Multi-Stage Valuation for Start-Up High Tech Projects and Companies

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Economic growth is propelled by new technology developments. However, valuating early stage high tech development projects or companies is a very demanding task. In order to decide whether to fund a high tech development project or not, whether to sell or buy shares at a certain price, or to set the right price in an M&A, one needs to value the project or company. Traditional approaches such as using multiples, DCF analysis and/or combinations of these all have fundamental flaws. In this paper, we propose a multi-stage valuation approach as a pragmatic alternative to handle the valuation issue.

INTRODUCTION

Traditional valuation approaches to evaluate start-up high tech development projects or companies are ill suited to the job. None of the usual models -- the cost approach, the use of multiples, the DCF analysis, the real option analysis, or the venture capitalist method, give a rational valuation of such development projects. Cost approaches and the use of multiples are evidently not well suited: they say very little about the intrinsic value of the project. Standard DCF analyses suffer from the weakness that they cannot deal adequately with the long horizon and the need to incorporate risk into the discount rate. Real option analysis and the venture capitalist method suffer from exactly the same weaknesses as the DCF analysis.

In this paper, we propose a multi-stage valuation approach as a pragmatic alternative to value early stage companies/projects. The essence of this approach is to carefully divide the project into stages, each carrying different chances of success/failure and investment needs, and to discount the cash flows generated after each stage is completed successfully at a very low discount rate (such as the appropriate government bond yields).

A real life example from a high tech development company is given to show the irrational valuations and decisions that result from standard methods in contrast to the proposed valuation methodology herein. For our real life company, the only valuation methods "applicable" were DCF based approaches, since no comparables could be found, as is often the case with industrial high tech development projects. Ironically, standard DCF based valuation methods recommend that we should not invest in the company, even when success is almost there. Our proposed methodology instead assigns value to the project from the point when trustworthy estimates could be made of the chance of success and the amounts of investment needed – parameters that are also required by traditional DCF analysis, real option analysis and the venture capital method.

TRADITIONAL VALUATION METHODOLOGIES

There are several popular methods to value companies, the most common being the cost approach valuation, the use of comparable multiples, DCF analysis, the real option analysis and the venture capitalist method. All these methods are examined in this section with a focus on their suitability as a valuation method for early stage high-tech startups.

The Cost Approach

One method used to value early stage companies is to estimate the costs incurred to get to a particular stage, or the costs necessary to replicate the technology developed so far. A premium can be agreed upon as a bonus for those who brought the technology to that particular stage.

The trouble with this approach is that it does not reflect the intrinsic value of the technology. Moreover those buying the technology or company will need to know whether they are paying too much. The approach is sometimes used for small projects, and in cases where early stage high tech development companies are out of cash and need to accept "any" deal, or when they are forced upon such a deal because of the imminent threat of the buyer. Prospective buyers can effectively force a deal upon startups by threatening lawsuits over intellectual property issues – something that happens regularly in the pharmaceutical world[1]. Accepting a cost based valuation may be the only viable alternative for the start-up to survive.

Comparable Company's Multiples

Another method to value early stage high tech companies/projects is to use multiples or comparables. Multiples are either fundamental or relative multiples. Fundamental multiples are based on company fundamentals, for example, a multiple of enterprise value. The most common multiples used are based on: price/earnings, market to book value, revenues, ebitda, and operating free cash flows. In the case of valuing early stage high tech companies, these multiples are generated from more established companies, especially publicly traded companies, to estimate where the early stage company may go in financial terms, such as margins, costs, market share, etc. The idea is to arrive at a fair market value, even though (unlike an established company) there is little secure cash flow in the early stage company. The use of multiples gives more often than not a higher valuation of early stage high tech companies compared to DCF valuations (Pellegrino and Buuck, 2007).

