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- Insights from Capital Markets Theory and Practice –

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Abstract

In this paper, an analogy between IT firm valuation and IS valuation is used to learn from how investment banking professionals cope with the renowned valuation problem. It becomes clear that theoretically sound approaches like the discounted cash flow might be inappropriate to determine the true value of a software company. Especially for IT valuation, real options approaches are a promising way of capturing the "true" underlying value to new technologies. Unfortunately, as expert interviews reveal, the importance of this approach in investment banking practice is negligible.

Keywords: IS valuation, real options approach, value

1 Introduction

"Business and information systems (IS) executives continue to grapple with issues of risk and uncertainty in evaluating investments in information technology (IT). Despite the use of net present value (NPV) and other investment appraisal techniques, executives are often forced to rely on instinct when finalizing IT investment decisions" [Tallon et al. 2002, 136]. IS valuation has long been a core IS research challenge. Recently, real options approaches (ROA) have received attention as methodological means of overcoming some shortcomings of traditional valuation approaches like NPV, especially coping with uncertainties concerning

- the costs and benefits ("value") of IS infrastructure flexibility,
- the costs and benefits implied by postponing IS investments ("option" to invest later),
- the costs and benefits of partial investments.

In the paper, we learn from capital markets' experiences about coping with future uncertainty: how do capital markets valuate IT companies in theory and practice, and to what extent can we learn from them concerning the question of the true value underlying information systems? In section 3, traditional valuation methods are analyzed and compared, identifying advantages and shortcomings in practical applications. Alternatively, in section 4 real options analysis is discussed and its practical relevance explored using expert interviews. Throughout the paper, the various valuation methods are used to determine the respective values of SAP AG and Tiscali, demonstrating the huge impact of the choice of the valuation method (esp. Figure 4). The valuation procedures are explicated in the appendix. The paper was conceived

as teaching and introductory paper for future ROA applications in the E-Finance Lab at Frankfurt University. We are indebted to the E-Finance Lab and the German National Science Foundation for their support.

2 Valuation Problems

Innovative technologies have always influenced market trends, because technological progress has an impact on productivity and increased productivity usually causes earnings to rise which in turn is in most cases rewarded by capital markets. However, volatile stock markets have shown the difficulties assessing a "true" underlying value to new technologies.

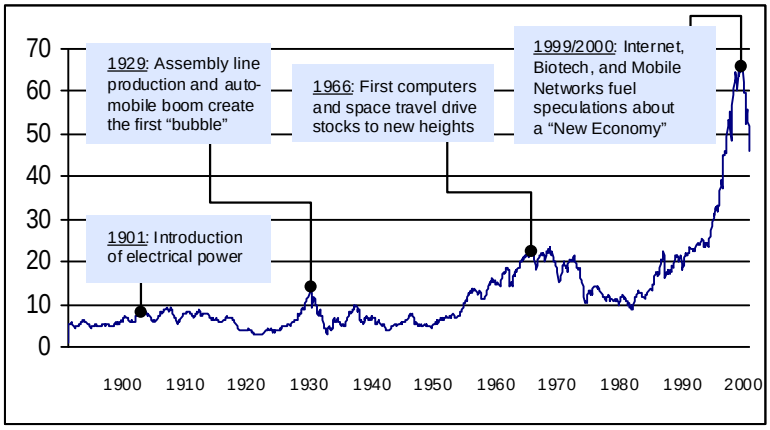

Figure 1: Inflation adjusted price history of S&P Composite Stock Price Index (rebased) [data source: http://www.econ.yale.edu/~shiller/]

The goal of all valuation efforts is to determine a price as close to the "true" or "fair" value as possible. In this context, "*price*" and "*value*" must be distinguished. A theoretical price of a company can be determined uisng valuation approaches like the discounted cash flow method (DCF) or the comparable companies (CC) approach while the true price can be observed in capital markets. If markets are efficient (i.e. all available information is considered), valuation based on trading multiples of comparable companies can reflect current trends and growth expectations. However, due to unavailable or unpredictable information (e.g. future market development) frequently neither prices determined by valuation approaches nor market prices represent the "fair" value of a company. Morgenson (2001) quotes that during *hype* phases the analysts' view often is, "We've got a new technology, therefore it's perfectly okay to have a new way of approaching the income statement and balance sheet". It seems that traditional valuation methods have reached their limits when it comes to determine a financial value for new technologies or high-growth companies. Varian (2001) identifies three technology sector investment shocks in the late 1990s that caused rapid growth and extreme expectations which could not be captured using traditional valuation methods: telecommunications deregulation in 1996, the "year2K" problem in 1998-1999 and the "dot.com" boom from 1999-2000. Stock price development during this period and the rapid downturn of technology stocks in 2001 hint that internal value drivers regarding innovation and future growth potential are truly a "black box" and are neither fully understood by the capital markets nor completely captured by theoretical valuation approaches.

3 Traditional Valuation Approaches

In this section, different valuation techniques are introduced. Focus is set on discounted cash flow (DCF) analysis and multiple valuation as these approaches are the most commonly used by investment banks. All valuation methods share four principles: first, they all relate to the future, as investors do not pay for the past. Second, only cash matters. Third, due to uncertainties cash today has more value than cash tomorrow. Fourth, the higher the risk, the higher expected returns [Dermine/Wildberger 2001].

3.1 Discounted Cash Flow Approach

The DCF analysis measures the intrinsic value of any asset as a function of three variables - how much it generates in cash flows, when these cash flows are expected to occur, and the uncertainty associated with these cash flows. Precisely, DCF analysis estimates the value of a company as the sum of the present value of its unlevered free cash flows over a forecast period between five to ten years and a terminal value at the end of this forecast period, based on the weighted average cost of capital (WACC) as the discount rate.

