project a market value above this figure.

4 SUMMARY

Software development is rich in strategic opportunities, but it is subject to multiple sources and high levels of uncertainty. Since development costs are irrecoverable, it is important to manage the uncertainty. When managed properly, uncertainty creates value. Therefore, software projects are best structured and development decisions are best taken with these considerations in mind.

The real options approach not only provides a framework in which to address these considerations, but also allows decision makers to make the elusive connection with the capital markets. Indeed, software development involves many types of real options, including growth, flexibility, reuse, timing, exit, platform, and learning options [3, 4, 5, 8]. With the proliferation of securities based on software technology, the markets are becoming increasingly useful sources of information to assess and price various types of technological uncertainty that gives rise to these potentially valuable options.

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