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Valuation of Convertible Bonds with Sequential Conversion**

Abstract

In this paper, we characterize optimal conversion strategies and the related values of convertible bonds and stocks under a sequential conversion policy. Contrary to the existing literature, we consider firms that have both subordinated debt outstanding and convertible bonds. The additional debt results in wealth transfers among the holders of stock, convertible bonds, and additional debt, depending on the conversion strategy. These wealth transfers lead to remarkable differences in the optimal conversion policy and for the values of convertible bonds and stocks. It is possible that only a fraction of outstanding convertibles are converted at the last conversion date, that the stock value is partly strictly decreasing in the firm value, and partly decreasing in the dividend payment. It is also possible that certain stock values cannot occur when block conversion takes place, and that the value of a block-convertible bond is below and never above the corresponding value of a convertible bond under unresticted conversion.

JEL-Classification: G12, G13, G32.

1 Introduction

Convertible bonds represent complex financing instruments with a special challenge. The theoretical analysis of these instruments comprises two major research fields. The first research addresses the question of why firms issue this hybrid financial claim. One possible answer is given by the theory of optimal contracting under asymmetric information. Convertible bonds and warrants can be used to mitigate moral hazard and adverse selection problems[1]. The second field takes the terms of convertible bonds as given and asks for their fair value. This question is also the focus of our paper. In the following analysis, we concentrate on convertible bonds.

Convertible bonds can be considered as a straight bond plus an additional option component for their holders. Typically, conversion is possible *at any time* after an

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1 See e.g. *Barnea/Haugen/Senbet* (1985), chapter 6; *Brennan/Schwartz* (1988); *Welcker* (1968).

initial time period except for few days a year. Therefore, the value of a convertible also depends on the *conversion strategy* that the convertible bond holders follow.

In most cases, the literature prices the option component of a convertible analogous to American call options traded on derivatives exchanges. The difference between these two financial claims is basically accounted for by a dilution factor and modified boundary conditions. Consequently, all these approaches implicitly or explicitly assume that all convertible bond holders completely convert their bonds *at the same time* or *not at all*. This behavior is denoted by *block* conversion[2].

However, the block conversion assumption is questionable from both an empirical and a theoretical perspective. *Table 1* shows the observed conversion volume as a percentage of the initially outstanding amount for the KSB convertible bond issued in 1983. This Table indicates that in every year, as long as it was feasible to convert, bond holders convert part of the outstanding convertibles. In total, the bond holders converted 99.28 % of the outstanding issue.

Table 1: Conversion over time

The Table shows the annual conversion volume for the nine year 6.5% convertible bond issued by KSB in 1983. A conversion was feasible during a time period from 1984/1/1 until 1992/12/15.

year	83	84	85	86	87	88	89	90	91	92
conversion volume in %	–	70.43	1.23	0.07	0.51	15.06	3.03	1.45	1.31	6.19

It is natural to argue that the sequential conversion is a result of frictions such as information asymmetry between the holders of the convertible bonds, different implicit or explicit conversion costs, or non-rational behavior of the convertible bond holders. However, frictions are not necessary to explain a sequential conversion behavior. *Emanuel* (1983) and *Constantinides/Rosenthal* (1984) show that sequential conversion can be optimal if one investor holds all convertibles (the monopolistic case), or if competitive convertible bond holders act strategically (unrestricted conversion). The reason for this finding is that the conversion strategy impacts the number of outstanding stocks, their value, and the firm's capital structure. Therefore, the value of the convertible bonds held by one individual investor depends on the conversion strategy followed by the other investors. As a result, the convertible-bond holders are involved in a strategic game. Its results depend on the game structure and the market form. Stockholders who do not hold any convertible bonds are passive participants in this game. The objective of the convertible-bond holders is to maximize the value of their portfolios.

2 See *Ingersoll* (1977); *Brennan/Schwartz* (1977; 1980); *Swoboda/Kramschal* (1979); *Reiß/Schöbel* (1999). The approaches for warrants presented by *Galai/Schneller* (1978); *Lauterbach/Schultz* (1990); *Schultz/Trautmann* (1994) and *Crouby/Galai* (1994) allow for one exercise date, only.

Constantinides (1984) shows that for the important case of unrestricted conversion, there is at least one *Nash*-equilibrium in conversion strategies. Moreover, the highest value of the convertible bond in these *Nash*-equilibria coincides with its *value in the block case*. Therefore, the option-theoretic approach to valuing convertible bonds under the block assumption presented by *Ingersoll* (1977), *Brennan/Schwartz* (1977), *Swoboda/Kramschal* (1979), *Schulz/Trautmann* (1994), *Reiß/Schöbel* (1999) and others experiences a subsequent justification when the firm has no additional debt outstanding. However, it is an open question whether the results of *Emanuel* and *Constantinides* still hold if the firm has issued straight bonds in addition to the convertible bonds. Therefore, it is also an open question whether the models by *Brennan/Schwartz* (1980) and *Crouhy/Galai* (1994) result in correct values for the convertible bonds. These models allow for both additional debt and outstanding hybrid securities and assume block conversion. This open question is the core of our analysis.