When estimating the enterprise value of a company, four steps are necessary (Figure 3). First, cash flows representing future expected payouts are determined. Then, a discount rate representing different risk inputs must be assessed. Third, estimating growth is crucial which mostly relies on personal know-how and expertise. Finally, a terminal value for the period of stable growth after the explicit forecasted period has to be determined.

Estimating Cash Flows

The discounted value of expected future free cash flows (after taxes and reinvestment needs, but prior to debt payments) equals the value of operations. In order to estimate the operation income, some adjustments to the financial statement information are necessary (Figure 2).

	Revenues
-	Costs of Goods Sold
-	Cash Operating Expenses
=	EBITDA (Earnings before interest, taxes, depreciation and amortization)
-	Depreciation and Amortization
=	**EBIT (Earnings before interest and taxes**
-/+	Interest Expenses / Income
=	EBT (Earnings before taxes)
-	Taxes
=	Earnings / Net Income
+	Depreciation
+	Non-cash compensation
+	Other non-cash operating expenses
+	Change in provision
=	**Funds from operations**
+	Delta Working Capital
=	**Operating Free Cash Flow**
-	Capital Expenditures
-	Acquisitions
+	Sales of assets
=	**Free Cash Flow**

Figure 2: Determination of free cash flow [Damodaran 2001, 105-138; Copeland et al. 2000, 131-154]

Estimating Discount Rates

Discounting estimated cash flows reflects the risk involved. A discount rate describes the opportunity costs borne by equity investors when buying into a company's assets or providing

capital. The opportunity cost weighted by their relative contribution to the company's total capital is called weighted average cost of capital (WACC) [Copeland et al. 2000, 134].

The **risk-free rate** is the return on a security that has no default risk and is completely uncorrelated with returns or anything else in the economy [Copeland et al. 2000, 215]. In practice, returns for government securities are applied. The **risk premium** represents the extra return demanded by an investor for shifting his money from a riskless investment to an average risk investment. The capital asset pricing model (CAPM) suggests two kinds of risk premium - the historical and the implied premium. The difference is the belief whether markets are efficient. If yes, prices are justified and an implied premium should be used. If no, i.e. if it is assumed that markets are under- or overvalued and it is believed that future will be like the past, then the historical risk premium should be applied. The **beta** is a relative measure of risk. It measures risk added on to a diversified portfolio, rather than total risk. For example, a beta of 1.5 means that if the underlying index changes by one percentage point, the valued stock changes by 1.5 points. Based on the CAPM, the cost of equity are: $r_e = r_f + \hat{a}(r_M - r_f)$, where r_e = *Cost of Equity,* r_f = *Risk free rate,* $r_f - r_M$ = *Risk premium,* ß = *Beta.*

To finally determine the WACC, the cost of equity and debt have to be weighted with the respective amount of equity and cash reflecting the firm's capital structure. As free cash flows after debt payments are discounted, the debt ratio has to be tax-adjusted:

$$WACC = \frac{E}{(E+D)} r_e + \frac{D}{(D+E)} r_d (1-t)$$

where
E = Equity
D = Debt
r_e = *Cost of Equity*
r_d = *Cost of Debt*
t = tax rate

Formula 1: Weighted average cost of capital

Estimating Growth Rates

Estimating growth opportunities involves the difficult task of predicting the future development of aspects like technology, financials, management, and markets. Damodaran (2001, 141-181) suggests that growth rates can be estimated in three different ways: first, historical growth rates can be adapted, acknowledging that the future is a condition of the past. A second way is using analysts estimates, also suggesting that growth is exogenous. A third way is to see growth as a function of quality and quantity of firm investment. This endogenous approach emphasizes the importance of the present and bases growth on a firm's fundamentals. It is most commonly used by investment banks.

Estimating Firm Value

The value of a firm consists of the current value of its expected cash flows for a certain growth period and the so-called terminal value which often accounts for a large percentage (in most cases more than 50%) of the total value of a company [Copeland et al. 2000, 267].

$$\text{Present Value of Free Cash Flows} = \underbrace{\sum_{t=1}^{t=T} \frac{FCF_t}{(1+WACC)^t}}_{\text{growth period}} + \underbrace{\frac{\text{Terminal Value}}{(1+WACC)^T}}_{\text{period of stable growth}}$$

Formula 2: Present value of cash flows

If it is assumed that a company's cash flow beyond the terminal year will grow at a constant rate forever, the terminal value can be calculated by dividing the free cash flow of a firm by the cost of capital less the constant growth rate (*g = terminal growth rate*).

$$\text{Terminal Value} = \frac{\text{Free Cash Flow to Firm}_{T+1}}{(\text{Cost of Capital}_{T+1} - g_T)}$$

Formula 3: Terminal value

As especially the software sector is characterized through fast change, often multiple options for future strategies occur. The DCF approach doe not capture these options. Figure 3 sums up all steps necessary to arrive at a firm value by discounting expected cash flows.