From the standpoint of an investor it makes sense to look at the value of the company in terms of multiples, which enable an investor to find out how similar companies are valued based on basic accounting numbers. This presupposes however that there are comparable companies, that those companies are valued correctly and that these valuations are constant over time and in line with the market in the future. In the case of early stage high tech companies this approach is probably not appropriate for the following reasons:

- It is far from sure that others have done the job properly: valuing the company at the true value such as not to destroy the acquirer's economic value. If everybody reasons in the same way – that someone else has done the job - large biases will occur. In fact, from a macro economic perspective this following the pack approach is very dangerous[2]. Using multiples implies that someone else has done careful analysis *and* that these analyses contain some unchangeable eternal truth about the real value of the company, based on the prospective profits that the startup will generate.
- Comparing early stage companies with more established companies is riddled with difficulties. For one, we cannot compare the revenues, there is great uncertainty concerning whether the early stage company will ever reach such a state of maturity. There may be large differences in cost structures that are inherent in the technology and/or business model. In addition, the market for shares in early stage companies is as a rule very small or nonexistent: it is usually a matter of negotiation between the company with its founders and a few possible

new investors. To put it simply: there is no *fair market* value, a value based on market principle that is fair to both the buyer and the seller, that can be established for such companies.

- Development takes time: by the time the company reaches the stage of exit, the whole market may be completely different. If we value the company on the basis of comparables without considering exit at the same time and accordingly set the price for new investors or to dilute those who do not participate in the current round of financing, such valuation may be quite different from the case when exit is contemplated in several years.

For these reasons, multiples should not be used to value high tech development companies.[3]

DCF Valuation

A very popular methodology for valuing companies and new investment opportunities such as high tech development projects is the discounted cash flow valuation.[4] Hayes and Garvin (1982) show that companies using DCF calculations to make investment decisions rose from 19 percent in 1959 to 94 percent in 1974.[5] The principle is elegant and simple: one makes an estimate of the future profits (free cash flow) as well as the investments needed to reach that stage, and then discounts all these cash flows at the required rate that reflects the risk inherent in the project.

There are some fundamental problems with the DCF methodology when applied to start-up high tech companies, as follows:

1. The timing problem
2. The problem of incorporating risk into the discount rate
3. The discount rates used in the venture capital (VC) industry are simply too high
4. “Stop and change” options are not taken into account

The Timing Problem

Discounting does not work well over longer periods of time. Anyone that would have invested 1 dollar in a bank even with very low real long term interest rates, say 2%, at year 0 a very long time ago would now be able to “buy the whole world”. Similarly, any project that is worth billions of whatever currency in fifty years but that carries just a little risk is within the purchasing power of almost anyone on the planet at this moment. The “time to market” of high tech development projects becomes a very sensitive factor in any DCF valuation.

High tech development projects often have long time horizons: 10-30 years is not unusual, especially in the pharmaceutical and energy industries. None of these projects would ever get started given their high uncertainty (and thus high discount rate) and long period without positive cash flow. However, once these technologies are proven and on the market the cash inflows are very stable and last for a long time.

Incorporation of Risk into the Discount Rate

The discount rate is supposed to incorporate risk. High tech development projects have however varying degrees of risk throughout different stages of their lives. It is close to impossible to set even a mildly “correct” weighted average cost of capital to account for this changing risk.[6] Once the technology is proven, the risk becomes very low: there will not be many competitors. In addition to the difficulty of setting a single risk adjusted discount rate, DCF analysis undervalues high tech development projects since it does not consider various options such as technology spin offs, options to reduce uncertainty during the development, and options to gain much larger returns at similar or lower risk by redirecting the project. In short, DCF analysis does not take into account the flexibility existed in the real world and the degree of control enjoyed by managers running the project (Hayes and Abernathy, 1980; Hayes and Garvin, 1982).

The Discount Rates Used in the VC Industry Are Too High

VC's cost of capital is composed of expected returns from investors in the funds they manage and fees for managing the fund. Expected returns from investors are high -- it is quite usual to demand 20%. Investors demand a high expected rate of return because of the risk involved: quite a few funds never deliver any returns. In addition to calculating the risk of the company they are investing in, VC managers must take into account of the cost of capital connected to the management fees and the rate of return expected by the fund investors. The problem with this model is that risks get incorporated twice (and a lot of people want to make a good living from this fund money): once by the investors in the fund and once by the managers of the fund. As a result, VCs typically apply a discount rate of between 25% to over 50%, which is high enough to kill almost any early stage high tech development projects.

"Stop and Change" Options Are Not Taken into Account

Fundamentally, DCF analysis is based on the summation of linear scenarios where all expected investments and free cash flows are accounted for in advance. It does not allow for a valuation based on "stop" and "change" which managers and investors can often take in the real world. These options command a high value in high tech development projects since they allow investments not be made or be adjusted in terms of amounts and the timing in relation to the perceived risks and possibilities.

