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Valuing Joint Ventures Using Real Options

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Abstract: As the valuation of strategic measures becomes increasingly important, relatively few articles have discussed the valuation methods pertained for joint ventures. This paper shows that real options contribute to a better valuation of joint venture projects through superior reflection of the value drivers compared to traditional valuation methodology. Particularly, the strategic value of a joint venture and the value of flexibility that stems from a less than full commitment can be determined using options valuation. Besides reviewing the basics of real options, the paper discusses the key levers of joint ventures and shows the power of real options in the valuation process. We apply four option types (option to defer, option to expand/acquisition option, option to innovate, and option to abandon) to an imaginary joint venture example and show how to use the Black/Scholes and binomial valuation techniques to value these options. Of the four option types, particularly the option to innovate is important, as it allows to reflect the strategic value of a joint venture generating future business opportunities. Despite its advantages, this valuation methodology also has some drawbacks that are discussed in the concluding section.

Keywords: Joint ventures, real options, option valuation, Black/Scholes model, binomial option valuation

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α, α_X	Share of company in joint venture equity
δ	Continuously adjusted option delta
σ [σ_{JV}]	Volatility [of JV returns]
Δ	Option delta (hedging ratio)
Ω	Continuously adjusted financing amount
$\phi(\cdot)$	Binomial distribution function
B	Riskless investment
B_X	Benefits of joint venture for partner company
CF_i	Cash-flow in period i
C_X	Costs of joint venture for partner company
C	Call option value
C_A	Value of acquisition option
C_d	Call option value under negative circumstances
C_u	Call option value under positive circumstances
C_W	Value of option to defer (waiting option)
d	Gross asset return under negative circumstances
d_1, d_2	Black/Scholes parameters
D	Dividend payments
$E(\cdot)$	Expected value
I_{JV}	Investment into joint venture
JV	Joint Venture
$N(\cdot)$	Cumulative normal density function
NPV_{Opt}	Net Present Value including real options value
n	Sample size, number of periods
P	Put option value
P_A	Value of option to abort
P_C	Call option price
P_d	Put option value under negative circumstances
P_{JV}	Joint venture profits
P_P	Put option price
P_u	Put option value under positive circumstances
r	Risk free rate
t	Option maturity
u	Asset return under positive circumstances
V, V_i, V_0	Asset value
V_{JV}	Basic joint venture value
V_n	Expected net present value of investment in JV
$V_{Options}$	Real options value
WACC	Weighted Average Cost of Capital
X	Strike price

1. Introduction

Many criteria for the evaluation of corporate success exist, but the creation of shareholder value is by far the most commonly used today.[1] In this mindset, any strategy or strategic measure implemented by management ultimately aims at adding value for the company's shareholders.[2] Therefore, the quantitative evaluation of strategic measures is an important tool for management complementing qualitative strategy frameworks.[3] Moreover, decision making based on purely qualitative criteria is not sufficient from the perspective of financial management.[4]

A popular measure from the toolbox of corporate strategy are joint ventures. Creating a new organizational unit with two separate corporate owners can among others help a corporation to establish a new strategic position.[5] Several examples from recent years show that the popularity of joint ventures remains high: Siemens and Fujitsu setting up a PC joint venture, Sony and Ericsson cooperating in mobile phones, or Deutsche Bank creating a joint venture to enter the Chinese equity market.[6]

While the strategic intent of joint ventures and their critical success factors have been widely discussed in the academic literature, there is, however, little coverage of their valuation so far. This paper aims at contributing to the understanding of joint venture valuation by looking at real options as a means to value joint ventures. It concentrates on the relationship between the value levers of joint ventures and the value-driving parameters of real options, as well as the practical application of real options methodology to the valuation of joint ventures. The analysis shows that real options, compared to traditional valuation methods, are better able to reflect the flexibility inherent to collaborative ventures. We use four real option types that can be applied to the valuation of joint ventures. This valuation method, however, is also limited by the complexity of its application and the large number of estimated parameters.

The existing literature can be classified into three broad categories: quantitative financial literature, laying out the foundations of the option valuation methodology, real options literature, discussing the application of option valuation to investment decisions, and literature treating the valuation of joint ventures.

The first category contains an abundant amount of literature based on the classical articles of *Black and Scholes (1973)* and *Cox, Ross and Rubinstein (1979)*. *Black and Scholes* develop a continuous valuation formula while *Cox, Ross and Rubinstein* work out a binomial model. Compound options described by *Geske (1979)* are another important building block.

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1 Rappaport (1986), Copeland/Koller/Murrin (1996), Pape (2004)
2 And of course, as a consequence, for other stakeholders, too.
3 Hitt/Hoskisson/Ireland (1997) among others provide an overview of such frameworks.
4 Kester (1984), p. 157, Amram/Kulatilaka (1999a), p. 100, Amram/Kulatilaka (1999b), p. 30, Rappaport (1992), p. 91
5 Kogut (1988), Kutschker/Schmid (2002), pp. 851-861
6 Financial Times (1999a), Financial Times (1999b), Harnishfeger/Rahman (1999), The Economist (2001), Guerrera/McGregor (2003)

An equally large amount of articles and monographies transfer the option valuation concept to real-life investment decisions. *Dixit and Pindyck (1994)*, *Trigeorgis (1996*) and *Amram and Kulatilaka (1999b)* provide an overview of the methodology and discuss the application to investment decisions under high uncertainty. *Luehrman (1998a)* and *Copeland and Keenan (1998)* provide a more managerial approach to the valuation technique; *Luehrman (1998b)* even develops a framework considering strategic decisions as real options. *Kogut and Kulatilaka (2001)* approach the strategic angle by valuing core competencies of a company using options. Valuing an entire business using option methodology has been systematically analyzed by *Koch (1999)* and *Rams (1999)*; *Buckley et al. (2002)* apply real options to determine the market value of stocks. *Leithner and Liebler (2003)* discuss the use of real options for M&A transactions.

Valuing a joint venture business using real options, however, has not yet been widely discussed. *Kogut (1991)* uses real options to deduct the optimum exercise time for an acquisition option on a joint venture. *Chi and McGuire (1996)* apply options valuation to explicit options secured in joint venture agreements. *Kim and Seth (2001)* discuss some real option types that can be present in an international joint venture with a particular focus on compound options.

The paper is laid out as follows. The next section reviews the basics of real options valuation. Part three discusses the value drivers of joint ventures and draws parallels to real options. Part four develops four types of real options that can be used for joint ventures, while part five critically discusses the advantages and drawbacks of the methodology. The final part summarizes the conclusions.

2. Introduction to real options

This section reviews basics of option valuation and real options and discusses the value drivers of real options. We use two methods to value options, the binomial model developed by *Cox, Ross and Rubinstein (1979)* and the continuous valuation formula of *Black and Scholes (1973)*. Both valuation methods are briefly reviewed at the beginning of the section.

2.1 Valuing financial options

A financial option represents the right of the option holder to purchase (call option) or sell (put option) shares at a set price (the strike price) and at a predetermined time (in the case of a European option) or within a predetermined period of time (in the case of an American option).[7] The value of an option is determined by the value of the underlying security at the time of exercise. Let C and P denote the value of a call and put option respectively, X the strike price and V the value of the underlying security. The option value when exercised (i.e. the intrinsic value) can then be written as:

[7] Koch (1999), p. 40, Cox/Ross/Rubinstein (1979), p. 229, Brealey/Myers (1996), pp. 558-559, Damodaran (1996), pp. 356-357, Merton (1973), pp. 256-257

(E.1) $C = Max\ (0; V - X)$

(E.2) $P = Max\ (0; X - V)$

2.1.1 Binomial option valuation

The binomial model to value options is based on a series of assumptions:[8]

(A.1) The model assumes that the price of the underlying security follows a binomial process and either increases by u or decreases by d in each discrete time period. The two states are mutually exclusive and are realized with probabilities p or (1 - p) respectively. The rates of return (u - 1) and (d - 1) are based on the volatility σ so that

(E.3) $u = e^{\sigma} \text{ and } d = \frac{1}{u}$

Consequently, the call option value C in period t = 1 is either $C_u = Max (0; uV_0 - X)$ or $C_d = Max (0; dV_0 - X)$, where V_0 denotes the value of the underlying asset at t = 0.[9] Similarly, the put option value is either $P_u = Max (0; X - uV_0)$ or $P_d = Max (0; X - dV_0)$.

(A.2) The financial markets are considered to be frictionless with no transaction costs, taxes or arbitrage opportunities. The risk free rate r is known and constant. Securities are freely divisible and can be purchased and sold without limitation. Short-sales of securities with full use of the proceeds are allowed. Investors can borrow and lend without limitations at identical rates.

(A.3) There are no dividends.[10]

(A.4) All options will exclusively be exercised at the expiration date.[11]

Based on these assumptions, the option value can be determined by creating an equivalent portfolio that has an identical pay-off structure and the same risk as the option. The portfolio is composed of Δ shares of the underlying security and riskless bonds with a market value of B. Assuming no arbitrage opportunities, the option value must equal the portfolio value. The option value can then be expressed as[12]

(E.4) $C = \Delta V_0 - B$ where

(E.5) $\Delta = \frac{C_u - C_d}{(u-d)V_0}$ and

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[8] Koch (1999), pp. 42-43, Black/Scholes (1973), pp. 640-641, Cox/Ross/Rubinstein (1979), pp. 231, Trigeorgis (1996), p. 83

[9] (E.3) applies only to single period calculations of u and d. For the calculation of multiple period rates of return see Hull (2003), pp. 393.

[10] Dividends generally reduce the value of calls and increase the value of puts. We will introduce dividends to the analysis later.

[11] We will consider premature exercising for American put options later.