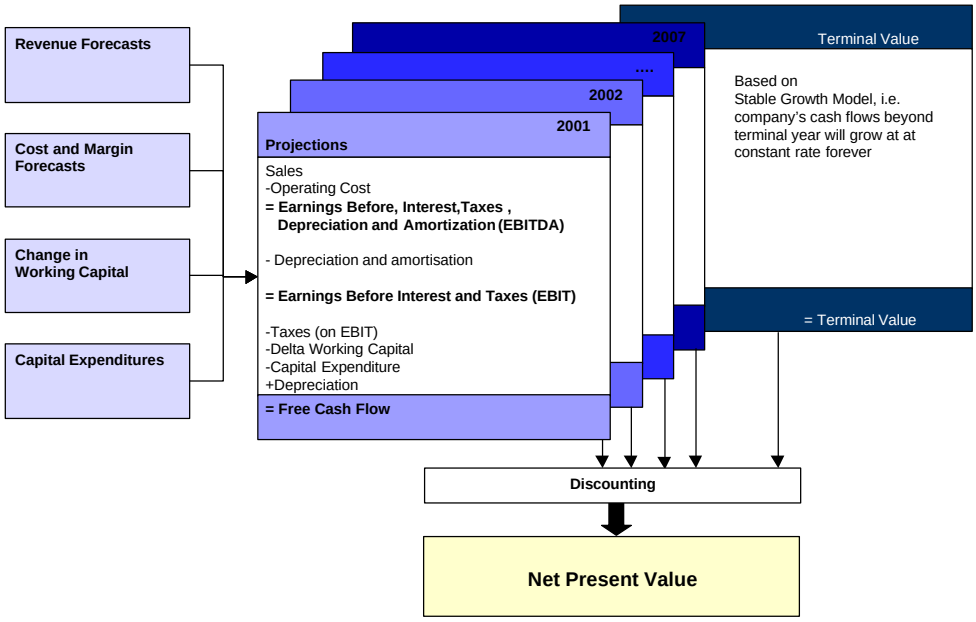

Figure 3: Illustration of the DCF approach

3.1.1 Advantages

As DCF analysis is based on the assumptions of the CAPM, it is an analytically correct valuation method. In contrast to the Comparable Companies analysis, volatile market conditions do not have an impact on the results. DCF therefore is often used as an additional point of reference. Since the discount rate is usually derived from the WACC, the DCF takes account of the relative riskiness of the projected cash flow. Accounting rules do not influence this approach, as valuation is based on projected cash flow.

3.1.2 Shortcomings

Since the terminal value often represents more than 50% of the entire DCF value it is therefore highly sensitive to the underlying assumptions, especially regarding the growth component in the terminal value and the discount rate. Using historical stock returns when estimating the beta depends heavily on the choice of the index. For volatile companies the beta is very high, resulting in a relatively high discount rate and a low net present value of cash flows. Estimating a "correct" value by applying the DCF approach therefore depends to a

large extend on the expertise and industry knowledge of the person doing the valuation. Moreover, the DCF approach neither considers different management options nor future investment opportunities. It only works if cash flows are subject to little uncertainty and the company is managed by a static management team. It does not capture the "true" value if there are large initial losses, highly volatile earnings or immense initial growth rates.

3.1.3 Case Study: DCF Valuation for SAP AG

To compare the different methods, we applied them to SAP AG and Tiscali. The valuation rangers are summarized in Figure 4 and explicated in the appendix. For all case studies, we used actual market data provided by investment bankers of one of Germany's top 5 banks.

The DCF valuation of SAP results in an estimated net present value per share of €151 or a total NPV of €MM 47,391. The corresponding spreadsheet for the calculation can be found in Appendix A, including a sensitivity analysis showing how a change in the underlying parameters of the terminal value changes the total value of the firm.

3.2 Comparable Companies Approach

Relative valuation using comparable companies aims to value assets based on the market price of similar companies [Damodaran 2001, 251-273] [Benninga/Sarig 1997, 305]. The quality of the CC approach is based on the selection of the peer group. Comparable companies must belong to the same industry and thereby offer similar products and do business in similar geographical markets. The size of the companies in terms of revenues and market capitalization must be comparable as well as capital and ownership structure.

3.2.1 Price Earnings Ratio

One of the most widely used ratios - the price earnings (P/E) ratio - compares the current stock price of a company with its earnings per share. The underlying idea behind P/E ratios is that high P/E ratios imply investors' belief in above average growth opportunities and relatively safe earnings for the firm. However, companies can also have a high P/E ratio not because the price is high but because the earnings are low [Brealey/Myers 1996, 72].

$$\text{Price Earnings Ratio} = \frac{\text{Market price per share}}{\text{Earnings per share}}$$

Formula 4: P/E ratio

Empirical studies found the precision of P/E ratios to increase when using companies with similar historic earnings growth rates, instead of considering the same industry classification [Boatsman/Baskin 1981]. Alford (1992) finds that adjustments in risk, growth differences, or in leverage do not lead to an improvement of valuation. Confirmed by Liu/Nissim/Thomas (2000), he concludes that a focus on the same industry classification is of utmost importance. According to Kim/Ritter (1999), multiples have only modest predictive ability because of the variations of these ratios within an industry. They prove that P/E multiples using forecasted instead of historic earnings result in much more precise valuations.

3.2.2 Revenue Multiples

As young companies often have no or negative earnings, valuation based on P/E multiples cannot be assessed. Using revenue multiples is an alternative approach. It is understood that firms trading at low multiples of revenues are viewed as comparatively cheap. As revenue is less volatile than earnings and not influenced by accounting decisions, revenue multiples are more reliable. The Enterprise Value to Sales (EV/Sales) ratio can be calculated as:

$$\text{Enterpise Value to Sales Ratio} = \frac{(\text{Market Value of Equity} + \text{Market Value of Debt - Cash})}{\text{Revenues}}$$

Formula 5: Enterprise Value to Sales ratio [Damodaran 1996, 338 and 2001, 319-352]

3.2.3 Earnings Multiples

The Enterprise Value to Earnings Before Interest, and Taxes (EV/EBIT) ratio and the Enterprise Value to Earnings Before Interest, Taxes, Depreciation and Amortization (EV/EBITDA) ratio are other multiples often used to value companies:

$$\text{Enterprise Value to EBIT(DA) Ratio} = \frac{(\text{Market Value of Equity} + \text{Market Value of Debt - Cash})}{\text{EBIT(DA)}}$$

Formula 6: Enterprise Value to EBIT(DA) ratio

Multiple	Advantages	Disadvantages
P/E	- Simple - Most often applied multiple	- Sensitive to corporate tax rate - Sensitive to capital structure
PEG	- Considers future earnings expectations	- Limited applicability if growth ratios low
EV/Sales	- Simple - applicable if no or negative earnings - Facilitates cross-border comparisons	- Ignores financial structures - Does not consider profitability
EV/EBIT(DA)	- Avoids bias caused by different taxation rates, capital structure - Facilitates cross-border comparisons	- Equity value is very sensitive to net debt for highly leveraged companies

Table 1: Summary advantages and disadvantages of different multiples

3.2.4 Advantages

As the comparable companies method is based on public information, market moods and perceptions are reflected, since it measures the relative and not the intrinsic value. Relative valuation is based upon fewer assumptions and can be conducted faster than DCF valuation.