Real Option Valuation

Because of the above mentioned fundamental weaknesses with DCF analysis, many practitioners have attempted to directly incorporate the embedded options' value into the prospective cash flows of a project. Rarely will a development project be decided by just one decision: "do the R&D and invest in production upon successful completion of the R&D". The outcome of the R&D will as a rule be different from what one expects. Moreover, the probabilities of different outcomes will change during the development of the technology as one learns more of the market, the costs, and the applicability of the technology. A DCF analysis cannot take into account the changing conditions of the real world: capacity can be expanded upon positive outcomes, or the project can be liquidated or run at a smaller but safer scale.

Real option analysis (ROA) takes into account that a project may evolve in different ways. At different junctures of the project, one can defer investments until uncertainty is reduced or liquidate the project, before deciding to fund the next stage. Unfortunately, ROA also requires complex calculations that are beyond the reach of the average business decision makers.

Combining Multiples and NPV Calculations: The Venture Capital Method

Sahlman (1987) illustrates a method that combines discounted cash flow analysis with multiples. The rationale is that at a certain point in time (x), an early stage investor will want to exit the project. Given a series of projected free cash flow for the invested company, one can calculate the value of the company at time x based on some multiples of a proxy company's accounting variables, e.g. P/E, sales, etc.[7]

This combined DCF- multiples approach has its merits since it takes as a starting point projected cash flows and takes into account that at the exit point, valuation will be based on the market multiples of some sort. However, there are several significant drawbacks for this approach:

- One still adheres to the "following the pack" doctrine.
- It is still very hard to find good comparable companies or projects that have been valued for truly original technology projects/companies.
- The risk discounting is not rational (as discussed above), as every traditional DCF based method is flawed when used for early stage high tech companies.
- Valuations are usually substantially higher than what can be realized at exit (Pellegrino and Buuck, 2007).

A MULTI-STAGE APPROACH TO VALUE START-UP HIGH TECH PROJECTS OR COMPANIES

Four Prerequisites

As shown above, all the traditional valuation methods have their problems when applied to early stage high tech projects or companies. The main thread that runs through all methods is that they all use a DCF type analysis in which risk is accounted for by a "high" discount rate, which may not be appropriate. In this paper, we propose a pragmatic multi-stage approach that more reasonably incorporates the varying level of risk at different stages of a startup project.

For any high tech project, there are four prerequisites that have to be fulfilled before any serious evaluation can take place:

1. Thorough knowledge of the technology in question.
2. A comprehensive list of all the assumptions that need to be fulfilled for the project to become a success has to be drawn up.
3. The capital for the project has to be of a long-run nature.
4. The project has to be dividable in stages, making staged investment decisions possible.

The rationale for these prerequisites is rather obvious. High tech development projects are characterized by high uncertainty about outcomes. One needs a deep understanding of the technology and market to estimate the risk. This usually is done by an expert panel of both insiders and outsiders (prerequisite 1). All the major assumptions underlying positive potential outcomes of the technology development need to be listed: from pure R&D assumptions that have to be proven or developed in the lab to market assumptions (prerequisite 2). These development projects take time; therefore long term capital that is free from concerns about liquidity is needed (prerequisite 3). Since the world changes and more will be known about the development possibilities and limitations for the project over time, the project should be divided in stages that allow segregated investments per stage, following the decision tree model. In fact, because the world constantly changes even the decision tree itself can change in the course of the project (prerequisite 4). [8]

Valuation at Stage 1: Pure Research

In stage 1, the most important technological principles have to be demonstrated. As a rule this is pure R&D work done in labs. The costs involved are low. At this stage it is important to keep funding decisions really simple. There is too much uncertainty to justify any degree of sophistication in valuation, risk assessment, and funding decision at this stage. To manage the volatility at this stage, the following conditions have to hold true to justify using a small amount of money to fund stage 1 or parts of it:

- Experts do not exclude the possibility of success for the technology; they may however disagree fiercely about the likelihood.
- There is a real visible advantage made possible by the technology that arguably leads to enhanced customer value, either in terms of lower costs or enhanced quality or both.
- There is a relevant market size which does not require disproportionate investments in R&D or in commercial production. This is to rule out costly and long development projects for "improved" old products that only have a very small potential market.