[12] Cox/Ross/Rubinstein (1979), pp. 233-234, Brealey/Myers (1996), p. 574, Koch (1999), p. 45. The formulas are used for the valuation of a call; the valuation of a put is analogous. Cox/Ross/Rubinstein (1979) use a '+' sign in (E.4). Since B must be negative, we find this alternative expression more intuitive and have adjusted (E.6) accordingly.

(E.6) $$B = \frac{dC_u - uC_d}{(u-d)} \cdot \frac{1}{1+r}$$

In order to value more than one period, an iterative backward process is used: the options are valued period by period using the above shown methodology, starting with the last period and moving backwards. When using intervals different from years, the annual risk free rate r has to be adjusted to the respective lengths of the individual periods.[13]

Dividends paid to the holder of the underlying security change the value of options based on that security. As a call option holder, dividends paid on the security are not received unless the option is exercised; therefore, the present value of dividend payments has to be deducted from the share price (i.e., the value of the underlying asset). For the holder of a put option, dividends represent opportunity cost in case he exercises the option before a dividend payment. To include dividends D into the binomial valuation model, C_u and C_d (for calls) and P_u and P_d (for puts) are adjusted for those periods where dividends are paid.[14]

(E.7) $C_u = Max\ (0; (uV_0 - D) - X)$ and $C_d = Max\ (0; (dV_0 - D) - X)$

(E.8) $P_u = Max\ (0; X - (uV_0 - D))$ and $P_d = Max\ (0; X - (dV_0 - D))$

Assumption (A.4) supposed that all options are exercised at the expiry date. American options, however, can be exercised anytime before they expire. Premature exercising, therefore, is an issue.

An American call without dividends should never be exercised prematurely. The value of a potentially positive future development of the share price plus the interest payments on an investment of the strike price is always larger than zero, making the investor wait until the expiry date. An American put option without dividends, on the other hand, should be exercised before expiry if the value of interest payments on the proceeds from the sale exceeds the value of future share price changes. In the case of dividends, premature exercising can be reasonable if, in the case of a call, the value of the dividend payments exceeds the interest proceeds from the strike price or vice versa for a put.[15]

Premature exercising can be integrated into the binomial model by comparing the option value when exercised immediately to the value of holding out for another period. Immediate exercising is only reasonable if the exercise value is higher then the value of waiting. The respectively higher value is then used for subsequent calculations.

[13] Brealey/Myers (1996), pp. 595-596; Cox/Ross/Rubinstein (1979) develop a general valuation formula for multiperiod valuations.
[14] Koch (1999), pp. 61-62, Amram/Kulatilaka (1999b), pp. 131
[15] Koch (1999), pp. 64-65, Trigeorgis (1996), p. 79, Merton (1973)

2.1.2 Black/Scholes Valuation

The binomial model assumes a discrete development of the underlying asset value. Yet, the value of most underlying assets, and particularly that of shares, adjusts continuously. *Black and Scholes (1973)* develop a valuation model that allows to take a continuous price development into account. The model is based on assumptions identical to those of the binomial model except:

(A.1) *Black and Scholes (1973)* assume a continuous development of the security price following a random walk. The period returns on securities are assumed to be lognormally distributed.

(A.4) Only European options are considered.

Similar to the approach of *Cox, Ross and Rubinstein (1979)*, the option is valued by creating an equivalent portfolio with an identical risk-return-profile composed of δ shares of the underlying security and a borrowed amount of Ω. Since the value of the portfolio equals the value of the option, a valuation formula similar to (E.4) can be derived:

(E.9) $C = \delta V0 - \Omega$

As the underlying share price develops continuously, however, the portfolio needs to be adjusted continuously as well, leading to differential equations determining the values for δ and Ω. *Black and Scholes (1973)* have proven that solving these equations is possible and derived the following valuation formula:[16]

(E.10) $C = N(d_1)V_0 - N(d_2)Xe^{-rt}$

where

$$d_1 = \frac{\ln(\frac{V_0}{X}) + (r + \frac{\sigma^2}{2})t}{\sigma\sqrt{t}} \text{ and}$$

$$d_2 = \frac{\ln(\frac{V_0}{X}) + (r - \frac{\sigma^2}{2})t}{\sigma\sqrt{t}} = d_1 - \sigma\sqrt{t}$$

$N(d_1)$ replaces the option delta δ and the term $N(d_2)Xe^{-rt}$, derived from the continuously discounted strike price Xe^{-rt}, is substituted for Ω. Differences in option value between the binomial and the continuous model are due to the approximate nature of the bino-

[16] A detailed derivation of the valuation formulas can be found in Black/Scholes (1973). See also Koch (1999), p. 82 and Brealey/Myers (1996), p. 578. N(·) denotes the cumulative normal density function.

mial valuation; for a large number of periods ($t \rightarrow \infty$) the results of both models converge.[17]

Put options can be valued using the same formula, albeit with opposite signs:[18]

$$\text{(E.11)} \quad P = -N(-d_1)V_0 + N(-d_2)Xe^{-rt}$$

Since American options can only be valued using the Black/Scholes formula if they are not exercised prematurely, a valuation of American options with dividends must use the binomial model. In the case of European options, dividend payments can be integrated by subtracting the present value of all dividend payments up to the expiration of the option from the current underlying security price.[19]

2.2 Real options valuation

2.2.1 Options and real investment projects

For most investment projects, management can adapt their investment strategy as the environment of the project changes and, thus, can influence the cash flows of a project even after the initial investment has been made. Practitioners frequently recognize these opportunities as "strategic" issues, but they fail to assign a value to this flexibility.[20] Traditional discounted cash flow (DCF) valuation or the net present value rule are not able to reflect this flexibility as they assume a stationary structure of future cash flows. Uncertainty and flexibility in an investment project are neglected.[21]

Consequently, practitioners and academics have started to use real options transferring the option valuation methods discussed above to real investment projects or decisions.[22] Based on the traditional DCF valuation, real option methodology corrects for the value of managerial choices by explicitly valuing them as options: the DCF value of a project is increased by the value of its options.[23]

$$\text{(E.12)} \quad NPV_{Opt} \equiv -CF_o + \sum_{t=1}^{T}\left(\frac{E(CF_t)}{(1+WACC)^t}\right) + E\left(V_{Options}\right)$$

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17 Cox/Ross/Rubinstein (1979), pp. 251, Brealey/Myers (1996), pp. 598, Koch (1999), p. 83; Cox/Ross/Rubinstein (1979) develop a formula for any number of periods t based on the binomial distribution: $C = V_0\,\phi(a;t,p') + X(1+r)^{-t}\,\phi(a;t,p)$. Replacing the binomial distribution by a normal density function for $t \rightarrow \infty$ and discounting X continuously yields the Black and Scholes formula.

18 Black/Scholes (1973), pp. 641-642

19 Brealey/Myers (1996), pp. 605-606

20 Brealey/Myers (1996), p. 589; Howell/Jägle (1997), however, only found a weak relationship between investment decisions and the recognition of strategic values in practice.

21 Kim/Seth (2001). It is possible to a certain degree to integrate uncertainty and flexibility into a traditional cash flow valuation by using decision trees. However, decision trees are frequently criticized for not being able to sufficiently take into account asymmetric investment pay-offs. Furthermore, the choice of the appropriate discount rate is difficult to make; Brealey/Myers (1996), pp. 255 and p. 594, Copeland/Koller/Murrin (1996), pp. 467, Meise (1998), pp. 40-41, Freihube (2001), pp. 148-149, Antikarov/Copeland (2001), p. 90.

22 Koch (1999), pp. 35-36, Trigeorgis (1993), pp. 202-203, Brealey/Myers (1996), p. 592, Meise (1998), pp. 6

23 Koch (1999), p. 36, Trigeorgis (1993), p. 203, Trigeorgis (1996), p. 124, Kogut (1991), p. 21

NPV_{Opt} represents the net present value of the project taking into account the initial investment [CF_0], the expected cash flow in period t [$E(CF_t)$], the weighted average cost of capital [WACC] and the expected real options value [$E(V_{Options})$]. The last term represents the expected value of options created by managerial flexibility. In order to value it, the real option concept exploits an analogy between real investment projects and financial options: Similar to financial options, the flexibility inherent to many investment projects can be interpreted as the right to acquire or to sell the cash flows of an underlying asset in exchange for an additional investment or the cash flows of a strike asset.[24] Whether these rights are explicit (e.g., contractual agreements) or implicit (e.g., the flexibility to abort an R&D project) is a secondary concern. This analogy allows us to use option models to value the options included in an investment by transferring the model parameters to their real equivalents, as depicted in Table 1 below.[25]

Financial option	Real option
Share price V_0	Present value of future cash flows of underlying asset
Strike price X	Necessary investment to exercise real option or present value of strike asset
Maturity t	Length of time during which opportunity exists
Volatility of security price σ	Volatility of cash flows of basis asset
Risk free rate r	Generally risk free rate, alternatively volatility of cash flows of strike asset[26]
Option price P_C or P_p	Initial investment into the project that creates the option

Table 1: Equivalent real option parameters

[24] Trigeorgis (1996), pp. 4 and pp. 121, Trigeorgis (1993), Koch (1999), pp. 35, Brealey/Myers (1996), pp. 589, Copeland/Koller/Murrin (1996), pp. 464, Amram/Kulatilaka (1999b), pp. 13, Dixit/Pindyck (1995), Kester (1984), Majd/Pindyck (1987), Pindyck (1991). The parallels between financial and real options are limited, mainly due to the fact that there is no capital market for real options or their underlying assets; Trigeorgis (1996), pp. 127, Koch (1999), pp. 76. We will come back to these limitations when critically reviewing the methodology.

[25] Trigeorgis (1996), p. 125, Luehrman (1998a), p. 52, Koch (1999), p. 72, Kim/Seth (2001), p. 154

[26] The risk free rate is used for the valuation of financial options because the strike price is paid with fully liquid assets. As liquidity is risk free, the usage of the risk free rate for discounting is justified. In the case of a real option, the strike asset can be risky as well; only if the strike asset is risk free is the usage of the risk free rate appropriate; Koch (1999), p. 72.