3.2.5 Shortcomings

The simplicity of valuation by multiples is its deficiency [Benninga/Sarig 1997, 305]. Since no value determinants are analyzed, it is important to carefully select comparable firms. Also, outside variables like mergers and acquisitions in the respective sector can influence stock prices. Figures often fail to capture intangible assets, like quality of management. Hence, CC

based valuation should provide a valuable "sanity check" to assure the validity of a DCF analysis, but it should not be the only valuation method used [Benninga/Sarig 1997, 305].

3.2.6 Case: Comparable Companies Valuation of SAP AG

Applying CC approaches results in a forecasted SAP AG value of €26,311.32 MM. Results in different valuation ranges for each multiple as can be seen in Figure 4 and Appendix B.

3.3 Advantages and Disadvantages of Valuation Methods

Table 2 provides an overview of the advantages and disadvantages of the DCF and comparable companies approach as discussed before. Some of the disadvantages of the DCF and CC approaches can be overcome by applying the real options approach (ROA). As can be seen from Figure 4, the DCF values are high relative to CC valuations.

Approach	Advantages	Disadvantages
DCF	- The most theoretically sound method - Not influenced by temperamental market conditions - Appropriate for mature businesses with strong and stable cash flows	- Valuation is highly sensitive to underlying assumptions for cash flow, terminal value, and discount rate - Terminal value represents significant part of total value
Comparable Companies	- Based on public information - Market efficiency ensures that results reflect industry trends, risks, growth potential - Value obtained does not include a control premium	- Difficult to find truly comparable companies - Trading valuation may be affected by thin trading activities or small capitalization - Stock prices influenced by M&A activity - Result reflects what the market "tells" no matter if it is right or wrong

Table 2: Advantages and disadvantages of DCF and the CC approaches

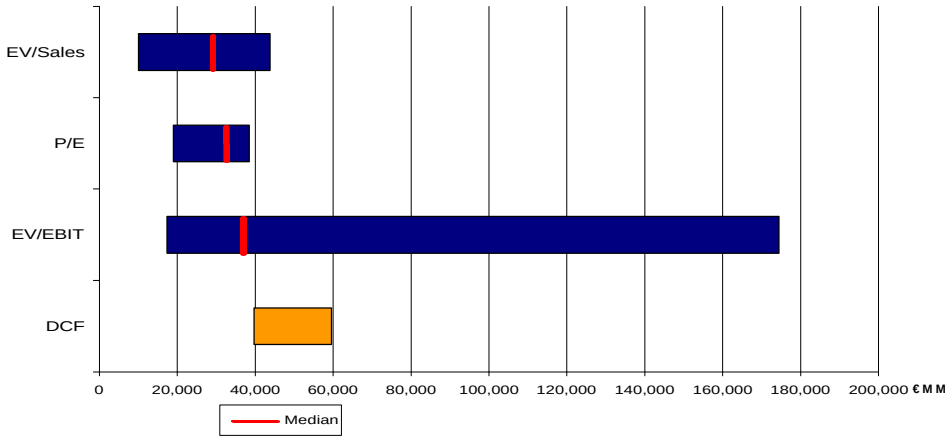

Figure 4: Valuation range of different multiples for SAP company value

4 The Real Options Approach

The premise underlying the application of the real options approach (ROA) is the challenge of an uncertain future. Trejo (2000) points out that the business strategy of a company resembles a series of options rather than a single projected cash flow. Options imply uncertainty and these alternatives can be captured with the help of the ROA. Hommel (2000) states that

disregarding management flexibility leads to a systematic undervaluation of companies. As Copeland et al. (2000, 399) state, ROA captures the value of this flexibility. The value determined using DCF does not differentiate between possible scenarios (e.g. successful product launch, development of an innovative technology, failure of an innovation). Especially software design and sourcing strategies are largely processes of decision-making under uncertainty, including the threats of competitive entries [Sullivan et al. 1999], making ROAs well suited to be applied when valuing software companies or IS strategies.

4.1 Real Options Defined

The real options approach employs the financial option theory based on the Black-Scholes formula [Mauboussin 1999]. The idea of options pricing is that an option provides the holder with the right, but not the obligation, to sell or buy a specified quantity of an underlying asset at a fixed price, called the strike price. A call (put) option gives the buyer the right to buy (sell) the underlying asset at the strike price any time prior to the expiration date of the option [Damodaran 2001, 354-356]. Figuratively, a ROA model can be described as follows:

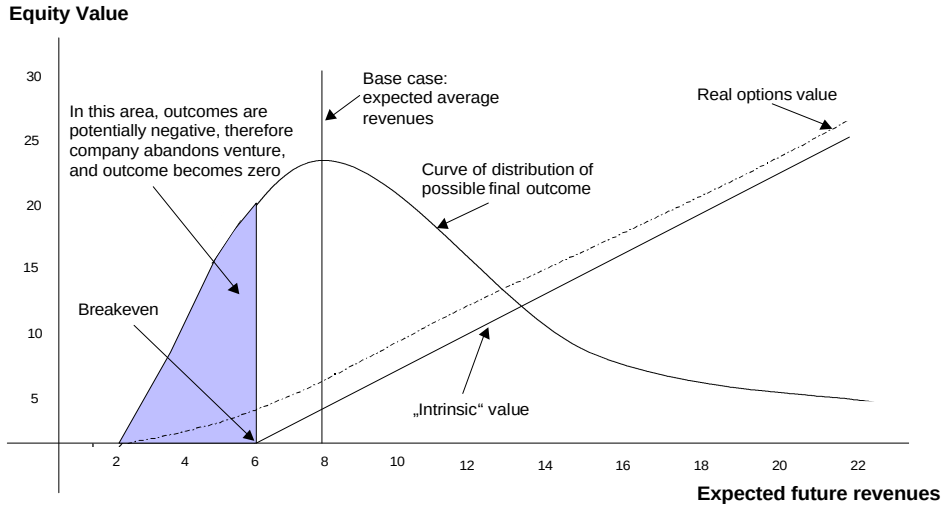

Figure 5: Real options model [based on: Hommel/Pritsch 1999]