At this stage one should not try to financially value the project, but one should have incentives in place for founders to stay with the venture. Financial valuation at this stage causes a lot of negative feelings between those that give the funding and those that receive it. Valuation is moreover useless since it is close to certain that they will be grossly wrong. There is one exception to not doing the numbers -- it is important to have an idea at an early stage what the final product will cost, and whether there is a real price/quality advantage compared to the current alternatives used by customers. If the project is promising, we should fund it with the resources needed to overcome the main technological hurdles as long as the above mentioned conditions are met.

Valuations of the Development Stages after the Initial Pure Research Stage until Full Scale Production

Having overcome the most important technological hurdles (proof of concept), valuation needs to become a little more sophisticated. The main question many investors need to answer is: *what is a rational amount of money they should spend on a project that will balance the opportunity of making a lot of money in the future with the threat of losing sizeable amounts of money*. In order to answer this question, one needs a valuation of the investment.

Below a simple model is formulated to determine the value of the company at this early stage. The model presupposes some homework to be done before a valuation can be made:

1. Estimate the likelihood of technological success.
2. Estimate the time and costs for each project stage.
3. Estimate the net present value of the project using very low discount rates – the appropriate government bond yields.

1. Up until the technology is fully proven in industrial scale under industrial production conditions, the focus of the project is to develop the technology, and we need to constantly cross-check our assumptions: Given what needs to be achieved at the next milestone, what will be the chance of success for the technology development by then? Denote this factor "s" and assign it a number between 0 (no chance of success) and 1 (no chance of failure). Hopefully as a result of the development work, the risk factor diminishes. Or the project needs to be terminated.

2. Each project stage proves or disproves some assumptions from the assumptions list. The development costs and time have to be estimated for every project stage. These estimates have to be updated every time one reaches a new stage, based on the new information uncovered during the previous stages. These estimates will be important inputs to incorporate risk under our multi-stage valuation approach. One should reexamine the original assumptions preferably by independent experts. The project team that made the original assumptions may be disproportionally biased.[9] Setting upper spending limits at various stages may also be a good idea, in order to discourage the project team from manipulating the numbers to make the project look NPV positive.

3. If the technology succeeds up to a particular stage, one has to calculate the terminal value (TV) of the production and commercialization stage of the project assuming that the development and commercialization stage of the project will be completed as planned. Ideally, this is best done by using real option analysis. For practical reasons, we suggest that investors should keep it simple by conducting scenario analysis. One can calculate the TVs of the project for the worst case, the base case and the best case. With that, the weighted average TV for the project can be computed.

THE MULTI-STAGE VALUATION APPROACH

After one has made estimates of the chances of success at every project stage and the costs per stage, as well as a valuation of the project after the technology is successfully developed (the terminal value, TV), one can value the project at any point in time using the following model:[10]

$$\text{Project value at stage “}i\text{”} = \text{Project } NPV_i = PVTV_i - \sum_{t=i}^{n} (1/s^2)\, €_t\,,$$

Where "i" denotes the project stage, "s" is the chance of success at that particular stage, "€" is the amount of money needed at stage "*i*" to reach the next milestone, $PVTV_i$ denotes the present value at time i of the project's weighted average TV at the production stage discounted at a conservative government bond yield.

Whereas the variables "i" and "€" are straight forward, some more clarification is needed for "s" and "PVTV":

PVTV, the Present Value of the Project's Terminal Value

PVTV denotes the present value of the project's estimated weighted average terminal value (from various scenarios) after successful completion of the technology development stage (i.e. the TV of the project at the production stage). The discounting of this value to the present is done at the appropriate government bond yield since profits will almost certainly start to come once the technology has been developed successfully. At the production stage, there is very little risk on the free cash flows. In contrast to "normal" DCF valuations, risk for the investment is accounted for one phase at a time; not with all investments at once, and not with the positive free cash flows once the development project has reached fruition.

"s", the Chance of Success

The chance of success varies dramatically in each stage of the project. At the beginning of the development project, there are many assumptions that have to come true. In general, as more assumptions are proven to hold true, the project becomes less volatile. Therefore, the risk of failure in the project depends on the stage one is in. The investment needed to go from one milestone to the next bears this risk.