2.2.2 Types of real options

The numerous types of real options can be classified into three main categories: learning options, growth options and insurance options. Within these categories, we distinguish several option types. Table 2 depicts an overview of these real option types along with the equivalent financial options. [27]

Category	Option type	Equivalent financial option
Learning options	Option to defer	Call option
	Time-to-build option	Compound call option[28]
Growth options	Option to expand	Call option
	Option to innovate	Call option
Insurance options	Option to contract	Put option
	Option to shutdown and restart	Call option
	Option to switch	Combined call/put option
	Option to abandon	Put option

Table 2: Real option types and their financial equivalents

- **Learning options** offer management the opportunity to react to changes in the environment and to adapt investment strategies to new information that they may acquire at a future point of time. An *option to defer* allows management to wait to invest into a project and gather more information on the project; oil leases are an example for defer options. *Time-to-build options* exist when investments are staged, i.e. the company can stop an investment project before making all the investments; research and development efforts are usually staged investments.

[27] Hommel/Pritsch (1999a), pp. 125, Hommel/Pritsch (1999b), pp. 13, Trigeorgis (1993), pp. 211, Trigeorgis (1996), pp. 9, Amram/Kulatilaka (1999b), pp. 10-11, Meise (1998), pp. 97, Freihube (2001), pp. 24, Brach (2003), pp. 68 and Copeland/Koller/Murrin (1996), pp. 474 all provide a detailed discussion of the different options types; see Lander/Pinches (1998), pp. 539-540 for an overview of relevant articles on the different real option types. Only some of the option types can be used to value joint ventures. We will discuss the characteristics of the option to defer, to expand, to innovate and to abandon more in detail later.

[28] Compound options are options that create new options when exercised. They will not be discussed in detail here as we do not apply them to joint ventures; Geske (1979) and Koch (1999), pp. 50-51 provide a valuation method for compound options, Majd/Pindyck (1987), Pindyck (1991), pp. 1135 and Brach (2003), pp. 95 discuss compound real options.

- **Growth options** let the company react to positive market or project developments: Management may be able to expand their business activities in a market or their commitment to a project by making additional investments (*option to expand*). Companies can also acquire new knowledge or skills through investment projects, generating opportunities for follow-up projects based on these skills, i.e. *options to innovate*.
- **Insurance options** can be found whenever a company is able to react to (negative) changes in the market environment by adapting an existing investment project or abandoning it altogether. An *option to contract* lets management reduce the companies activities once market conditions deteriorate. An *option to shutdown and restart* represents a special case of an option to contract, allowing the company to completely shut down operations for a certain period and restart them as soon as the market environment improves. If management can put the company's assets to another, more profitable use, it has an *option to switch*, i.e. exchange one investment project for another. Finally, a company can leave the market altogether and shut down operations permanently in exchange for the salvage value (*option to abandon*).

Real options are not mutually exclusive; investment projects can create several types of options at the same time.

Another characteristic of real options that is important for the choice of the correct valuation methodology is its exclusiveness.[29] Depending on the competitive situation, **exclusive options** can only be exercised by one company, while **collective options** may be exercised by competitors as well. Valuing collective options requires taking into account the competitive situation: Premature exercising of an option might be necessary to preempt competitors and avoid losing value. [30]

2.3 Value drivers of real options

Identifying the value drivers of financial options is simple. From the valuation formulas discussed above we can derive five factors that change the value of an option, dividend payments are an additional parameter influencing option value.[31] When applying these factors to real options, we can identify five specific value drivers that pertain to real options.[32]

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[29] Trigeorgis (1996), pp. 142 and Koch (1999), pp. 73 list two more characteristics of real options, namely compoundness and urgency. We have omitted both, for compound options will not be applied to joint ventures in this paper and because the "urgency" of an option as defined by Trigeorgis (1996), p. 144 is identical to the maturity of the option and need not be classified further.

[30] Trigeorgis (1996), pp. 128-129; see also Tomaszewski (2000), pp. 143 and Brach (2003), pp. 133 for a detailed discussion of the influences of the competitive situation on real option value.

[31] Fabozzi/Ferri/Modigliani (1998), p. 562; Brealey/Myers (1996), p. 573, Leslie/Michaels (2000), p. 9

[32] Leslie/Michaels (2000), p. 9 and pp. 13; in the following we describe the value drivers for real call options; like for financial put options, the value of real put options is in most cases influenced in the opposite direction.

- *Increase of present value of net cash flows expected after exercising the option.* By increasing cash inflows, e.g., revenues, or decreasing cash outflows, e.g., operating cost, the present value of net cash flows grows, representing a rise in share price.
- *Reducing the necessary investment to exercise the real option.* Similar to a reduction of the strike price of a financial option, reducing the exercise investment can increase the value of a real option. Yet, companies usually have only limited possibilities to influence this factor.
- *Extend the duration of the opportunity.* The longer the time period until an investment decision has to be made to exercise the real option, the larger the opportunity for the company to exploit uncertainty and to benefit from future positive developments. The value of this flexibility increases with an extension of the opportunity's "maturity". Management can take an active role in extending the duration of an opportunity by, for example, trying to extend the exclusive right to invest into a project.
- *Increasing uncertainty underlying the expected cash flows.* Since management has the possibility to actively limit losses in the case of negative development, the pay-off structure of a real option is asymmetric. The higher the uncertainty the higher the upside from a positive evolution while the downside remains limited. A company that has invested into a real option, therefore, might be interested in actively increasing the uncertainty underlying its project.[33]
- *Reducing the value lost before exercising the option.* While waiting to exercise an option, the company may forego project cash flows reducing the value of the real option. Particularly in the case of collective options, the premature entry of a competitor might dramatically reduce option value. Management can try to prevent such loss of value by keeping competitors from prematurely exercising real options.

The risk free rate is not a true value driver as it is unrelated to the respective investment projects and is not under the company's control.

Uncertainty plays a major role for the value of a real option and we will see that uncertainty and risk are equally important for the creation of joint ventures.

3. Joint venture value drivers

3.1 Defining joint ventures

In order to understand the value drivers of joint ventures, we first need to clearly define our understanding of the term "joint venture". We base our definition on three key characteristics:[34]

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[33] This conclusion might be counterintuitive and contradicts traditional discounted cash flow analysis that reacts negatively too uncertainty.

[34] Anderson (1990), p. 19, Blodgett (1991), p. 63, Beamish/Inkpen (1997), p. 178, Kogut (1988), p. 319, Harrigan (1988), p. 142, McConnell/Nantell (1985), p. 520, Madhavan/Prescott (1995), p. 900, Hennart (1988), p. 363, Kutschker/Schmid (2002), p. 852; Contractor/Lorange (1988) and Harrigan/Newman (1990) point out that cooperative ventures do not necessarily need an equity

- Common usage of resources of two or more independent companies through a new organizational unit
- Redistribution of joint venture profits and losses to the parent companies through an equity participation
- Incorporation into a separate legal entity and common control of the joint venture by the parent companies

The objective of a joint venture is the pursuit of strategic goals by the partner companies.[35]

3.2 Value creation through joint venture strategies

3.2.1 Overview

In general, a joint venture is creating value if the net benefits of a joint venture for one partner company outweigh the profit participation it has to give up to its partner(s):[36]

$$\text{(E.13)} \quad B_x - C_x \overset{!}{>} (1-\alpha_x)P_{JV}$$

B_x denotes the value of the benefits partner company X can gain from the joint venture. These can, theoretically, consist of both financial or non-financial benefits. When discussing the value of benefits in practice, however, it comes down to the value of present or future cash flows. C_x and P_{JV} represent the value of the cost for partner company X and the joint venture profits respectively, while α_x signifies the joint venture equity stake of company X.

In order to better understand the value creation mechanisms of joint ventures, we will break down the benefits into specific value drivers. These value drivers are often identical with the motivation driving the creation of a joint venture: reducing cost and increasing revenues, improving the competitive positioning or the combination of competencies, to name a few examples. We use the following classification for our discussion of value drivers.[37]

- A reduction of the transaction cost that would have to be born by the partner companies without the joint venture
- An improvement of the strategic positioning
- Learning effects created through the cooperation

participation to redistribute profits. However, they do not use the term "joint venture" for this kind of venture. Contractor/Lorange (1988), p. 6, list other forms of cooperative agreements between companies. Buckley/Casson (1988) and Buckley/Casson (1996) discuss the nature and typology of interfirm cooperation.

[35] Geringer/Hebert (1991), p. 249, Harrigan/Newman (1990), pp. 418-419, Hennart (1988), p. 363

[36] Contractor/Lorange (1988), p. 20

[37] Kogut(1988); the following discussion concentrates on the positive effects of joint ventures, although there are also cost and risks that can be incurred. For a brief discussion of cost related to joint ventures see Koh/Venkatraman (1991), p. 872.

3.2.2 Reduction of transaction costs

Companies use joint ventures to reduce the cost induced by transactions with other companies. In markets with a limited number of buyers and/or sellers, i.e. in **oligopolies,** the number of partners for a transaction, i.e. the sale or purchase of a product or service, is restricted. Thus, a company can be in an inferior market position effectively increasing its purchase cost or decreasing its sales price. Furthermore, the continuous negotiation to improve its position increases the cost of transacting. A joint venture may allow the company in some instances to reduce these cost by creating a fixed relationship with its partner(s) at lower cost compared to a merger.[38]

Companies also have to face the cost of securing the delivery and/or the quality of a service or product procured from a partner company. Additional expenses are incurred because of **agency costs** caused by doubts on whether the partner company is willing or able to perform.[39] Particularly the exchange of strategic resources (e.g., knowledge) can create high cost.[40] In this case, a joint venture integrates the operations of both companies and secures the delivery and quality of the product/service as both partners benefit from the success of the common operation. By reducing uncertainty and increasing trust, a joint venture can create value by reducing the agency costs and offer opportunities for further cooperation or integration.