In this figure, uncertainty in the value of expected future revenues and the accompanying equity value is represented by the shape of the curve as a distribution of possible outcomes. This lognormal distribution reflects outcomes observed in reality since a large portion of revenue is satisfactory, i.e. between 4 and 14 in Figure 5, and a small tail of revenues is extraordinary, i.e. above 14 in Figure 5. The spread of this distribution can be assessed through the volatility observed in markets of comparable companies. The base case describes the expected average revenue outcome and is used as a benchmark. The intrinsic value is shown by the straight line. It starts at an expected future revenue value of six as this reflects the worst case scenario. The dotted line represents the real options value. At the starting point the time value is greater than it is at the end when the expiration date is nearly reached. This is illustrated by the shrinking distance between the intrinsic value and the real options value. The blue shaded area reflects optionality. If the management of a company acts rationally, it will abandon the venture as soon as this area is reached.

4.1.1 The Black-Scholes Formula

In 1972 Black and Scholes presented their model for valuing dividend-protected European options (which can only be exercised on the expiration date). They used a portfolio composed of the options' underlying assets and a risk-free asset with the same cash flow as the option being valued to arrive at their formula. This portfolio is called 'replicating portfolio' [Damodaran 1996, 260-262] [Mauboussin 1999]. For a more detailed derivation of the equation see Grinblatt/Titman (1998, 274-312).

Companies can be valued using the Black-Scholes formula by mapping the relevant cash flow onto the Black-Scholes parameters (Figure 6). The remaining parameters are estimated based on similar companies. In 4.2 a practical four-step ROA approach is introduced

$$\text{Value of Call} = Se^{(b-r)T}N(d_1) - Xe^{-rT}N(d_2)$$

Formula 7:Value of a call

$$\text{Value of Put} = -Se^{(b-r)T}N(-d_1) + Xe^{-rT}N(-d_2)$$

Formula 8:Value of a put

where

S = stock price of underlying stock
X = strike of the option
R = risk free rate
B = 'cost of carry', defined as risk-free rate minus the dividend yield
T = expected life of option in years
s^2 *= variance of the underlying security*
N = notation for normal distribution

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(b + \frac{s^2}{2}\right)T}{s\sqrt{T}}$$

$$d_2 = d_1 - s\sqrt{T}$$

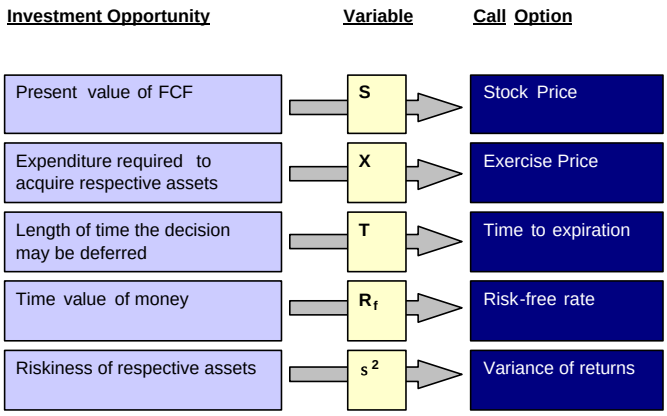

Figure 6: Link between investment opportunities and Black-Scholes inputs [Luehman 1998]

4.2 A Practical Approach

In order to assess a more "correct" value of a company, an option premium for uncertainty and flexibility must be included in the valuation. The total value of a company should therefore be the net present value determined by DCF analysis and an option premium calculated through the ROA. A thorough derivation and description of the practical implementation of the ROA can be found in Copeland/Antikarov (2001, 219-240), suggesting the following four-step process to value companies with the help of the ROA:

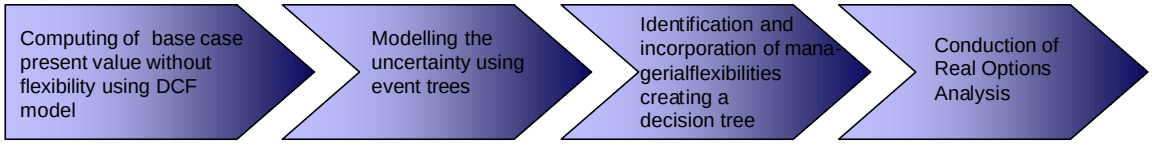

Figure 7: Four-step process to apply the real options approach

First, a company's NPV has to be determined, using the DCF approach. Step two is to build an event tree, based on the set of combined uncertainties that drive the volatility of the company's value. An event tree models the uncertainty that drives the value without any decision built into it and help clarify how the present value develops over time. The third step is to put the decisions that management may make into the nodes of the event tree to turn it into a decision tree. The event tree models the values that the company reaches through time, while the decision tree shows the payoffs from optimal decisions due to the respective scenario. These payoffs are those that would result from the option that is being valued. The final step is the valuation of the payoffs in the decision tree using the method of replicating portfolios applying the Black-Scholes formula.

4.2.1 Advantages

The traditional DCF model cannot value flexibility, contingency, or volatility because it fails to account for the set of options involved in business decisions. Since it can value uncertainty, the ROA can overcome this shortcoming. For example, if a company decides to defer an investment until it has more information on the market, the DCF approach would value this eventual opportunity zero, while the ROA correctly allocates some value to the future potential cash flow. Moreover, in standard finance, higher volatility means higher discount rates and lower net present values. When real options are priced, the higher the volatility , the higher the value of the implicit option due to the asymmetry of payoff schemes [Copeland/Koller/Murrin 2000, 428] [Mauboussin 1999].