By assigning a probability of success to every stage of the project we can estimate the risk in the following manner. If the stage of the project has a one third chance of success, we would on average need three attempts to have one successful outcome. This would mean that we should multiply the stage investment by 1/s. For example, if from milestone 0 (startup) to milestone 1, the success chances are estimated to be 20%, the money needed to get to milestone 1 should be weighed 5 times more since out of five similar investments, only one will succeed. All this weighted investment money should be summed up and deducted from the discounted terminal value of the project at the production stage after the development stage is completed.

For the above model, the investment needed to reach each subsequent milestone during the development stage is multiplied by the inverse of the estimated probability of success raised to the square (s^2). The reason for this is that estimating the chance of success is extremely difficult in complex high tech projects at the earliest stages of the project. Since entrepreneurs (be it inside a company or an individual) as a rule are very upbeat about the chance of success, we should therefore discount the chance of success factor.[11]

The formula given above does this by making the money needed at the first project stages more costly than the money needed at the later stages. By using "s^2" instead of "s", the money needed at the beginning of the project is weighted much more heavily than during later stages. If the chance of success is 20%, then the money that we should deduct from the NPV would be 25 times the money expected to be needed. In this manner, we penalize projects that have high upfront costs whilst still having high uncertainty and vice versa. When the outcome becomes more certain, larger amounts of money can be spent. By investing stepwise and valuing the company as proposed, there is a strong incentive to focus on the projects that give the best risk/cost ratio first.

Note that using s^2 (instead of s) also replaces the use of a discount rate. The money invested at the beginning of a project can have to wait a long time before it is paid back. The time horizon is as a rule very difficult to estimate. Instead of using an interest rate, we simply use s^2 in the model. Admittedly, this adjustment is ad hoc but as noted there are strong practical reasons to do so. In addition, the decision maker can easily change the adjustment weight, say, from s^2 to 2s depending on the projects and macroeconomic conditions.

Valuation at Full Scale Production Stage

Once the technology is fully developed and full scale production is entered, traditional techniques to value the company can be used. The best method is to use real option analysis (ROA), since there will be some options open in the near future, such as expanding quickly. As argued above, the DCF analysis does not take into account of the various embedded options. If ROA is beyond the capabilities of the investor, one can rely on scenario analysis and estimate the weighted average NPV of the project at the production stage.

VALUATION EXAMPLE OF CRUCO: AN EARLY STAGE HIGH-TECH DEVELOPMENT COMPANY

Below an example is given to demonstrate how a real life high tech development project can be valued with the multi-stage method. This stylized example is taken from real life based on the authors' experience.

Stage 0: the Idea

Three scientists working on their PhD's get an idea to make a crucible from a brand new material, since the current industry standard has clear weaknesses. The high tech development project (later becomes a company) evolves as follows:

Stage 1: Theoretical Research

The scientists choose to start with a theoretical study, partly based on the results of their PhD dissertations, to analyze whether other materials are suitable as an alternative to current material used in the industry for crucibles. Few people believe that there is much of a chance of success. At this early stage, the probability of success is not calculated, nor are costs estimated.

Stage 2: Lab Testing

Based on theory and literature studies, they identify some interesting materials and apply for a small internal grant at their university to test these materials' basic properties. Given the studies made on strengths, conductivity, cleanliness, etc. of these materials, chances of success has now improved.

Stage 3: Lab Prototype of Material Sample

After identifying a promising material, they decide to make a small prototype of this material. They succeed and decide to establish a company "CruCo". They look for further research funding and cash from private equity firms. At this stage, financial valuation has to start. The battle for funding is extremely difficult given the low valuation of the project. The founders manipulate, mainly unwillingly, the numbers so as to attract VC interests.

Stage 4: Production Method Development

The founders conclude that making large scale objects of the chosen material is not possible with traditional methods. Therefore, they start on a long road (which eventually far exceeds their initial estimation) to develop a new production method. It took three long years. Due to new financing rounds based on low early valuation, the founders' shares risk being heavily diluted. However, by co-investing in new rounds they manage to maintain a reasonable stake in the company.

Stage 5: Up-Scaling to Industrial Size

Up scaling from lab scale to industrial size starts. This is done in several progressive steps, which all take a long time since the production method has to be developed further to overcome fundamental physical difficulties with the material: breakage as a consequence of thermal stress induced on the crucibles under industrial use condition.