Ambiguity about the future development of a market can generate additional cost for companies related to the risks of entering a market.[41] A joint venture can reduce these cost by simply distributing it among several partners. Furthermore, the partner companies gain flexibility to react to market developments by canceling or expanding their involvement in the case of negative or positive market evolutions respectively.[42] This is the reason why one can observe a high number of joint ventures when uncertainty about the market is high.[43]

Joint ventures can also help companies to realize **economies of scale** and thus reduce cost.[44] Another possibility to realize cost synergies through joint ventures is the creation of a critical mass for high research and development (R&D) cost or the usage of complementary technologies.[45] Finally, teaming up with a partner in a joint venture can be used to overcome **economical or political barriers to entry** into a market (e.g., tariffs or access requirements) and, thus, to reduce transaction costs.[46]

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[38] Banks/Beamish (1987), p. 4, Hennart (1988), p. 364, Contractor/Lorange (1988), pp. 15, Buckley/Casson (1988), pp. 41

[39] Banks/Beamish (1987), p. 4, Buckley/Casson (1988), p. 46 and p. 52, Kogut (1988), p. 321, Chi/McGuire (1996), p. 287

[40] Chi (1994)

[41] Banks/Beamish (1987), p. 4, Koh/Venkatraman (1991), p. 872

[42] Buckley/Casson (1988), p. 45, Contractor/Lorange (1988), pp. 11-12

[43] Chi/McGuire (1996), p. 287

[44] Contractor/Lorange (1988), pp. 12-13 and pp. 15, Koh/Venkatraman (1991), p. 872, Hennart (1988), p. 363

[45] Koh/Venkatraman (1991), p. 872, Contractor/Lorange (1988) pp. 13-14

[46] Contractor/Lorange (1988) p. 14. This is, for example, the rationale behind the cooperation between DaimlerChrysler and Beijing Automotive Industry Holding Company; see, for example, DaimlerChrysler (2003).

In summary, joint ventures create value by reducing costs and risks and, therefore, increasing net present value. They are effectively creating flexibility for management. Furthermore, joint ventures can be advantageous because they offer a reduction in transaction cost without the large cost of a greenfield venture or an acquisition.[47]

3.2.3 Strategic positioning

Companies can improve their competitive position in a market through a joint venture and, thus, increase their profit potential.[48]

First, a company can obtain greater **bargaining power** in purchasing or sales markets by teaming up with other companies in a joint venture. It can use such bargaining power to improve its pricing situation.[49]

Second, a strategic aim of a joint venture can be **to secure access to new markets** and to open up new revenue sources.[50] These revenue sources are not necessarily exploited by the joint venture itself but they can be created as future opportunities for the partner companies, depending on a positive market development.

Third, companies can gain a **competitive advantage** by first accessing a new market and subsequently creating barriers to entry for competitors or by developing a superior position in difficult markets.[51] This allows them to create present or future profit opportunities.

Finally, the integration with one or more partners can be used to facilitate **further cooperation**. This can, for example, lead to a faster introduction of innovations using existing integrated infrastructure and, thus, a faster realization of potential profits.[52]

A company can, therefore, use a joint venture to improve its strategic position and increase its cash inflows through the realization of present profit opportunities. A joint venture can also create value by generating future profit opportunities that may lead to higher future cash flows.

3.2.4 Learning effects

Ultimately, joint ventures are created by companies to acquire new capabilities and, thus, either increase present cash flows or generate opportunities for future cash flows.[53]

The **combination of skills from two different companies** can be used to create new products or services, for example when companies exchange technologies. In this case, it is easier and faster for the partner companies to acquire these skills as if they had to develop them themselves. Companies can also aim at **learning skills from the**

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[47] Buckley/Casson (1988), p. 41
[48] Kogut (1988), pp. 321-322
[49] Buckley/Casson (1988), pp. 47-48
[50] Anderson (1990), p. 19, Contractor/Lorange (1988), p. 14, Hennart (1988), p. 363
[51] Contractor/Lorange (1988), p. 14, Koh/Venkatraman (1991), p. 872; Harrigan (1988) analyzes the relationship between the competitive situation and the creation of joint ventures.
[52] Buckley/Casson (1988), p. 52, Contractor/Lorange (1988), pp. 15
[53] Kogut (1988), pp. 322-323

partner and re-use them for their own purposes outside the joint venture, creating value for the company that is benefiting from this knowledge transfer.[54] The exchange or transfer of skills between companies is particularly important if an international joint venture is created in order to adapt a product or a service to local markets.[55]

3.3 Joint venture value drivers and real options

Joint ventures generate value when their creation creates benefits for all partner companies that outweigh the cost and disadvantages of their foundation. We have demonstrated that joint ventures mainly create value through three mechanisms:

- Joint ventures can be used to reduce cost or increase revenues from operations. Higher revenues are generated either through expanding existing or creating entirely new revenues opportunities. In all cases, the cash flows of the partner companies rise and, as long as the net present value of the new business is positive, the companies create value. This value creation can be modeled by a simple discounted cash flow calculation if there is only little uncertainty - in this case real options do not offer additional benefits.
- We were also able to show that joint ventures create value by offering flexibility in an uncertain environment and/or spreading risk onto partner companies. They allow the management of the partner companies to adjust the degree of commitment in dependence on the evolution of market conditions or the project development. Real option methodology can help to incorporate this flexibility into the valuation as it takes into account the possibility of management decisions in the future. To the extent that traditional DCF valuation is not able to incorporate this kind of flexibility, real options can improve the valuation.
- Finally, we have demonstrated that joint ventures often open up new opportunities for future cash flows. These opportunities, however, are anything but certain. This uncertainty makes it difficult to reflect their value in a traditional DCF valuation, while real options appropriately value these opportunities by considering them as options.

4. Applying real options to joint ventures

4.1 Assumptions and valuation process

This section discusses the concrete application of real options using an imaginary joint venture case. Suppose two partner companies have decided to create a joint venture for research and development; they invest EUR 50m each for fifty percent of the equity. The joint venture will be incorporated at the end of the current business year and start its activities at the beginning of the following year. Due to the focus on research and development, the joint venture will incur high R&D cost in the first three years after

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[54] Anderson (1990), p. 19, Buckley/Casson (1988), p. 47, Contractor/Lorange (1988), pp. 13-14, Blodgett (1991), p. 63, Hamel (1991)

[55] Buckley/Casson (1988), p. 46, Beamish/Inkpen (1997)

which the developed product is expected to be launched into an uncertain market. To simplify the following discussion we will make several additional assumptions.

(A.1) The project horizon is five years; after that period, the venture will be valued using a perpetual terminal value.

(A.2) The joint venture is unleveraged at its creation; debt will be used as needed in years 1-5 to balance liquidity shortages (liquidity is always held constant).

(A.3) There will be no injection of fresh share capital by the partner companies.

(A.4) Joint venture management reinvests all possible profits back into the venture's activities during the first five years; after that, all profits will be distributed to the partner companies through dividends.

(A.5) Any losses can be carried forward.

When valuing a real option, it is useful to follow five steps.[56]

- **Confirm real option analogy.** While one might suspect that real options are present in an investment project, this step requires the explicit check whether the project offers flexibility in an uncertain environment where investment decisions are irreversible.
- **Determine relevant real option types.** Every project offers different types of real options that need to be determined on a one-by-one basis. Only the main option types should be chosen to limit the valuation's complexity.[57]
- **Choose the valuation model.** Once the relevant option types have been determined, the adequate valuation model needs to be chosen for each real option identified. The choice of valuation models depends on the structure of the project and the option; some options may, for example, only be valued with a binomial model.
- **Value the options.** On the basis of the project's DCF value, each option in the project needs to be valued separately and the interaction between different option types need to be taken into account.
- **Fine tune the model.** After the valuation is finished, the work is not yet done. As with each valuation, fine tuning the model is the most important step. A sensitivity analysis or a what-if analysis can deliver important insights into the behaviour of the model and - of course - the investment project.

We will subsequently go through each of these steps to illustrate the application of real options and to discuss a framework of four option types that can be useful for the valuation of joint ventures.

[56] Hommel/Pritsch (1999b)
[57] Kemna (1993), p. 269, Trigeorgis (2002), p. 9

4.2 Confirming the option analogy

Along the three criteria for real options introduced in the previous section, we can now determine whether our illustrative joint venture can be valued using real options methodology.

First, the project needs to offer management the **flexibility** to react to changes in its environment. Without making any additional assumptions about our case at hand, it has become clear from section 3 that joint ventures in general generate opportunities for management to act. Management can, for example, terminate an involvement in a joint venture by selling their stake or use knowledge obtained from the venture to start new own projects.

Second, the **environment** of the investment project has to be uncertain, i.e. the specific outcome of the project cannot be predicted and might require a change of plans in the future. This is also true for most joint ventures in general, as they usually are created where uncertainty is especially high. Our imaginary joint venture is also created in an uncertain environment, as the research and development efforts might fail or the product might not succeed in the market place.

Finally, the application of real option methodology requires investments to be **irreversible**. This is true for many investment projects: Investments made are sunk cost and cannot be fully recovered, so that, for example, the option of delaying an investment or finding a different use for assets purchased with the investment can have additional value.[58] Especially when uncertainty is high, projects that offer the flexibility to recover part or all of the initial investment when their development is unfavourable must be of higher value than others without this possibility. In the case of joint ventures it depends on the type of joint venture whether this criteria is fulfilled or not, as it might be possible that one of the companies can recoup their investment by selling their stake to the other partner(s) or even to third parties. In many joint ventures, however, the initial set-up cost of the joint venture can rarely be recovered if the venture fails. This is especially true for our R&D joint venture: if the research fails or the product flops the equity share will not be of much value anymore. Consequently, we consider the investment into our joint venture to be irreversible.