The objective of our paper is to value convertible bonds and to characterize the optimal conversion strategies when a firm has additional debt in its capital structure. We focus on the differences between block conversion and unrestricted conversion. In addition to the strategically acting convertible-bond holders and the passive stock holders, we deal with the investors who hold additional debt. This further group of investors also plays a passive role in this game. The value of their bonds depends on the conversion strategy, because a conversion impacts the default probability of the debt. This conversion results in a wealth transfer between the different groups of investors and in several new results beyond those in *Constantinides* (1984) and *Emanuel* (1983). We extend the results in *Crouhy/Galai* (1994) by allowing for different conversion variants and more than one conversion date.

The new results concern the optimal conversion strategy and the equilibrium value of convertible bonds. We find that in general, a *sequential conversion* is optimal rather than a *block conversion*. Even at the last conversion date, a partial conversion might occur. In contrast to the result of *Constantinides*, the value of a convertible bond under unrestricted conversion can be higher than that under block conversion. Thus, the block conversion assumption, imposed by most of the convertible bond pricing literature, is not justifiable. We find that the wealth transfer related to a conversion yields several remarkable results for the equilibrium prices of stocks and convertible bonds, and has a considerable impact on the dividend and the additional debt's face value on these prices.

The paper is organized as follows: In Section 2, we specify the model framework and derive the asset values independent of the conversion variant. Section 3 characterizes the optimal conversion strategy and the related asset values of the convertible bonds and the stocks at maturity of the convertible bond. In Section 4, we present the same analysis for an arbitrary prior conversion date. Section 5 concludes. The appendix contains a *Table of symbols*.

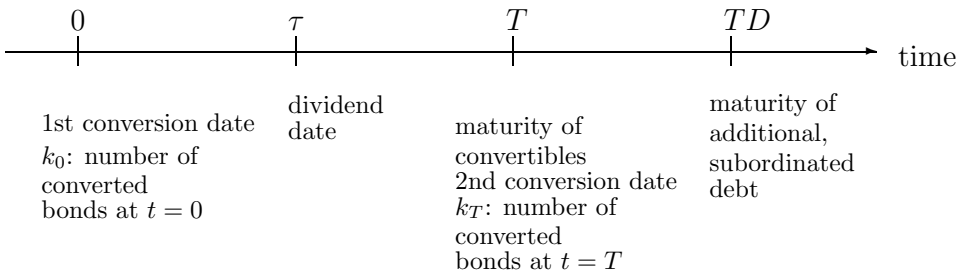
2 Model and Basic Relationships of Asset Values

2.1 Framework

In the following analysis, we consider a firm which has n stocks, m convertible bonds, and an additional zero bond outstanding. Every convertible bond has a redemption value of N. The face value of the zero bond is equal to ND. All the stocks have identical rights. We denote the bond issued in addition to the convertible as additional debt to distinguish this bond from the convertible. The redemption of the additional debt is set for a point of time TD after the maturity of the convertible bond.

We assume that the convertible bond is also designed as a zero coupon bond. Every convertible allows for a conversion into one stock. If there is no conversion, and as long as the firm value is sufficiently high for the redemption, each convertible bond pays N at time T. If the firm value is not sufficient to cover redemption, then each individual convertible-bond holder is entitled to trigger bankruptcy. In this case, the firm is liquidated and the proceeds, which equal the firm value, are distributed without bankruptcy costs among the convertible-bond holders in proportion to their holdings. This bankruptcy rule implies that the additional debt holders claim is subordinated. A premature default due to overindebtedness or the inability to pay cannot occur. This assumption goes back to *Merton* (1974) and it allows us to characterize the defaultable debt as a *European* put option.

Figure 1: Time Structure of the Model



In principle, we could model bankruptcy in a more advanced way by allowing it to happen exogenously[3] or endogenously[4] *at any time*. We do not do so because these generalizations would considerably complicate the analysis of optimal conversion strategies and distract from the primary goal of this paper.

3 See e.g. *Black/Cox* (1976); *Geske* (1977); *Kim/Ramaswamy/Sundaresan* (1994); *Longstaff/Schwartz* (1995).

4 See e.g. *Leland* (1994; 1998); *Leland/Toft* (1996); *Mella-Barrel* (1999); *Fan/Sundaresan* (2000). See *Ubrig-Homburg* (2001) for the modelling of both default reasons "inability to pay" and "overindebtedness".

Figure 1 shows the time structure of the model. The symbols we use here and throughout the paper are summarized in the *Table of symbols* contained in the appendix.

We consider two conversion dates, $t = 0$ and $t = T$, where the optimal conversion volumes, k_0^* and k_T^* respectively, must be determined subject to the restriction $k_0^* + k_T^* \leq m$. The focus on only two conversion dates is not an essential restriction, but it does allow us to use a better way of stressing the reasons and the determinants for a sequential conversion. Due to the characteristics of convertible bonds, there is only a finite set of possibly optimal conversion dates, namely the *end of the years*. First, a conversion set not later than at the end of a year is necessary to participate in the dividend payment of the following year. Second, without a dividend claim, a premature conversion is not optimal. The generalization for more than two conversion dates is straightforward; in the last section, we will return to this point.