4.2.2 Shortcomings

As practical knowledge about how to use the ROA is not yet widespread, and as this is a very time-consuming approach, the readiness to adapt this method is currently relatively small. The underlying assumptions of the Black-Scholes formula, such as known volatility, fixed interest rates, and zero dividends are very strict and typically cannot be assumed in reality.

4.2.3 The Tiscali Case

As there is no reliable data for a valuation of SAP based on the ROA, Tiscali is valued using the ROA. Its IPO was priced at €46 in October 1999. The theoretical IPO price calculated by the Real Options Group was €309, consisting of a NPV calculated by the DCF approach of €56, plus an option to enter eCommerce equaling €65, plus the option to expand to Europe worth €110, and finally the option to enter UMTS equaling €78. Compared to a value of €46 determined by traditional valuation methods, a value of €309 seemed exaggerated until two month after the initial public offering when Tiscali shares hit this value as shown. See Appendix C for details.

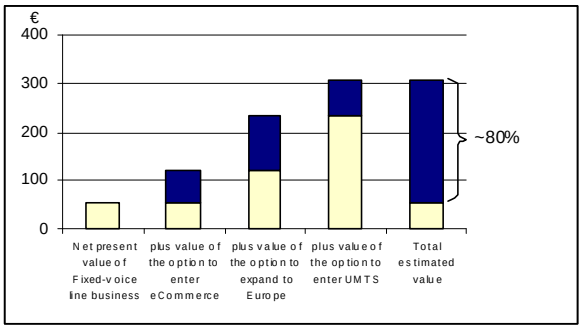

Figure 8: Value components of estimated Tiscali IPO price applying the ROA

4.3 Status Quo Science versus Practical Implementation

4.3.1 ROA is investment banking

Despite growing public and academic interest, the practical relevance of ROA seems to be small. To understand the reasons behind this discrepancy, we conducted extensive personal interviews with investment bankers from Deutsche Bank, Merrill Lynch, Morgan Stanley, and Commerzbank. According to them, the ROA is in fact not yet being applied there. Due to its complexity and the problems arising when estimating the underlying parameters, this approach lacks acceptance. As it is not taught at most universities, analysts entering investment banking are typically not equipped with the necessary knowledge. Some investment bankers admit that it is just too troublesome to acquire a working knowledge of this matter as long as established methods are broadly accepted. Furthermore, clients do not accept this approach as they lack understanding for it. One associate states that it is easy to argue with a client whether or not a company should be priced at 4 or 6 times an EBIT-multiple but that it is rather hard to convince someone that the time to expiration of the underlying option should be extended in order to arrive at a higher company value.

In most cases, a company is valued uisng the DCF and the CC approach. The DCF result is often used to check the value based on the CC approach for plausibility. However, there are tendencies to apply the ROA in the field of Equity Research when valuing new emerging technologies, for example in the semiconductor industry. Besides, ROA is quite popular within the oil industry.

4.3.2 ROA in IS research

There is a growing IS research community discussing ROA based methodologies for addressing the problem of IS valuation. As the quote from the ICIS 2001 debate summarized, especially valuing IS flexibility and the associated problem of optimal IT investment time and scope are focused on. As Taudes/Feurstein/Mild (1999) note: „Infrastructure is a necessary investment that business units of functional areas are unlikely to make“. Here, ROA is discussed as a means of overcoming deficiencies of controlling theory when applied to network problems. Especially in the context of IS sourcing decisions, the valuation of IS is key. How can fair prices for the future production of IS services be determined when the value contribution by the IS cannot be measured in a sophisticated way and when the future is indeterminate? IS valuation approaches from controlling theories are presented in [Kargl 2000; Krcmar

2000] and include TCO models (total cost of ownership) as proposed by Gartner Group in 1986 [Berg/Kirwin/Redman 1998; Emigh 2001; Riepl 1998], scoring models or qualitative models such as Balanced Score Cards [Wiese 2000]. Most of these models focus on the cost side of IS and cannot cope with many important value aspects like positive network effects and future uncertainties and opportunities. Responding to the challenge of valuing IS flexibility, Taudes/Feurstein/Mild 2000 argue that a particular uncertainty endemic to (typically long-term) infrastructure decisions is the scope of future (usually shorter-term) applications utilizing that infrastructure. Application software is significantly more subject to changes in functionality (and thereby utility) over time than is the underlying infrastructure which is typically very hard to change, politically as well as financially. This has the infrastructure's flexibility regarding future applicability appear an important aspect that has not been dealt with so far. Corresponding to our findings above, they find that budgeting models like the NPV method only determine lower utility bounds for unchanged software applications and that future changes might be considered using option price models. An online bibliography of "Software Investment Analysis – Real Options and related Topics" is provided at http://wwwsel.iit.nrc.ca/~erdogmus/SIA/SIA-Biblio.html. Other contributions arrive at similar findings, see also [Merton 1998] [Gaynor/ Bradner 2001] [Amram/Kulatilaka 1999] [Balasubramanian/Kulatilaka/Storck 1999] [Taudes/Feurstein/Mild 2000].

In the future, we will use the ROA as part of a network analysis framework supporting sourcing decisions for financial service providers by modeling the cash flow implications of different IS infrastructures and choice of sourcing partners.

5 Conclusions

What is true value of IT firms and how do capital markets professionals like especially investment bankers cope with the valuation problem occasioned by an uncertain future? It turns out that there are several alternative methods that all yield quite different results. For demonstrating the influence of the choice of the valuation method on the valuation result, we determined the values of SAP AG and Tiscali resulting in substantially different company values. When valuing a company, the DCF method or the CC approach are mostly applied by investment banks. While they have analytical (DCF is conforming with the CAPM) and practical (widespread, multiples are simple) advantages, substantial problems remain like especially ignoring future optionalities so they most probably miss the true economic *value*. The methodological shortcomings, such as their static character or bias caused by market moods can partially be overcome by using the real options approach.