4.3 Determining applicable option types

After having confirmed that there is an analogy between our investment project and an option, we can now determine which real option types are relevant for our valuation. Of all the types introduced above, four seem particularly appropriate for the model:[59]

- An option to defer could be present if one or both of the partners have the possibility to postpone the creation or the start of business of the joint venture as new information on the project unfolds.

[58] Pindyck (1991), pp. 1110-1111

[59] Kim/Seth (2001), p. 163 propose a slightly different list of real option types applicable to joint ventures.

- An option to expand can be created when a partner company has the contractual or the factual right to acquire the stake(s) of the other partner(s). We will, therefore, refer to this option as acquisition option.
- An option to innovate is probably the most obvious option type present in joint ventures and at the same time the most difficult to value. Based on experiences from the cooperation, both partners may have the possibility to initiate follow-up projects outside the venture that create additional value.
- Finally, we could find an option to abandon if one of the partner companies can sell its stake to the other partner(s).

4.4 Building the valuation model and calculating option value

We now have four option types that need to be valued in our fictitious example. As necessary, we will make additional assumptions about our case in the respective sections.

The basis for the valuation is a DCF scenario model based on three scenarios, a good one, an average one and a poor one; Figure 1 below depicts the assumed cash flows for each scenario. We use these scenarios to determine a distribution of possible project values; Table 3 shows the resulting project values V_i for Year 0 and Year 1.[60] If we assign equal probabilities to each scenario we can calculate an expected project value, or basic joint venture value, of

$$\text{(E.14)}\quad E(V_{JV}) = \frac{1}{n}\sum_{i=1}^{n} V_{i,t=0} = \frac{1}{3}(162{,}6 + 38{,}4 + 25{,}2) = 75{,}4$$

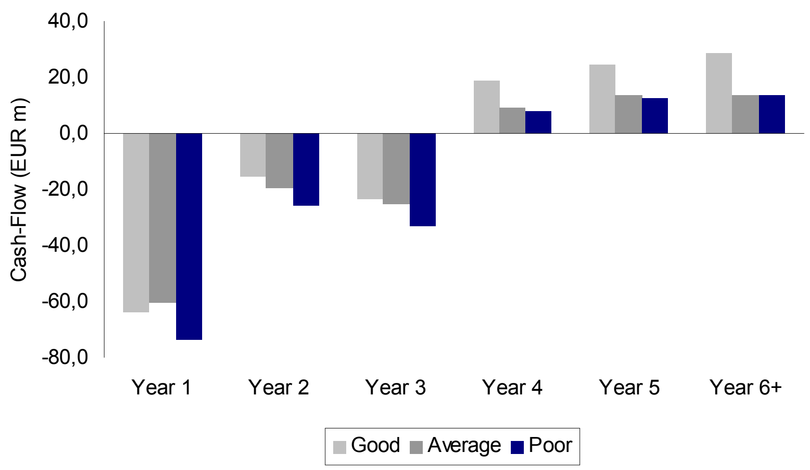

Figure 1: Assumed joint venture cash flows

[60] The cash flows are discounted using a yearly estimated WACC based on 11% cost of equity and 5% cost of debt. Another, albeit more complex, possibility to arrive at a distribution of possible project outcomes is a Monte Carlo Simulation; Brealey/Myers (1996), pp. 247 and Antikarov/Copeland, pp. 245.

Since the companies are required to invest EUR 100m into the project, the investment in itself valued using discounted cash flows is not creating value and should be avoided.

We can also use the discrete distribution of project values to estimate the volatility, a parameter that we will need to value the options. Using the values from Table 3, we calculate an estimated volatility of σ_{JV} = 109%.[61]

Scenario	**Projected joint venture value V_i in Year 0** (EUR m)	**Projected joint venture value V_i in Year 1** (EUR m)	**Percentage change to expected project value**
Good	162,6	176,5	+134%
Average	38,4	41,7	- 45%
Poor	25,2	27,3	- 64%
Expected project value	75,4	-	-

Table 3: Value distribution of joint venture project

4.4.1 Option to defer

Let us assume that the partners have the opportunity to delay the creation of the joint venture by one year while new information on the target market unfolds. (Alternatively, we could assume that they have already formally incorporated the venture and deposited their investments, but can delay the start of the research efforts by one year.)

This option creates value by giving management the opportunity to wait for new developments and to make the decision to invest dependent on a positive evolution.[62] When waiting to invest, the companies assume that the uncertainty about the market evolution will have reduced one year later and that the projection of the project's success will be easier. We model this assumption by pretending that the basis value of the investment project would develop continuously in the meantime, using an estimated volatility based on our three scenarios. This is - of course - an unrealistic assumption since the project itself has not been created yet. It allows us, however, to take into account the expectation that the project value will be less uncertain one year later.

We can value this real option as a European call using the Black/Scholes model with the following parameters:

[61] The three scenarios where considered as sample of all possible scenarios. Consequently, we can use the standard deviation as true estimator for the volatility. Therefore, with n denoting sample size and $r_i = (V_{i,t=1}/V_{i,t=0}) - 1$, we use the following formula [Amram/Kulatilaka (1999b), pp. 212]:

$$\sigma_{JV} = \sqrt{\frac{n\sum(r_i - \bar{r})^2}{n(n-1)}}$$

[62] Koch (1999), pp. 96 describes a similar waiting option in relation to corporate acquisitions.

- The security price V_0 is the expected value of one partner company's share of the joint venture, i.e. V = 37,7.[63]
- The standard deviation of the joint venture value under three scenarios is used as estimator for the volatility, i.e. σ = 109%.
- The strike price X represents the investment that the companies need to make when exercising the option, i.e. creating the venture. In our case, the "strike price" is EUR 50m per partner, required as equity capital. We assume that the required set-up investments remain constant, independent of the time of foundation.
- The maturity of the option t represents the time frame of the decision to invest; in our case one year.
- Dividends can be excluded from the analysis since the venture is not yet created.

Using the Black/Scholes formula and the above assumptions, we can determine the value of the option to defer C_W to be EUR 13,1m.[64] On the basis of this option value, the partner companies should defer the creation of the joint venture because the expected net present value after an immediate creation of the joint venture would be lower.[65] We can postulate the following rule for the decision to defer an investment:[66]

(E.15) $C_W > V - X$

V	σ = 60%	σ = 70%	σ = 109%
t=1			
20,0	0,6	1,1	3,8
37,7	5,8	7,3	13,1
50,0	12,8	14,6	21,5
t=3			
20,0	3,8	5,2	10,3
37,7	13,5	15,8	23,8
50,0	22,1	24,8	34,1
t=5			
20,0	6,7	8,4	13,9
37,7	18,5	21,1	29,2
50,0	28,0	31,0	40,2

Table 4: Sensitivity of option to defer, option value in EUR m

Table 4 shows the sensitivity of the call option value to changes in several parameters. It is reasonable that the value of the option increases with the volatility of the value of underlying asset since more uncertainty increases the value of waiting and the flexibility to react to future developments. The rise in option value with the length of time that the decision can be deferred is also plausible because the longer the time of deferral, the larger the chance to avoid negative consequences.

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[63] This represents 50% of $E(V_{JV})$ as each partner owns 50% of the equity.

[64] We assume a risk free rate of r = 5% for this and all following calculations.

[65] The expected net present value V_n of the investment into the joint venture is calculated by $V_n = [E(V_{JV}) - I]\ \alpha$. In this case V_n = -12,3

[66] Koch (1999), pp. 105-106, Pindyck (1991), p. 1112; V – X represents the value created if the option was exercised immediately.

The time period, during which a decision to create a joint venture can be made, may in reality be more virtual than real. We assume a factual right to create a joint venture that can, for example, exist when both partners agree on the creation of the venture, but decide to delay the incorporation.[67] This may constitute, however, a collective real option, since competitors can decide on starting a similar venture, possibly even under participation of one of the two partners. The maturity of this real option, therefore, depends critically on the competitive situation in the industry and might in most cases rather be closer to nil.[68] An immediate exercise might still be warranted to secure the cooperation.

In conclusion, it has to be carefully verified whether the competitive situation and the state of the negotiations with a partner company warrant the use of an option to defer to value part of a joint venture project.

4.4.2 Option to expand (acquisition option)

The assumption that one of the two companies sees the possibility to acquire the remaining equity of the joint venture from its partner at the end of five years forms the basis of the following discussion. Alternatively, the partner companies could agree on a contractual fifth-year acquisition option.[69] This option creates additional value for one partner company as it is able to decide between expanding its commitment to the market if it develops favorable and just keeping its current stake if things develop less positive. A contractual option is a direct means to participate in the upside of the project. Exercising a factual acquisition option, however, also depends on an asymmetric assessment of the joint ventures value among the partners.[70]

Under the assumption that the acquisition is exclusively possible after five years,[71] this option is a European call option and can be valued using Black/Scholes. Both the parameters V and σ are identical to those assumed for the option to defer. The other parameters are set as follows:

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[67] A contractual right to create the joint venture could, in some circumstances, exist in the second case mentioned above where the companies have already incorporated a joint venture with the necessary investments, but have decided to postpone the start of its business activities.

[68] Koch (1999), pp. 118 and Tomaszewski (2000), pp. 143 analyze the influence of the competitive situation on the value of real options in relation to corporate acquisitions; see also Ankum/Smit (1993), Trigeorgis (1996), pp. 272, Weeds (2002), Brach (2003), pp. 140, Kim/Seth (2001), p. 160

[69] Blodgett (1992) among others discusses the factors that lead a joint venture partner to increasing its stake in a joint venture. She points out that, for example, companies contributing technology to an international joint venture are more likely to increase their stakes. These companies obtain a factual acquisition option that they can exercise after having acquired local knowledge from their parrner(s). Folta/Miller (2002) examine the factors that influence the acquisition of equity stakes in research-intensive industries, considering among other issues the competitive environment and its influence on the time of exercising an acquisition option. Chi/McGuire (1996), pp. 301 present three hypotheses on when it is likely that partner companies in a joint venture possess explicit acquisition options.