At time τ, the firm pays off a fixed total dividend equal to D; its present value at time t is denoted by D_t $(0 \leq t < \tau)$. The total is distributed to the stockholders, including the new shareholders who own stocks obtained by conversion. Thus, D_t is independent from the conversion volume k_0 at time $t = 0$. Under this assumption, the size of the dividend is independent of the conversion strategies.

The dividend payment at time τ results in a reduction of the firm value. In our model, the firm value is the exogenous variable. Up to the dividend date, the variable consists of a risk-free part with a value equal to the present value of the dividend D_t and a risky part V_t. The risk-free part serves as a protection for the dividend payment. The risky part V_t follows a geometric Brownian motion

$$dV_t = \mu \cdot V_t \cdot dt + \sigma \cdot V_t \cdot dz_t \qquad (0 \leq t < TD; t \neq T). \tag{1}$$

z_t denotes the value of a standard Wiener process. μ and σ stand for the positive mean and volatility of the instantaneous firm value return, respectively.

Here, we must specify how the redemption of the non-converted convertibles affects the firm value at and after the maturity of the convertible. We make two standard assumptions. First, we assume that the redemption payment is covered by the sale of assets, resulting in a reduction of the firm value by this amount. Another possible assumption is to cover the redemption payment by external equity and/or debt. This assumption would require the analysis of several different cases, each of which has obvious consequences. Second, we assume that the drop in the firm value affects the volume, but not the structure of real assets. These two assumptions justify the dynamics (1) of the firm value with drift and diffusion coefficients independent of the conversion strategy.

For the conversion strategy (k_0, k_T) the firm value after conversion and redemption of the non-converted convertibles is given by

$$V_T = \begin{cases} V_T^- - (m - k_0 - k_T) \cdot N, & \text{if this difference is not negative,} \\ 0, & \text{otherwise.} \end{cases} \tag{2}$$

Here, V_T^- denotes the (existing) left limit of the firm's value process V_t.

The stocks, convertibles, and the additional debt are traded continuously on competitive, complete, and frictionless markets. Moreover, we assume competitive and frictionless markets for riskless zero bonds with arbitrary maturities and yield to maturity r. Together with V_t, these markets form a market model of the *Black/Scholes* type[5], Every derivative written on V_t can be replicated by a dynamic strategy.

Following *Emanuel* (1983) and *Constantinides* (1984), we consider two basic conversion variants. In the first case, all convertibles are converted simultaneously (*block conversion*: $k_0 \cdot k_T = 0$). In the second case, the convertible bonds are held by numerous investors, each of which has no price impact. Their individual conversion strategy is not subject to any restrictions (*unrestricted conversion*).

2.2 Basic Relationships of Asset Values

The total firm value V_t, at an arbitrary time t after the first conversion date but before the maturity of the convertible bond, is given by[6]:

$$V_t + D_t = (n + k_0) \cdot S_t + (m - k_0) \cdot W_t + B_t, \qquad (0 \le t < T),$$

where $D_t = 0$ for $t \ge \tau$. S_t denotes the value of one stock, W_t stands for the value of one convertible bond, and B_t is the total value of additional debt.

These asset values depend on the conversion strategy $k_0(\cdot)$, $k_T(\cdot)$, which itself might depend on the whole path of the firm value until the particular conversion date. Due to the *Markov*-property of V_t and the relations between asset values that we derive below, optimal conversion strategies can be fully characterized by V_0 and V_T^-, respectively. For ease of notation, we do not explicitly take into account the dependency $k_0(V_0)$ and $k_T(V_T^-)$, respectively.

When the convertible bond matures, and during the time period before the maturity of the additional debt, the firm value determines whether a default occurs at time T:

$$V_t = \begin{cases} 0, & \text{if } V_T^- < (m - k_0 - k_T) \cdot N \\ (n + k_0 + k_T) \cdot S_t + B_t, & \text{otherwise} \end{cases} \qquad (3)$$
$$(T \le t \le TD)$$

5 See *Black/Scholes* (1973).

6 Note that the stock value and the value of the additional debt show continuous paths. This property follows from the fact that the optimal conversion strategy is fully characterized by the firm value, which is observable immediately before conversion at time t = 0 or t = T, respectively. Therefore, the asset values after conversion are already known immediately before conversion. To exclude arbitrage opportunities, the asset values before conversion must be equal to those immediately after conversion. Since the firm value is independent of the conversion strategy, both the wealth of the convertible bond holders and the value of a convertible bond cannot show jumps in t for both conversion variants.

For our further analysis, it is sufficient to consider the asset values at the two conversion dates and at maturity of the additional debt. At the maturity of the additional debt, the asset values of both additional debt and total equity result from the values of European options in a manner

$$B_T(V_T) = e^{-r\cdot(TD-T)} \cdot ND - P_T(V_T),$$
$$(n + k_0 + k_T) \cdot S_T(V_T) = C_T(V_T).$$

P_T denotes the *Black/Scholes*-value of a European put option written on the firm value V_t with strike price ND and time to maturity $TD - T$. The call value C_T is defined analogously. Due to $V_T = \max(0, V_T^- - (m - k_0 - k_T) \cdot N)$, the values of both assets depend on the conversion strategy k_0, k_T. In case of bankruptcy, the values of the additional debt and the equity are zero.