“Real options capture the value of managerial flexibility to adapt decisions in response to unexpected market developments. The real option method enables corporate decision-makers to leverage uncertainty and limit downside risk. Companies create shareholder value by identifying, managing and exercising real options associated with their investment portfolio. The real options method applies financial options theory to quantify the value of management flexibility in a world of uncertainty” (http://www.real-options.de/). Generally, ROA are perhaps the most promising area for valuation of intangible assets, Information Systems Infrastructure and other non primary commercial assets. According to Upton (2000), “real option approaches attempt to extend the intellectual rigor of option-pricing models to valuation of non-financial assets and liabilities. Instead of viewing an asset or project as a single set of expected cash flows, the asset is viewed as a series of compound options that, if exercised, generate another option and a cash flow”.

As the practical knowledge of the ROA is not yet widespread and as the underlying estimation of parameters is difficult, this approach is not often applied, neither in IPO price determination nor in IS valuation. But interestingly, "when NPV was introduced in the mid 1960's, it was rejected for having unrealistic assumptions and for being overly complex" [Tallon et al. 2002, 138].

For the IS domain, ROA provides a rich ground for developing "tools for disciplined decision making" [Chen et a. 2001]. Besides valuing IT flexibility [Taudes et al. 2000], the management of IT investment risk is an important application domain [Benaroch 2002]. Recently, the value of applying ROA instead of traditional valuation approaches has been shown by Benaroch & Kauffman (2000) who use a case study to demonstrate how traditional approaches would have generated wrong IT investment recommendations in an electronic banking network. Of course, to end with a caveat of Nobel Laureat Robert Merton (1998), one has to be cautious when applying any valuation model and when "their mathematics become too interesting. The mathematics of financial models can be applied precisely, but the models are not at all precise in their application to the complex real world. Their accuracy as a useful approximation to that world varies significantly across time and place. The models should be applied in practice only tentatively, with careful assessment of their limitations in each application"

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Appendix A: DCF valuation of SAP AG

A 15% sales growth for the first three years decreasing over time to a sales growth of 11% in 2011 is assumed. Based on estimates for the EBIT margin, tax rate, depreciation, capital expenditures, and the change in working capital by Credit Suisse First Boston [Clayton/Hammond/Volkel/Laverty/ Lyall/Nester 2001, 40, 41] and Metzler [Kuerten 2001, 5] the free cash flow for each year within the period of stable growth from 2001 to 2011 is assessed. The sum of all cash flows has a total value of €23,530.31 MM. The WACC of 9% is calculated on the basis of a beta of 1.15 and a risk free rate of 4.0%. These cash flows are discounted back to the present with the WACC resulting in a total net present value of all cash flows of €12,715.81 MM. Assuming a growth rate of 4.5%, which is typical of companies within the software sector, a terminal value of €89,478 MM starting in the terminal year 2011 is calculated. Discounting this value back to the present with a discount rate of 9% results in a net present value of the terminal value of €34,675 MM. Adding the net present value of cash flows of €12,715.81 MM to the net present value of the terminal value of €34,675 MM leads to a total sum of €47,391 MM. The current market capitalization of SAP is approximately between €40,000 and 50,000 MM. Dividing the calculated sum by the number of shares (314.715 MM) results in a net present value of €151.07 per share. The sensitivity analysis shows how a change in the underlying parameters of the terminal value changes the total value of the firm.

[in € MM]

	2001E	2002E	2003E	2004E	2005E	2006E	2007E	2008E	2009E	2010E	2011E	Sum	TV
Sales	7,400.00	8,510.00	9,786.50	11,254.48	12,830.10	14,626.32	16,527.74	18,676.34	20,917.50	23,427.60	26,004.64	169,961.22	28,865.15
Growth Rate	15%	15%	15%	14%	14%	13%	13%	12%	12%	11%	11%		
EBIT	1,443.00	1,659.45	1,908.37	2,194.62	3,849.03	4,387.89	4,958.32	5,602.90	6,275.25	7,028.28	7,801.39		8,659.55
EBIT margin	0.20	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30		0.3
Tax	-548.34	-630.59	-687.01	-702.28	-1,231.69	-1,404.13	-1,586.66	-1,792.93	-2,008.08	-2,249.05	-2,496.45		-2,771.05
Tax rate	0.38	0.38	0.36	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32		0.32
Depreciation	230.00	270.00	320.00	380.00	451.00	535.00	634.00	751.00	889.00	1,052.00	1,293.00		1496
Earnings	1,124.66	1,298.86	1,541.36	1,872.34	3,068.34	3,518.77	4,005.66	4,560.97	5,156.17	5,831.23	6,597.95		7,384.49
Capital Expenditures	-250.00	-270.00	-320.00	-380.00	-451.00	-535.00	-634.00	-751.00	-889.00	-1,052.00	-1,254.00		-1385
Delta Working Capital	-427.00	-280.00	-367.00	536.00	-632.00	-746.00	-880.00	-1,039.00	-1,226.00	-1,446.00	-1,753.00		-1973
Free Cash Flow	447.66	748.86	854.36	2,028.34	1,985.34	2,237.77	2,491.66	2,770.97	3,041.17	3,333.23	3,590.95	23,530.31	4,026.49
Net present value (WACC 9%)	410.70	630.30	659.72	1,436.93	1,290.34	1,334.31	1,363.02	1,390.66	1,400.24	1,407.99	1,391.61	12,715.81	
NPV of CF	12,715.81												