[70] Kim/Seth (2001), p. 164

[71] Alternatively, we could assume an acquisition at any time within the five years, creating an American call option. In that case, the option could only be valued using Black/Scholes if there were no dividends. The binomial model would have to be used if the joint venture paid out dividends during the acquisition time; Kogut (1991) lists factors determining premature exercising in the latter case.

- The strike price X represents the acquisition price for the acquired stakes agreed by the two partners. The price usually is determined through a negotiation process and depends on the value of the joint venture at the time of acquisition. To keep things simple, we assume the strike price to be X = 100.[72]
- The maturity of the option t represents the time period after which the acquisition can take place, in this case five years.
- Dividend payments are excluded by the assumptions made. If the joint venture paid out dividends, the value would have to be corrected accordingly.[73]

This leads us to an option value of C_A = 26,0, yielding a total value of the company's stake of EUR 63,7m according to (E.12).[74] With an initial investment of EUR 50m, the total net present value of the investment project is positive and, therefore, the investment reasonable to make. Yet, with 41% of total value, the option constitutes a major part of the value of the investment. If I_{JV} denotes the investment made into the joint venture, we can posit the decision rule

(E.16) $\alpha \cdot E(V_{JV}) + C_A > \alpha \cdot I_{JV}$ [75]

V	σ = 50%	σ = 70%	σ = 109%
t=3			
20,0	3%	11%	28%
37,7	10%	20%	34%
50,0	15%	24%	36%
t=5			
20,0	10%	21%	37%
37,7	19%	29%	41%
50,0	23%	32%	42%
t=7			
20,0	17%	29%	42%
37,7	25%	35%	44%
50,0	29%	37%	45%

Table 5: Sensitivity of acquisition option; relative value contribution in percent

As would be expected, the value contribution of the option increases with the length of the time period where an acquisition can take place and with the uncertainty of the environment (Table 5). We can also observe, that the option's value contribution is less sensitive to the acquisition price as one would expect, leading to the conclusion that the price negotiated is of lesser importance (Table 6).

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72 Koch (1999), pp. 107 shows how to integrate the assumption of a stochastically changing acquisition price into the calculation.

73 Brealey/Myers (1996), pp. 605-606

74 Koch (1999), p. 90, Trigeorgis (1996), p. 124

75 Assuming that the investments are split according to the relativ equity stakes; Trigeorgis (1996), p. 371

1- α	X = 100	X = 200	X = 400
20%	12%	10%	8%
30%	21%	18%	15%
40%	31%	27%	23%
50%	41%	37%	33%
60%	52%	48%	44%
70%	63%	60%	56%
80%	75%	72%	69%

Table 6: Sensitivity of acquisition option depending on stake size and acquisition price; relative value contribution

Having the opportunity to expand a commitment to a joint venture by acquiring the partner's stake, therefore, can make out a considerable part of the joint venture's value for a partner company.

4.4.3 Option to innovate

As we have discussed above, joint ventures can create value by generating opportunities for participating companies to initiate follow-up projects in the future based on experiences acquired through the joint venture. The viability of these follow-up projects, however, depends on the uncertain development of the joint venture and the market environment; in the case of an unfavourable development no investment needs to be made. Thus, companies acquire a factual right to "purchase" the cash flows possibly generated by such projects.[76] We can interpret these rights as an option to innovate and use the option valuation technique for their valuation.

This real option can be valued as an American call option using Black/Scholes, since dividends are not present. The parameters are determined as follows:

- The security price V is the discounted cash flow value of the follow-up project.
- The volatility σ of the project's cash flows needs to be estimated in a similar fashion as for the joint venture itself.[77]
- The strike price X represents the initial investment that needs to be made for the new project. We assume X to always be 120% of the DCF value; X = 1,2V.
- The length of time during which the follow-up project can be started is the maturity of the real option t. This time period depends on factors like the competitive or technological environment and needs to be estimated.

[76] Many joint ventures are created with this rationale in mind. For example, Kodak and Hewlett Packard created a joint venture to develop new digital products that could be marketed by both companies profitably [Kehoe (2000)].

[77] Luehrman (1998a)

V	σ = 20%	σ = 40%	σ = 60%
t=2			
60,0	2%	13%	24%
80,0	12%	27%	38%
100,0	30%	41%	49%
t=4			
60,0	8%	25%	37%
80,0	24%	39%	49%
100,0	40%	50%	57%
t=6			
60,0	16%	33%	44%
80,0	32%	46%	54%
100,0	47%	56%	62%

Table 7: Sensitivity of option to innovate; relative value contribution in percent

Table 7 shows some exemplary values for the option to innovate assuming different project values and different uncertainty levels. The total value of the project is calculated according to (E.12) and decision rule (E.16) applies. The value of the option is a linear function of the value of the underlying project (see Figure 2) and can constitute a significant part of the joint venture's total value if the underlying project is potentially highly valuable.

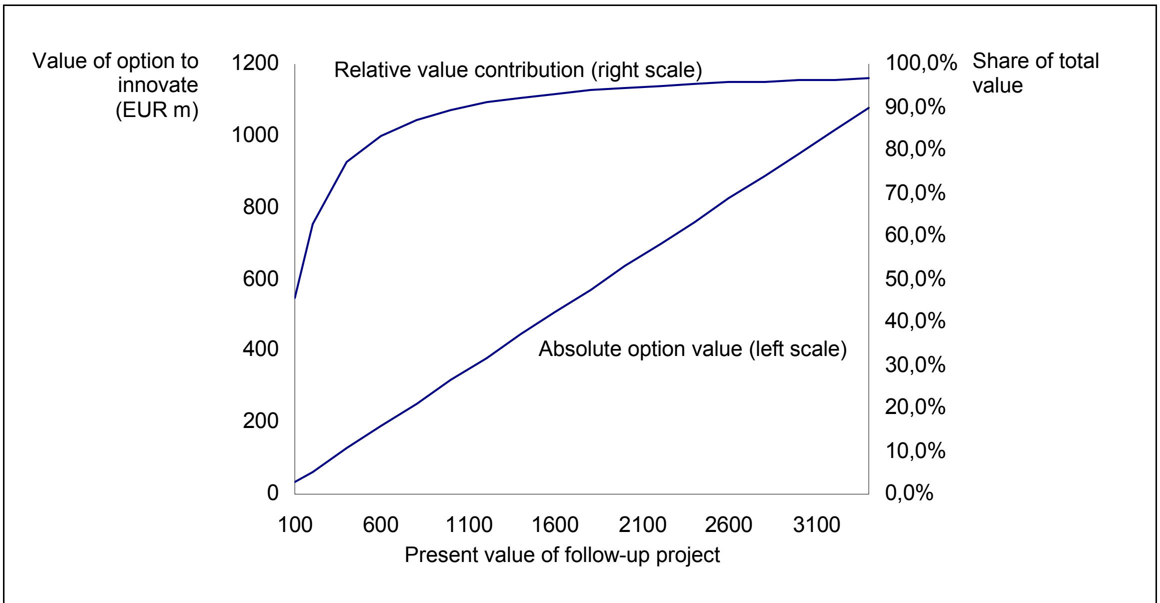

Figure 2: Value contribution of option to innovate[78]

Even if we assume that the follow-up project has a negative net present value, the fact that its value fluctuates and can become positive in the future (e.g., through learning effects from the joint venture when companies learn how to realize the new project profitably) makes the option to realize this project valuable. In extreme cases, the option to innovate can constitute almost all of the value of the joint venture, for example

[78] The figure is based on the following parameters: σ = 40%, t=4, X = 1,2V. The follow-up project is assumed to have a negative net present value as of today, since X > V.

if the venture has high strategic value because it opens up the opportunity for highly profitable future investments.

We have to make clear, though, that this valuation technique largely depends on a company being able to value the future project and determine its development potential with a certain confidence. The valuation of completely unknown future opportunities is simply not possible.

4.4.4 Option to abort

Similar to an acquisition option, a partner company can have the right to sell its stake in the joint venture to its partner or to a third party. As discussed above, a joint venture can avoid a full commitment to a project and offer an opportunity to leave the cooperation when things go bad, thus creating value. Like the acquisition option, this opportunity can either be factual or contractual.[79]

Let us assume that one of the two partner companies can sell their stake to its partner at any time during the first five years for the original book value of EUR 50m. This constitutes an American put option and has to be valued using a binomial model since a premature exercise might be reasonable. The parameters of the option are determined in the same way as for the acquisition option and according to (A.4) we can ignore the question of dividend payments.[80]

As can be seen from the first box in Figure 3, we value the option at $P_A = 34{,}2$ in $t = 0$ and calculate the total joint venture value according to (E.12) as EUR 72m. Since the put option can be exercised at any time during the five years and a premature exercise might be reasonable, we yet have to consider the question of the optimal selling strategy by backtracking the valuation from year five to year one. Figure 3 shows the development of the option value through the years and can help determine the optimal year to sell the stake depending on its development. Whenever the value of exercising the option immediately (i.e. selling the stake) exceeds the value of the option itself, an immediate exercise is reasonable (the gray shaded boxes show the optimal exercise times for the example).

[79] The creation of the Siemens / Fujitsu joint venture was, for example, partly based on a factual opportunity to sell the stake as Siemens contemplated leaving the PC sector. The sale of its stake in the joint venture was, therefore, part of its rationale; Financial Times (1999a), Harnischfeger/Rahman (1999). A contractual put option was, for example, integrated into the agreement between Suzuki and the Indian government on the joint venture car manufacturer Maruti. Suzuki has negotiated a "leave clause" awarding the right to sell its stake to the government; The Economist (1997).