Stage 6: Building the First Small /Medium Size Factory

After successfully up scaling the product and proving a small amount of these crucibles under industrial condition, pilot customers are eager to sign contracts since the technology is a real breakthrough. It is assumed that it will take a long time for competitors to come up with an alternative, since the intellectual property position is very strong. The decision to build a small/medium size factory that can capture 5-10% of the market is made. It has already taken 10 years to reach this point, including one year to build the factory. The founders have become diluted to insignificant shareholders with large personal debt burdens.

How to Value the Project: Invest or Not?

The founders needed investment after the first theoretical studies done between 1999 and 2000. Now they needed to convince investors. How should they go forward? The needed investments are given in Table 1 below (which was not something the founders at that time had compiled).[12]

According to our model:

$$\textit{Project value at stage "i"} = \textit{Project } NPV_i = PVTV_i - \sum_{t=i}^{n} (1/s^2)\, €_t ,$$

the success rates are raised to the square and inverted. This then has to be multiplied by the money needed at each stage. The "risk adjusted" cash flows are subsequently subtracted from the present value of the terminal value of the project at the production stage. The accumulated cash investment that is risk adjusted in this manner is €-27.6m at the start of the project.

TABLE 1
RISK ADJUSTED CASH FLOWS AT THE DEVELOPMENT STAGES

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Investment	0.1	0.2	0.3	0.5	0.5	0.5	0.5	1	1	10
Success rates	0.2	0.3	0.4	0.5	0.6	0.6	0.8	0.8	0.8	0.9
s^2	0.04	0.09	0.16	0.25	0.36	0.36	0.64	0.64	0.64	0.81
$1/s^2$	25	11.11	6.25	4	2.78	2.78	1.56	1.56	1.56	1.23
Risk adjusted cash outflow	-2.5	-2.22	-1.88	-2	-1.39	-1.39	-0.78	-1.56	-1.56	-12.35

For the sake of simplicity, we assume that free cash flow will be €3m in the second year after investment in the production stage (year 12 after the project starts) and grow at a constant rate of only 2%, which is equal to the GDP in most highly developed countries.[13] When positive cash inflow from the project starts in 2013, risk has become very low. As a result, the discount rate can be set at a nominal rate of 6%. This would reflect the real cost of capital for a stable corporation funding its lowest risk activities in Europe. Now we can calculate the value of the project in 2013 -- the Terminal Value.

In the table below, the multi-stage valuation model is compared to a standard DCF analysis from a VC in which *all free cash flows are discounted at 40%* since the company is a very early stage startup. For the sake of comparison, a simple DCF analysis with a discount rate of 25% is also used. The valuations are done at two points in time: one at the start of the project and one in 2009, when the project has reached a much higher level of certainty and the "time to market" is not so far away anymore. The results of the different valuations are shown in Table 2 below.

Table 2 shows how much any valuation that bases its risk adjustment on the discount rate can go astray when applied to early stage technology development projects *even though the investments in R&D are comparatively small and the profits considerable if and when the development is successful*. Both

DCF analyses lead to a rejection of the project, whereas the multi-stage model attaches considerable value to the project already at the initial stage. The reason is that risk is adjusted in a more rational way, in effect taking into account the different options to abandon the project over time and taking into account that revenues are very secure once the technology is successfully developed.

TABLE 2
VALUATION SIMULATION RESULTS

Valuation at start of project	g (growth rate)	Discount rate	Terminal value	PVTV	Accumulated risk adjusted cash outflows	**Project NPV**
DCF 1	2%	40%	€10.5m	€0.2m	€-1.1m	€**-0.9m**
DCF 2	2%	25%	€16m	€1.1m	€-14.6m	€**-1.32m**
Multi-Stage Model	2%	6%	€75m	€37.3m	€-27.6m	€**9.7m**
Valuation at 01.01.2009						
DCF 1	2%	40%	€10.5m	€1.96m	€-4.87m	€**-2.9m**
DCF 2	2%	25%	€16m	€5.24m	€-6.56m	€**-1.32m**
Multi-Stage Model	2%	6%	€75m	€56m	€-15.5m	€**40.5m**

CONCLUSION

Given the huge uncertainty involved in early stage projects or companies, traditional valuation methods are ill suited for the purpose. In this paper, we propose a multi-stage valuation method based loosely on the real option valuation approach and value the project/company at each definable stage. Instead of adjusting the discount rate for the cash flows which is often irrational in practice, our method increases the de facto required investment for each stage. The logic of this approach is that entrepreneurs tend to intuitively base their decision on the dollar value of the project rather than on some abstract discount rate. This paper also demonstrates the use of the multi-stage valuation approach with a real life early stage company.