At an arbitrary point in time t ($0 \leq t < T$), the values of the additional debt and the equity read

$$B_t(V_t) = e^{-r\cdot(T-t)} \cdot \int_{V^{crit}}^{\infty} (e^{-r\cdot(TD-T)} \cdot ND - P_T(V_T)) \cdot f_t(V_T^-) dV_T^-, \tag{4}$$

$$(n + k_0) \cdot S_t(V_t) = D_t + e^{-r\cdot(T-t)} \cdot \int_{V^{crit}}^{\infty} \left(\frac{n + k_0}{n + k_0 + k_T} \right) \cdot C_T(V_T)) \cdot f_t(V_T^-) dV_T^-, \tag{5}$$

where V_T is related to V_T^- by $V_T = \max(0, V_T^- - (m - k_0 - k_T) \cdot N)$ and $V^{crit} = (m - k_0 - k_T) \cdot N$. $f_t(V_T^-)$ stands for the conditional risk-neutral density function of V_T^- at time t. The total value of the convertibles, which have not been converted prior to time t, is given by the firm value minus the values of additional debt and equity, respectively

$$W_{t,all}(V_t) = (m - k_0) \cdot W_t(V_t) = V_t + D_t - B_t(V_t) - (n + k_0) \cdot S_t(V_t).$$

From the equations (4), (5), the put/call-parity

$$V_T - e^{-r\cdot(TD-T)} \cdot ND + P_T(V_T) - C_T(V_T) = 0$$

and the relation $V_T = \max(0, V_T^- - (m - k_0 - k_T) \cdot N)$ follows the value of outstanding convertible bonds:

$$W_{t,all}(V_t) = e^{-r\cdot(T-t)} \cdot \left[\int_{V^{crit}}^{\infty} \left((m - k_0 - k_T) \cdot N + \frac{k_T}{n + k_0 + k_T} \cdot C_T(V_T) \right) \cdot f_t(V_T^-) dV_T^- + \int_0^{V^{crit}} V_T^- \cdot f_t(V_T^-) dV_T^- \right] \tag{6}$$

We can interpret equation (6) for the value of a convertible bond as follows. If no default occurs at maturity of the convertible bond, ($V_T^- \geq V^{crit}$), the outstanding convertibles prior to *conversion* at time T can be represented by a portfolio

consisting of k_T stocks with a value of $k_T \cdot S_T = \frac{k_T}{n + k_0 + k_T} \cdot C_T(V_T)$ and cash of the amount $(m - k_0 - k_T) \cdot N$. The first line in (6) corresponds to the discounted expectation of the value of this portfolio under the risk-neutral density function. In case of bankruptcy, ($V_T^- < V^{crit}$), the convertible-bond holders obtain the firm value V_T^-; the discounted expectation of this value is the second addend of (6).

3 Optimal Conversion Strategy and Equilibrium Asset Values at Maturity of the Convertible Bond

We can determine the optimal conversion strategy by backward induction, starting at the last conversion date that coincides with the maturity of the convertible bond. For our analysis, we deal separately with the two conversion variants block conversion and unrestricted conversion. The rationale for the following results is a conversion that depends on wealth transfers from equity holders to the debt holders, because the claim of the debt holders at time *TD* is backed in a better way when a conversion ($k_T > 0$) takes place, as compared to the case of no conversion ($k_T = 0$)[7].

3.1 Block Conversion

The following results A) and B) for an optimal block conversion and the related asset values of both the convertible and the stock correspond to those in *Crouhy/Galai* (1994). To simplify the comparison with the unrestricted conversion, we again derive them in a modified form.

a) Analysis of the Optimal Conversion Strategy as a Function of the Firm Value

In the block conversion case, the conversion volume at time T is restricted to two possibilities, $k_T = 0$ and $k_T = m$. Thus, a conversion decision at time T is possible only if $k_0 = 0$ is assumed. A conversion of all the m outstanding convertibles is optimal, if for the stock value $S_T^*(V_T)$ *after conversion*

$$S_T^*(V_T) > N$$

holds[8]. Since the stock value can be represented by the *Black/Scholes*-value of a call option written on V_T with strike price *ND*, it follows from the monotonicity of this value in V_T that a unique critical value $\overline{V}$ exists that satisfies

$$S_T^*(\overline{V}) = N,$$

7 By assumption the conversion strategy has no impact on the mean μ nor on the volatility σ of the firm value's return.

8 In the following, we denote the asset values under the optimal conversion strategy by *. This notation is a short form of $S_T(V_T, k_T^*)$. For the equilibrium convertible bond value, $W_T^* = W_T(V_T, k_T^*)$ holds if $k_T^* < m - k_0$ and $W_T^* = S_T^*$ if $k_T^* = m$.

and accordingly

$$C_T(\overline{V}) = (n+m) \cdot S_T^*(\overline{V}) = (n+m) \cdot N. \tag{7}$$

After a complete conversion, since $V_T = V_T^-$ holds, $\overline{V}$ is the critical firm value immediately *before and after conversion*. Therefore, a complete conversion occurs for $V_T^- > \overline{V}$ and no conversion for $V_T^- < \overline{V}$. In case of $V_T^- = \overline{V}$, both conversion volumes $k_T^* = 0$ and $k_T^* = m$ are optimal and yield identical values of a convertible $W_T^* = N$. To avoid a separate examination of this special case in detail, we assume $k_T^* = 0$ in this case of indifference.