[80] Dividend payments can easily be integrated into the valuation and do not considerably change the following analysis.

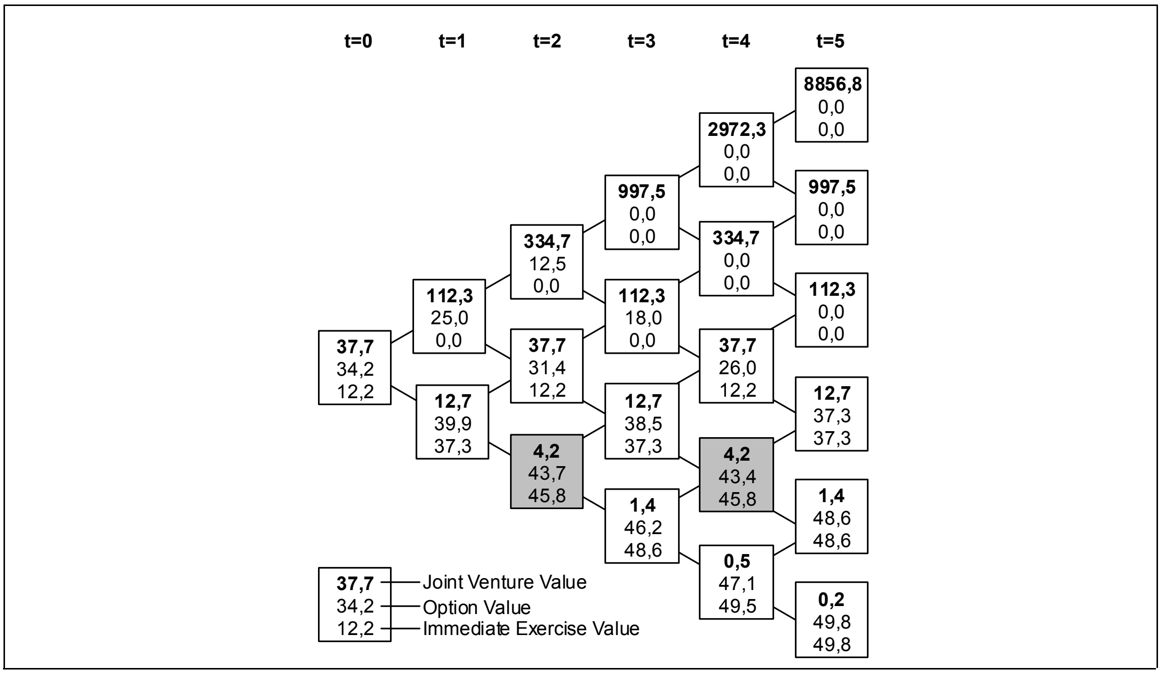

Figure 3: Determining the optimal exercise time for option to abandon (EUR m)[81]

As a conclusion to part 4, we can say that using real options can help to model some very specific characteristics of joint ventures. In this framework, the option to innovate plays an important role, as it allows to include rationales like strategic positioning or learning effects into the valuation. There are, however, some critical issues to the implementation of real options that we address in the following part.

5. Can we use real options then?

We have shown that real options can be quite useful to model the value drivers of joint ventures and to integrate the flexibility they offer to companies into the valuation. Especially, the valuation of strategic opportunities can be made more tangible by using and valuing options to innovate.

Table 8 summarizes and compares the reflection of joint venture value drivers by both a traditional DCF model and real options methodology.

[81] Parameters used for Figure 3: V = 37,7; X = 50,0; σ = 1,09; t = 5

Category	Type	Value effect	DCF	Real option
Transaction cost	Oligopolies	Lower negotiating cost	Yes	Yes
	Agency costs	Reduction of uncertainty	No	Yes
		Lower cost to secure performance	Yes	Yes
	Market ambiguity	Lower risk cost	No	Yes
		More flexibility	No	Yes
	Synergies	Economies of scale	Yes	Yes
		Technology effects	Yes	Yes
	Barriers to entry	Cost reduction	Yes	Yes
Strategic positioning	Bargaining power	Cost reduction	Yes	Yes
		Revenue growth	Yes	Yes
	Access to new markets	Immediate generation of additional cash flows	Yes	Yes
		Future generation of additional cash flows	No	Yes
	Competitive advantage	Immediate increase of cash flows	Yes	Yes
		Future increase of cash flows	No	Yes
	Further cooperation	Future generation of additional cash flows under uncertainty	No	Yes
Learning effects	Combination of skill sets	Immediate generation of additional cash flows	Yes	Yes
	Learning of new skills	Future generation of additional cash flows under uncertainty	No	Yes

Table 8: Reflection of joint venture value drivers in valuation

We need to make several critical comments on the usage of real options, however, both from a methodological and an implementation point of view.

- Applying financial option valuation models to real options assumes implicitly that the underlying asset is traded on a market and an equivalent portfolio with an identical risk-return structure can be composed.[82] This is rarely true in the case of joint ventures. DCF valuation, however, depends on problematic assumptions as well, namely the existence of securities with equivalent risk-return structures, in order to be able to deduct the cost of capital.[83]
- We assumed in our case study that the value of the joint venture evolves continuously in time, while in reality the value may make jumps due to certain events. These jump processes, however, can be integrated into the valuation model, although their anticipation in reality is certainly difficult, if it is possible at all.[84]
- The variance of the underlying asset's cash flows are needed for the valuation of the options. Since, generally, only rough estimates can be made, the question remains whether the variance of the cash flows is well represented in the model. We also have assumed that the variance remains constant throughout the lifetime of the option. This assumption is not always true; but there are models to take into account changing volatility.[85]
- Real options methodology also assumes implicitly that the real option can be executed without delay, like financial options. Yet, in reality most of the real options we have proposed and discussed above need some time to prepare and realize.[86]
- Real options depend to an even larger extent than DCF on several critical assumptions (e.g., the volatility). The valuation usually is highly sensitive to these assumptions, leading to the fact that almost any decision can be justified by the right assumptions. When using real options one has to be aware of this potential trap and ensure that the assumptions are reasonable. A "What-Do-You-Have-To-Believe" analysis might be helpful in these instances.
- Finally, using real options valuation in reality is complex. Determining the parameters needed for the valuation is difficult, building models that reflect all aspects of the project time consuming.[87] In addition, the complexity may lead to valuation errors.[88] In spite of the effort that goes into such a valuation the improvement in decision making can be important, even more so as standardized tools might facilitate the usage of such models in the future.[89]

[82] Damodaran (1996), p. 375, Tomaszewski (2000), pp. 192, Rams (1999), p. 353; Dangl/Kopel (2003)
[83] Koch (1999), p. 79, Trigeorgis (1996), p. 127
[84] Damodaran (1996), p. 376, Koch (1999), pp. 67
[85] Damodaran (1996), p. 376, Rams (1999), p. 353
[86] Damodaran (1996), p. 376
[87] Lander/Pinches (1998), p. 542 discuss more in detail the practical limitations.
[88] Fernandez (2002) lists the most common errors made when using real options methodology in practice.
[89] Tomaszewski (2000), pp. 208 discusses some ways of implementing real options valuation in practice.

6. Conclusions

In this paper, we have examined whether real options can contribute positively to the valuation of joint ventures. Considering different value drivers of joint ventures, we find that real options can reflect some critical value drivers in the valuation that traditional DCF models overlook. Particularly, the strategic value of a joint venture and the value of flexibility that stems from a less than full commitment can be determined using options valuation. We have applied four option types (option to defer, option to expand/acquisition option, option to innovate, and option to abandon) to an imaginary joint venture example and have shown how to use the Black/Scholes and binomial valuation techniques to value these options. Of the four option types, particularly the option to innovate is important, as it allows to reflect the strategic value of a joint venture generating future business opportunities.

Both the methodology and the implementation of real options, however, has considerable drawbacks. Particularly the fact that a large number of estimated parameters determine the value of the options and that the sensitivity of the option value to these parameters is generally high makes their interpretation a delicate issue. Also, the usage of real option models is highly complex. More research is certainly needed to make real options more usable to increase their acceptance in practice. Their difficult implementation is probably the reason why their spread among practitioners has been limited so far.

All in all, we still think real options are a good tool to value strategic advantages of joint ventures (particularly flexibility). Even though the project value derived using the technique may not be exact, real options can nevertheless provide a rough estimate of the value of flexibility and help with identifying the critical value levers.

Bibliography

Amram, M. / Kulatilaka, N. (1999a). Disciplined decisions: Aligning strategy with the financial markets. *Harvard Business Review* 77(1), 95-104.

Amram, M. / Kulatilaka, N. (1999b). Real options: managing strategic investment in an uncertain world. Boston.

Anderson, E. (1990). Two firms, one frontier: on assessing joint venture performance. *Sloan Management Review* 31(2), 19-30.

Ankum, L.A. / Smit, H.T.J. (1993). A real options and game-theoretic approach to corporate investment strategy under competition. *Financial Management* 22(3), 241-250.

Antikarov, V. / Copeland, T.E. (2001). Real Options - A Practitioner's Guide. New York.

Banks, J.C. / Beamish, P.W. (1987). Equity joint ventures and the theory of the multinational enterprise. *Journal of International Business Studies* 18(2), 1-16.

Beamish, P.W. / Inkpen, A.C. (1997). Knowledge, bargaining power, and the instability of international joint ventures. *Academy of Management Review* 22(1), 177-201.

Black, F. / Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy* 81(3), 637-654.

Blodgett, L.L. (1991). Partner contributions as predictors of equity shares in international joint ventures. *Journal of International Business Studies* 22(1), 63-78.

Blodgett, L.L. (1992). Factors in the instability of international joint ventures: An event history analysis. *Strategic Management Journal* 13(6), 475-481.

Brach, M.A. (2003). Real options in practice. Hoboken.