Sensitivity Analysis

Terminal Value

	Terminal growth rate		
WACC	4.0%	4.5%	5.0%
8.5%	89,478	100,662	115,043
9.0%	80,530	89,478	100,662
9.5%	73,209	80,530	89,478

NPV of TV

	Terminal growth rate		
WACC	4.0%	4.5%	5.0%
8.5%	36,474	41,034	46,896
9.0%	31,208	34,675	39,010
9.5%	26,978	29,676	32,973

Total Net Present Value

	Terminal growth rate		
WACC	4.0%	4.5%	5.0%
8.5%	49,190	53,749	59,611
9.0%	43,924	47,391	51,726
9.5%	39,694	42,392	45,689

Difference 19,918 €MM

NPV per share

	Terminal growth rate		
WACC	4.0%	4.5%	5.0%
8.5%	157	171	190
9.0%	140	151	165
9.5%	126	135	146

Appendix B: Comparable companies valuation of SAP AG

The choice of the SAP peer group is based on peer groups previously selected by Lehman Brothers [Skiba/Pollard/Herman 2001, 25] and Credit Suisse First Boston [Clayton/Hammond/ Volkel/Laverty/Lyall/Nester 2001, 42]. The EV/Sales multiple, the P/E ratio, and the EV/EBIT multiples estimates are taken from Bloomberg and JDC data. The corresponding spreadsheet for the calculation can be found in Appendix B.

First, the sum of each positive multiple of each of the years from 2000 to 2002 is calculated. This sum is then divided by the number of values within this sum, resulting in the mean multiple. This approach can show great biases, for example a value of €76,264.34 MM assessed by applying the mean multiple for EV/EBIT 01 which consists of a comparatively high estimate for EV/EBIT for BMC Software. It is therefore better to also determine the median and use this figure for further calculation. The estimated enterprise value is then assessed by multiplying the ratio with the respective figure in the denominator. For example, a company value based on the EV/Sales ratio in 2001 is calculated as follows: The median multiple of 4.5 is multiplied with the sales figure for 2000, €6,264.60 MM, resulting in a forecasted value of €26,311.32 MM based on the achieved sales in 2000.

The different valuation ranges for each multiple for the year 2001 can be seen in Figure 4. For example, the range for the EV/Sales multiple is determined by multiplying the sales figure for the year 2000 of €6,264.60 MM with the highest multiple of 7 which belongs to Oracle resulting in a value of €48,852.20 MM and with the lowest multiple of 1.6 which belongs to i2 Technologies, resulting in a value of €10,023.36 MM. If sales figures for the year 2001 were available these figures should be applied in order to receive more current results.

The final company value determined by applying the comparable companies approach depends in the end on the subjective estimation of the mean of all medians by the analyst valuing the company. In this case it would be around the value of €30,000 MM.

Peer Group	EV/Sales 00	EV/Sales 01	EV/Sales 02 e	P/E 00	P/E 01	P/E 02 e	EV/EBIT 00	EV/EBIT 01	EV/EBIT 02 e
Oracle Corporation	6.4	7	6.5	30.9	29.9	25.6	19.7	19.4	16.2
Siebel Systems Inc.	5.2	4.7	4.7	41.8	45.6	43.4	25.6	28.9	25.8
Bea Systems	7.8	6.1	5.9	58.2	48.3	44.9	93.6	58.8	36.7
BMC Software	n/a	5.7	n/a	20.1	52	28.2	n/a	194.5	n/a
i2 Technologies	1.5	1.6	1.8	22	n/a	n/a	-3.5	-1.3	-21.8
Ariba Inc	3.2	1.9	n/a	n/a	n/a	n/a	-2	-0.3	n/a
Peoplesoft Inc.	5.6	4.5	3.4	108.9	60.7	48.1	92.1	38.6	21.6
Commerce One	1.9	1.9	n/a	n/a	n/a	n/a	-5.1	-0.3	n/a
E.Piphany	2.5	3.1	3.3	n/a	n/a	n/a	-0.4	-1.1	-11.6
Mean	4.26	4.06	4.27	46.98	47.30	38.04	57.75	85.05	25.08
Median	4.2	4.5	4.05	36.35	48.3	43.4	58.85	38.6	23.7

Sales (2000)	6,264.60
Earnings (2000)	634.30
EBIT (2000)	896.70

Valuation Range

with Mean	26,702.86	25,406.43	26,728.96	29,801.53	30,002.39	24,128.77	51,784.43	76,264.34	22,484.75
with Median	26,311.32	28,190.70	25,371.63	23,056.81	30,636.69	27,528.62	52,770.80	34,612.62	21,251.79

Data source: JCF and Bloomberg

Appendix C: Real options valuation of Tiscali

Tiscali, founded in 1999, is a fast-growing Italian telecom and Internet company offering ISP, eCommerce services, and UMTS. Considering the company's future business opportunities, the ROA seems to be an applicable approach for determining an IPO price. Its initial public offering was priced at €46 in October 1999. The Real Options Group London went further and valued Tiscali at €309 a share. The following steps should be employed in the shares' valuation: first, Tiscali's existing business (Fixed-line voice) must be valued using the DCF approach. Second, the growth option to start an eCommerce business portal in Italy must be valued. Third, since depending on the success of its retail portal Tiscali plans to expand to Europe, this expansion option must also be valued. In addition, the company invests in UMTS technology, so this growth option must be valued as well. Finally, by summing up steps one to four, a theoretical IPO price can be assessed. It is clear that many of the business opportunities and uncertainties that confront Tiscali can be measured by real options.

The theoretical IPO price calculated by the Real Options Group was €309. It consists of a net present value calculated by the DCF approach of €56, plus an option to enter eCommerce equaling €65, plus the option to expand to Europe worth €110, and finally the option to enter UMTS equaling €78.

As shown in Figure 8 about 80% of the price is derived from the option premiums. The IPO price can increase further if new options appear and are optimally exercised. Parameters should to be updated continuously to keep this value as accurate as possible.