It follows immediately from the properties of European call options that $k_T^*(V_T^-)$ either does not change or increases discontinuously with V_T^-. Analogously, given a firm value V_T^- independent of *ND*, an increase of *ND* results in an increase of $\overline{V}$. Consequently, k_T^* either does not change or decreases with *ND* by a jump.

Result 1 (Conversion Strategy at Maturity under Block Conversion): *The optimal conversion volume k_T^* of the convertible bond at maturity T monotonously*[9] *increases with V_T^- and monotonously decreases with ND. The optimal block conversion strategy at maturity has the structure $k_T^* = 0$ for $V_T^- \leq \overline{V}$ and $k_T^* = m$ for $V_T^- > \overline{V}$.*

b) Analysis of the Values of the Convertible Bond and the Stock as a Function of the Firm Value

The value of a *convertible bond before conversion* at time *T* is continuous in V_T^-:

$$W_T^*(V_T^-) = \begin{cases} \frac{V_T^-}{m}, & \text{for } V_T^- < m \cdot N \\ N, & \text{for } m \cdot N \leq V_T^- \leq \overline{V} \\ S_T^*(V_T^-), & \text{for } V_T^- > \overline{V} \end{cases}$$

As long as no conversion takes place, an increase of the debt face value *ND* has no impact on W_T^* and can lead to a decrease of W_T^* if a conversion is advantageous. These observations lead to the following result for the value of a convertible bond at time *T*.

Result 2 (Value of a Convertible Bond at Maturity under Block Conversion): *The value of a convertible bond W_T^* at maturity T continuously and monotonously increases with V_T^- and continuously and monotonously decreases with ND.*

The *stock value* shows a drop in the firm value V_T^- at $\overline{V}$. This drop is caused by the full conversion at $\overline{V}$ and the related wealth transfer to the debt holders.

We note that there is a second critical firm value $\underline{V} < \overline{V}$ for which the stock value is also equal to the face value of a convertible bond. However, for this second

9 We use the usual terminology: $f(x)$ is increasing with x, if $x_2 > x_1$ implies $f(x_2) \geq f(x_1)$. $f(x)$ is strictly increasing with x, when $f(x_2) > f(x_1)$ holds.

critical firm value there is no optimal conversion. Otherwise, the stock value would fall below N. Therefore, for V_T^- between $\underline{V}$ and $\overline{V}$, it is not optimal to convert, even though the stock value is above the face value of the convertible bond.

This property can be explained as follows. Analogous to equation (7), we implicitly define $\underline{V}$ by the relation

$$S_T^*(\underline{V} - m \cdot N) = N$$

or

$$C_T(\underline{V} - m \cdot N) = n \cdot S_T^*(\underline{V} - m \cdot N) = n \cdot N. \tag{8}$$

It follows from (7) and (8) that

$$C_T(\overline{V}) = C_T(\underline{V} - m \cdot N) + m \cdot N \tag{9}$$

holds. Since the delta of a call option is below one, this equation can only be satisfied if $\underline{V}$ is below $\overline{V}$. Due to the strict monotonicity of C_T and S_T^*. Respectively, for $V_T^- < \overline{V}$, the stock value S_T^* exceeds the face value of a convertible bond for firm values $\underline{V} < V_T^- \leq \overline{V}$. However, for these firm values, it is not optimal to convert, because the related stock value *after conversion* would lie below N. Thus, the wealth of the convertible-bond holders would be less than it would be without conversion.

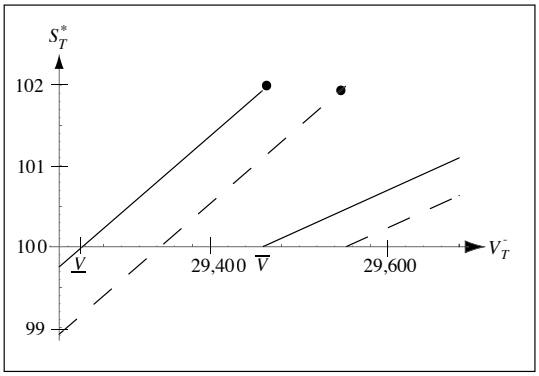
These considerations and the condition $S_T^*(\overline{V}) = N$ explain why the stock value shows a drop at $\overline{V}$. *Figure 2* shows a particular example for the stock value S_T^* as a function of the firm value V_T^-; the dashed curve will be addressed below. In this Figure, it turns out that the wealth transfer in favor of the debt holders that is triggered by conversion can result in a jump of the stock value and in no conversion despite stock values above N. For firm values $V_T^- > \overline{V}$, the stock value strictly increases again.

In general, the stock value, given a fixed firm value V_T^-, decreases with the face value ND of additional debt. However, if the firm value is slightly above $\overline{V}$, a comparison of both curves in *Figure 2* shows that the stockholders can increase the equity value by voluntarily increasing the redemption value of the additional debt. This unusual incentive to increase ND again rests on the fact that the wealth transfer from the stock holders to the debt holders that is triggered by conversion does not take place. In this case, it is possible that the stock value only, or both the stock value and the debt value increase with the debt face value. These considerations give us the following result for the stock value at maturity.