Brealey, R.A. / Myers, S.C. (1996). Principles of corporate finance. 5. edition, New York.

Buckley, A. / Eijgenhuijsen, H. / Rijken, H. / Tse, K. (2002). Stock Market Valuation with Real Options. *European Management Journal* 20(5), 512-526.

Buckley, P.J. / Casson, M. (1988). A theory of cooperation in international business. In: Contractor, F.J. / Lorange, P. [eds.]: *Cooperative Strategies in International Business*, Lexington 1988, 31-53.

Buckley, P.J. / Casson, M. (1996). An economic model of international joint venture strategy. *Journal of International Business Studies* 27(5), 849-876.

Chi, T. (1994). Trading in strategic resources: Necessary conditions, transaction cost problems, and choice of exchange structure. *Strategic Management Journal* 15(4), 271-290.

Chi, T. / McGuire, D.J. (1996). Collaborative ventures and value of learning: Integrating the transaction cost and strategic option perspectives on the choice of market entry modes. *Journal of International Business Studies* 27(2), 285-307.

Contractor, F.J. / Lorange, P. (1988). Why should firms cooperate? The strategic and economic bases for cooperative strategy. In: Contractor, F.J. / Lorange, P. [eds.]: *Cooperative Strategies in International Business*, Lexington 1988, 3-28.

Copeland, T.E. / Keenan, P.T. (1998). Making real options real. *McKinsey Quarterly* 34(3), 128-141.

Copeland, T.E. / Koller, T. / Murrin, J. (1996). Valuation: Measuring and managing the value of companies. 2. edition, New York.

Cox, J.C. / Ross, S.A. / Rubinstein, M. (1979). Option pricing: A simplified approach. *Journal of Financial Economics* 7(3), 229-264.

DaimlerChrysler (2003). DaimlerChrysler Chairman Jürgen E. Schrempp Meets with Chinese Premier Wen Jiabao in Beijing. Company press release, 08.09.2003.

Damodaran, A. (1996). Investment valuation. New York.

Dangl, T. / Kopel, M.O. (2003). Die Bedeutung vollständiger Märkte für die Anwendung des Realoptionsansatzes. In: Baecker, P. / Hommel, U. / Scholich, M. [eds.]: *Reale Optionen*, Berlin 2003, 37-62.

Dixit, A.K. / Pindyck, R.S. (1994). Investment under uncertainty. Princeton.

Dixit, A.K. / Pindyck, R.S. (1995). The options approach to capital investment. *Harvard Business Review* 73(3), 105-114.

The Economist (1997). India's car market: Local hero. *The Economist Online www.economist.com,* 14.08.1997.

The Economist (2001). Emergency calls. *The Economist Online www.economist.com,* 26.04.2001.

Fabozzi, F.J. / Ferri, M.G. / Modigliani, F. (1998). Foundations of financial markets and institutions. 2. edition, New Jersey.

Fernández, P. (2002). Valuing Real Options: Frequently Made Errors. Mimeo, Barcelona.

Financial Times (1999a). Siemens and Fujitsu set for computer deal. *Financial Times Online www.ft.com*, 17.06.1999.

Financial Times (1999b). Siemens-Fujitsu venture aims for leading role: The agreement covers PCs, Intel-based servers and Unix systems, as well as the two companies' mainframe activities. *Financial Times Online www.ft.com*, 07.07.1999.

Folta, T.B. / Miller, K.D. (2002). Real Options in Equity Partnerships. *Strategic Management Journal* 23(1), 77-88.

Freihube, K. (2001). Die Bedeutung und die Bewertung von Realoptionen (Handlungsspielräumen) in der wertorientierten Unternehmensführung. Frankfurt a.M.

Geringer, J.M. / Hebert, L. (1991). Measuring performance of international joint ventures. *Journal of International Business Studies* 22(2), 249-263.

Geske, R. (1979). The Valuation of Compound Options. *Journal of Financial Economics* 7(1), 63-81.

Guerrera, F. / McGregor, R. (2003). Deutsche seeks China underwriting deal. *Financial Times Online www.ft.com*, 25.08.2003.

Hamel, G. (1991). Competition for competence and interpartner learning with international strategic alliances. *Strategic Management Journal* 12 (Special Issue), 83-103.

Harnischfeger, U. / Rahman, B. (1999). Fujitsu deal may give Siemens a computer break: Germans might look to leave sector. *Financial Times Online www.ft.com,* 18.06.1999.

Harrigan, K.R. (1988). Joint venture and competitive strategy. *Strategic Management Journal* 9(2), 141-158.

Harrigan, K.R. / Newman, W. (1990). The bases of inter-organizational co-operation: propensity, power, persistance. *Journal of Management Studies* 27(4), 417-434.

Hennart, J.F. (1988). A transaction cost theory of equity joint ventures. *Strategic Management Journal* 9(4), 361-374.

Hitt, M.A. / Hoskisson, R.E. / Ireland, R.D. (1997). Strategic management. 2. edition, St. Paul.

Hommel, U. / Pritsch, G. (1999a). Investitionsbewertung und Unternehmensführung mit dem Realoptionsansatz. In: Achleitner, A.-K. / Thoma, G. [eds.]: *Handbuch Corporate Finance,* Köln September 1999 (Supplement), 1-65.

Hommel, U. / Pritsch, G. (1999b). Marktorientierte Investitionsbewertung mit dem Realoptionsansatz. *Finanzmarkt- und Portfoliomanagement* 13(2), 121-144.

Howell, S.D. / Jägle, A.J. (1997). Laboratory evidence on how managers intuitively value real growth options. *Journal of Business Finance and Accounting* 24(7&8), 915-935.

Hull, John C. (2003). Options, Futures, and Other Derivative Securities. 5. edition, New York.

Kehoe, L. (2000). Photofinishing: Kodak and HP in digital venture. *Financial Times Online www.ft.com*, 12.02.2000.

Kemna, A.G.Z. (1993). Case studies on real options. *Financial Management* 22(3), 259-270.

Kester, W.C. (1984). Today's options for tomorrow's growth. *Harvard Business Review* 62(2), 153-160.

Kim, S.M. / Seth, A. (2001). Valuation of International Joint Ventures: A Real Options Approach. In: Contractor, F.J. [ed.]: *Valuation of Intangible Assets in Global Operations*, Westport 2001, 147-169.

Koch, C. (1999). Optionsbasierte Unternehmensbewertung. Wiesbaden.

Kogut, B. (1988). Joint ventures: Theoretical and empirical perspectives. *Strategic Management Journal* 9(4), 319-332.

Kogut, B. (1991). Joint ventures and the option to expand and acquire. *Management Science* 37(1), 19-33.

Kogut, B. / Kulatilaka, N. (2001). Capabilities as real options. *Organization Science* 12(6), 744-758.

Koh, J. / Venkatraman, N. (1991). Joint venture formations and stock market reactions: An assessment of the information technology sector. *Academy of Management Journal* 34(4), 869-892.

Kutschker, M. / Schmid, S. (2002). Internationales Management, 2. edition, München, Wien.

Lander, D.M. / Pinches, G.E. (1998). Challenges to the Practical Implementation of Modeling and Valuing Real Options. *Quarterly Review of Economics and Finance* 38(3), 537-567.

Leithner, S. / Liebler, H. (2003). Die Bedeutung von Realoptionen im M&A-Geschäft. In: Baecker, P. / Hommel, U. / Scholich, M. [eds.]: *Reale Optionen*, Berlin 2003, 219-241.

Leslie, K.J. / Michaels, M.P. (2000). The real power of real options. *McKinsey Quarterly* 34(3), 4-22.

Lint, O. / Pennings, E. (1997). The option value of advanced R&D. *European Journal of Operational Research* 103(1), 83-94.

Luehrman, T.A. (1998a). Investment opportunities as real options: Getting started on the numbers. *Harvard Business Review* 76(4), 51-67.

Luehrman, T.A. (1998b). Strategy as a portfolio of real options. *Harvard Business Review* 76(5), 89-99.

Madhavan, R. / Prescott, J.E. (1995). Market value impact of joint ventures: The effect of industry information-processing load. *Academy of Management Journal* 38(3), 900-915.

Majd, S. / Pindyck, R.S. (1987). Time to build, option value, and investment decisions. *Journal of Financial Economics* 18(4), 7-27.

McConnell, J.J. / Nantell, T.J. (1985). Corporate combinations and common stock returns: The case of joint ventures. *Journal of Finance* 40(2), 519-536.

Meise, F. (1998). Realoptionen als Investitionskalkül. München.

Merton, R.C. (1973). Theory of rational option pricing. *Bell Journal of Economics and Management Science* 4(1), 141-183.

Pape, U. (2004): Wertorientierte Unternehmensführung und Controlling, 3. edition, Sternenfels, Berlin.

Pindyck, R.S. (1991). Irreversibility, uncertainty and investment. *Journal of Economic Literature* 24(9), 1110-1148.

Rams, A. (1999). Realoptionsbasierte Unternehmensbewertung. *Finanz Betrieb* 1(11), 349-364.

Rappaport, A. (1986). Creating shareholder value - The new standard for business performance. New York.

Rappaport, A. (1992). CFOs and strategists: forging a common framework. *Harvard Business Review* 70(3), 84-92.

Tomaszweski, C. (2000). Bewertung strategischer Flexibilität beim Unternehmens-erwerb - Der Wertbeitrag von Realoptionen. Frankfurt am Main.

Trigeorgis, L. (1993). Real options and interactions with financial flexibility. *Financial Management* 22(3), 202-224.

Trigeorgis, L. (1996). Real options: Managerial flexibility and strategy in resource allocation. Boston.

Trigeorgis, L. (2002). Real options and investment under uncertainty : what do we know? Mimeo, Brüssel.

Weeds, H. (2002). Strategic Delay in a Real Options Model of R&D Competition. *Review of Economic Studies* 69(3), 729-747.

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