ENDNOTES

1. Large pharmaceutical companies as a rule have thousands of patents that are vague and based on yet to be tested ideas, which can be a real obstacle for startup companies that do not have a strong patent position yet. Startups usually do not have the cash to take the costly legal fight.
2. Frykman and Tollerud (2003, p.28) point out that base valuations on multiples can lead to the “multiple pinball” issue: when one company upgrades its valuation, others follow and value “their” company even higher, which again triggers a reaction from the rest. This mechanism clearly played a role during the dotcom bubble in the late 1990s.
3. Multiples are also used to value companies that are generating revenues and have rather stable operations. There is no good reason for this other than that either the buyer or the seller sees an advantage in it, since it does not necessarily reflect intrinsic company value.

4. There exist many variations of this methodology. This paper uses the most common approach which was carefully explained by McKinsey's consultants Tom Copeland, Tim Koller and Jack Murrin in "Valuation – Measuring and Managing the Value of Companies", Wiley (2005).
5. Hayes and Abernathy (1980) go as far as to correlate the tendency to rely on DCF analysis by financial managers to the shrinking innovation efforts in terms of R&D spending and capital investment in the US from 1959 to 1975. This explanation probably is too far-fetched. This might have much more to do with the fact that the basic technologies from that time, oil and gas, and the car industry, were reaching a level of technology maturity that did not allow high R&D spending. As a result, cost cutting became more important. At the same time, the new growth industries, such as IT, media and communications industries, were too small yet to compensate for this shrinkage in spending.
6. Theoretically one could incorporate the varying chances of success into the model. This would make the calculations rather cumbersome: the project plan will have to be divided up into different stages each with a different duration and a different discount rate for that phase. This makes such calculations too complicated to be practicable.
7. One should correct for dividends that are expected to be paid, since they can constitute an important added on value. Early stage high development projects do not have positive cash flow and cannot pay any dividends so this issue is not relevant in this context.
8. It is important to note that there are great differences among industries. A high tech development project is in this paper understood to be the development of new technology based on new knowledge that is very difficult to copy. Therefore, it has a high degree of probability to create revenues once the technology is proven. Examples of such technology projects are the development of new drugs, new materials, new types of solar cells, new energy technology, etc. In far too much business literature "high tech" is treated as equivalent to the IT industry. This is absolutely misleading. In fact, IT industry is a very special case: development time is relatively short, development costs are low, competition can as a consequence enter quickly, getting valid patents is in many cases very difficult (apart from the hardware elements). One may argue that a large part of the IT industry is absolutely not high tech, they depend on educated brains but most software development is routine work, not high tech: it can be bought from the shelf. Other knowledge based industries, such as pharmaceuticals, renewable energy, materials, etc. are characterized very differently. The industry specifics have to be taken into account. Technologies with short life cycles and weak intellectual property positions have to be treated differently: once one succeeds one has no guarantee that a positive cash flow will follow for any considerable period.
9. Main and Lousteau (1999) show that some projects are prone to the noted entrapment mechanism. They cite extensively the F22 fighter jet project as a case. The F22 project went on using significant amounts of resources until the Obama administration finally eliminated it entirely in 2009 after 10 years of delays and cost overrun.
10. This model can also be used in a slightly changed form to decide whether to fund the next stage of the project. In that case, reject further funding at time i, if:

$$PVTV_i \leq \sum_{t=i}^{n} (1/s^2)\, €_t\,;$$

one should in this case ignore investments made in previous stages, since those are sunk costs.
11. A variation of it would be to double the risk factor at the earliest stage, and then lower the doubling effect throughout.
12. In reality only a small part of the costs were underwritten by the shareholders, a third was taken by the government via R&D subsidies and at least a third was taken by pilot customers.
13. In real life, the case is complicated by the fact that the company actually generated higher profits and higher growth than expected in the first year, but competition later on erodes the margins. Also, there will be change to a new technology standard starting 2020.

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