Result 3 (Stock Value at Maturity under Block Conversion): *The stock value S_T^* at maturity T continuously and monotonously increases with the firm value V_T^- for $V_T^- < \overline{V}$ and for $V_T^- > \overline{V}$. At the critical firm value $\overline{V}$, the stock value discontinuously decreases. Therefore, the stock value can lie above the face value of a convertible*

Figure 2: Stock value at Maturity of the Convertible Bond under Block Conversion

The Figure shows the stock value in the block case as a function of the firm value $V_{\bar{T}}$ *for* $ND = 100{,}00$ *(solid line) and* $ND = 10{,}100$ *(dashed line). The parameters are* $n = 100$, $m = 100$, $N = 100$, $\sigma = 0.5$, $r = 0.05$, $TD - T = 1$. *The critical firm values for* $ND = 10{,}000$ *result in* $\underline{V} = 29{,}276.1$ *and* $\overline{V} = 29{,}478{,}9$.



bond, and no conversion is advantageous. Thus, we see that an increase of the face value ND of debt can also increase the stock value.

c) Analysis of the Conversion Strategy and the Values of a Convertible Bond as a Function of the Stock Value

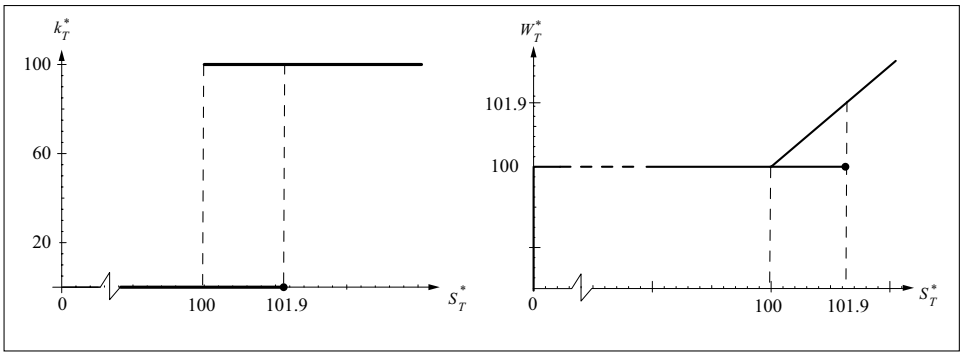
In general, we cannot observe the market value of a firm. Thus, investors usually base their conversion decision on the *stock value* S_T^*. From a theoretical perspective, we can account for this investor behavior in our firm value framework by determining the corresponding optimal conversion volume k_T^* and the endogenous stock value S_T^* for every firm value. Analogously, we can determine the value of a convertible bond W_T^*, depending on the endogenous stock value. k_T^* and W_T^* are shown in *Figure 3* as a function of the stock value for a particular example.

Figure 3 shows that both the conversion strategy and the value of a convertible bond are not uniquely defined by S_T^* for stock values between $N = 100$ and $S_T^*(\overline{V}) = 101.9$. This behavior follows from *Figure 2*. In this particular example, the same stock value can be related to a complete conversion $k_T^* = m$ and to no conversion $k_T^* = 0$. This non-uniqueness also holds for the value of a convertible bond. The stock value related to a complete conversion results from a higher firm value, and therefore if there is no conversion, the corresponding convertible bond value is higher than for the same stock value.

A second non-uniqueness of the convertible bond value occurs for a stock value equal to zero, i.e. in case of bankruptcy. In this case, the convertible bond value equals the prorated firm value, and, therefore, can attain every value between zero and N, depending on the firm value.

Figure 3: Optimal Conversion Volume k_T^* and Convertible Bond Value W_T^* under Block Conversion

The left diagram shows the optimal conversion volume k_T^* as a function of the stock value S_T^* in case of block conversion. The right diagram shows W_T^* as a function of S_T^*. The parameter values are n = 100, m = 100, N = 100, ND = 10,000, σ = 0.5, r = 0.05, $TD - T$ = 1.



Result 4 (Conversion Strategy and Convertible Bond Value at Maturity as a Function of the Endogenous Stock Value under Block Conversion): *The conversion strategy and the convertible bond value are not uniquely defined for stock values in the interval $(N; S_T^*(\overline{V})]$. The value of a convertible bond is not unique if bankruptcy occurs ($S_T^* = 0$). For $0 < S_T^* \leq N$, we have $k_T^* = 0$ and $W_T^* = N$. For $S_T^* > S_T^*(\overline{V}^+) = N$ a complete conversion is optimal and W_T^* is linear in S_T^**[10].

3.2 Unrestricted Conversion

a) Analysis of the Optimal Conversion Strategy as a Function of the Firm Value

In case of *unrestricted conversion,* a single convertible-bond holder cannot affect the stock value by his conversion decision. It is the aggregated conversion volume among all convertible-bond holders that can lead to a positive conversion volume with a price impact.

Following *Constantinides/Rosenthal* (1984), we can characterize the optimal conversion strategies by *Nash*-equilibria resulting from a non-atomic game. In this game, k_0 and k_T, respectively, denote the conversion volume aggregated over all convertible bond holders. According to a result from *Schmeidler* (1973), it follows that in this conversion game a *Nash*-equilibrium in pure strategies exists[11]. This equilibrium depends on the fact that every individual convertible bond holder can

10 $\overline{V}^+$ stands for the right limit of the firm value at $\overline{V}$.

11 See *Schmeidler* (1973), p. 296. *Blonski* (1999) develops a procedure to determine the *Nash*-equilibria.

determine his optimal decision by comparing the non-influenceable stock value S_T^* after conversion with the face value N of a convertible bond.

Depending on the aggregate conversion volumes k_0 and k_T, the stock value S_T after conversion is $S_T = \max\left(0; \frac{V_T^- - (m - k_0 - k_T \cdot B_T}{n + k_0 + k_r}\right)$. For $V_T^- < \underline{V}(k_0)$, S_T is below $\min\left(\frac{V_T^-}{m - k_0 - k_T}\ ;\ N\right)$ for all $k_T\,(0 \le k_T \le m - k_0)$[12]. Thus, it is optimal for every investor not to convert. For $V_T^- > \overline{V}$, the stock value S_T lies above the redemption value N for all $k_T(0 \le k_T \le m - k_0)$. Consequently, every convertible bond holder will convert his or her entire holdings.

In the interval $\underline{V}(k_0) \le V_T^- \le \overline{V}$, the aggregate conversion volume k_T^* must satisfy the equation

$$S_T^*(k_T^*, V_T^-) = \frac{V_T^- - (m - k_0 - k_T^*) \cdot N - B_T^*(k_T^*, V_T^-)}{n + k_0 + k_T^*} = N$$

or, equivalently,

$$S_T^*(k_T^*, V_T^-) = \frac{V_T^- - B_T^*(k_T^*, V_T^-)}{n + m} = N.$$

Otherwise, either no conversion ($S_T^* < N$) or a complete conversion ($S_T^* > N$) would occur for firm values $V_T^- > \underline{V}(k_0)$ and $V_T^- > \overline{V}$, respectively.

However, this conversion strategy contradicts the definition of $\underline{V}(k_0)$ and $\overline{V}$. As the debt value strictly increases with k_T^*, there will always be a unique equilibrium aggregate conversion volume k_T^* for every V_T^- in the considered interval. As a consequence, the unique aggregate conversion volume in equilibrium has the following structure:

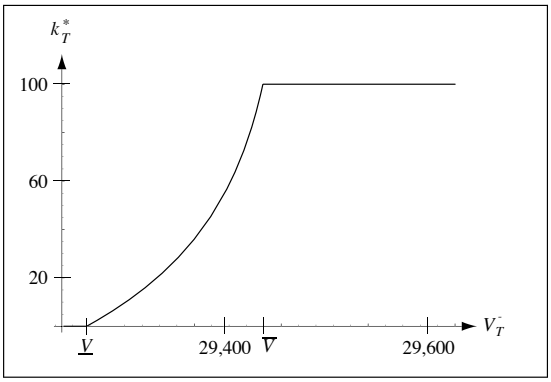
$$k_T^* = \begin{cases} 0, & \text{for } V_T^- < \underline{V}(k_0) \\ x, & \text{with } S_T(x, V_T^-) = N \text{ for } \underline{V}(k_0) \le V_T^- \le \overline{V} \\ m - k_0, & \text{for } V_T^- > \overline{V}. \end{cases}$$

As $S_T(k_T^*, V_T^-)$ is continous and strictly increasing with V_T^-, $k_T^*(V_T^-)$ also satisfies this property as long as k_T^* is different from zero or $m - k_0$. *Figure 4* shows k_T^* as a function of the firm value.

12 $\underline{V}(k_0)$ is uniquely defined by
$\underline{V}(k_0) - (n + m) \cdot N - B_T(\underline{V}(k_0)) - (m - k_0) \cdot N) = 0$.
This equation is analogous to (8), given that k_0 convertibles have been converted. This representation indicates that $\underline{V}(k_0)$ increases with k_0, but $\overline{V}$ is independent from k_0. The last property follows from (7).

Figure 4: Aggregate Conversion Volume k_T^* under Unrestricted Conversion

The Figure shows the aggregate conversion volume k_T^* as a function of the firm value V_T^- in the unrestricted case. The parameter values used correspond to those in Figure 2 $n = 100$, $m = 100$, $k_0 = 0$, $N = 100$, $ND = 10{,}000$, $\sigma = 0.5$, $r = 0.05$, $TD - T = 1$. The critical firm values result in $\underline{V}(k_0) = 29{,}276.1$ and $\overline{V} = 29{,}478.9$.



If the firm value is in the interval $(\underline{V}(k_0); \overline{V})$, an increase of the *face* value *ND* leads to a decrease of the aggregate conversion volume k_T^*. If k_T^* did not decline, the value of additional debt B_T would increase with *ND*. This effect would violate the condition that $B_T^* = V_T^- - (m + n) \cdot N$ remains constant or, equivalently, that S_T^* equals *N*. Therefore, k_T^* must decrease by an amount such that the independence of B_T^* from k_T^* is satisfied. Summarizing, we obtain the following result.

Result 5 (Conversion Strategy at Maturity Under Unrestricted Conversion): *The optimal conversion volume k_T^* at maturity T continuously and monotonously increases with the firm value V_T^- and continuously and monotonously decreases with the face value ND of the additional debt. A complete conversion occurs for firm values $V_T^- \geq \overline{V}$.*

A comparison of the optimal conversion strategies for the two conversion variants shows that in both cases the optimal conversion volume k_T^* increases with V_T^- and decreases with *ND*. On the contrary, a change of the optimal conversion volume in the block case must exhibit a jump by definition, while in the unrestricted case k_T^* is continuous in V_T^- and *ND*. Moreover, a partial conversion takes place in the unrestricted case for firm values V_T^- with $\underline{V}(k_0) < V_T^- < \overline{V}$, where a conversion in the block case only occurs if a complete conversion is optimal in the unrestricted case.

b) Analysis of the Values of the Convertible Bond and the Stock as a Function of the Firm Value

The value of a convertible bond W_T^* is continuous in V_T^-. It increases strictly with V_T^- for firm values below the bankruptcy value V^{crit} and for firm values above $\overline{V}$. A convertible bond value above its face value *N* requires a complete conversion,

just as in case of a partial conversion, $\underline{V}(k_0) < V_T^- < \overline{V}$, its value equals its face value N. Therefore, the value of a convertible bond reads ($m - k_0 > 0$):

$$W_T^* = \begin{cases} \frac{V_T^-}{m-k_0}, & \text{for } V_T^- < (m-k_0)\cdot N \\ N, & \text{for } (m-k_0)\cdot N \le V_T^- \le \overline{V} \\ S_T^*, & \text{for } V_T^- > \overline{V}. \end{cases}$$

When we compare the representation of W_T^* under block Conversion, we see that if, in the bock case immediately before conversion, $n + k_0$ stocks and $m - k_0$ convertibles are outstanding, the value of a convertible at maturity coincides with that in the block case.

Result 6 (Convertible Bond Value at Maturity under Unrestricted Conversion): *The value of a convertible bond W_T^* at maturity T continuously and monotonously increases with the firm value V_T^- and continuously and monotonously decreases with the debt face value ND.*

From the analysis in subsection A) it follows that the *stock value* S_T^* in equilibrium strictly and continuously increases with V_T^- for firm values $V^{crit} \le V_T^- \le \underline{V}(k_0)$ and $V_T^- > \overline{V}$. In the interval $(\underline{V}(k_0); \overline{V})$, S_T^* does not depend on V_T^- as it is equal to the face value N of a convertible bond. Therefore, as long as there are still convertible bonds outstanding, the stock value cannot be larger than the redemption value of a convertible bond. Moreover, the stock value attains the value N with a *positive* probability, while all the other positive stock values occur with a probability of zero. Therefore, S_T^* is given by:

$$S_T^* = \begin{cases} 0, & \text{for } V_T^- < (m-k_0)\cdot N \\ \frac{V_T^- - (m-k_0)\cdot N - B_T^*}{n+k_0}, & \text{for } (m-k_0)\cdot N \le V_T^- < \underline{V}(k_0) \\ N, & \text{for } \underline{V}(k_0) \le V_T^- \le \overline{V} \\ \frac{V_T^- - B_T^*}{n+m}, & \text{for } V_T^- > \overline{V}. \end{cases}$$

If the firm value is of an interval where the stock value strictly increases with V_T^-, an increase of the *debt face value ND* is associated with a reduction of S_T^*. This property follows immediately from the representation of S_T^* as the limits of the interval $\underline{V}(k_0)$ and $\overline{V}$ increase with *ND*. The stock value cannot increase with *ND*, as it does in the block case.

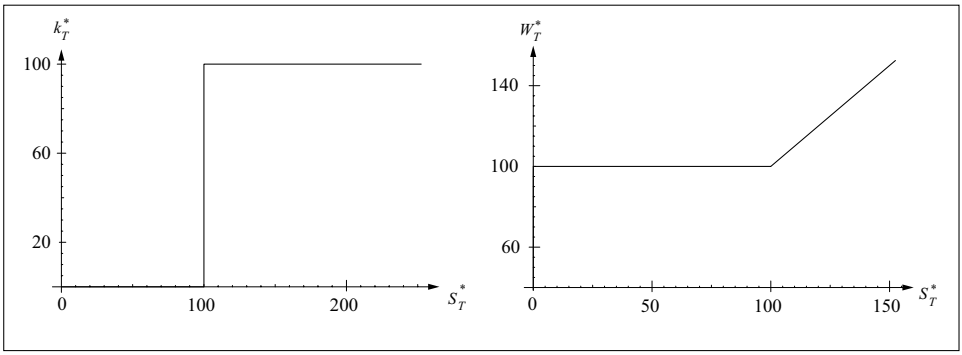
Result 7 (Stock Value at Maturity under Unrestricted Conversion): *The stock value S_T^* at maturity T continuously and monotonously increases with the firm value V_T^-. If no complete conversion takes place, it cannot be above the face value of a convertible bond. An increase of the debt face value ND does not lead to an increase of S_T^*.*

c) Analysis of the Conversion Strategy and the Values of a Convertible Bond as a Function of the Stock Value

In the case of unrestricted conversion, it is reasonable to question how the optimal conversion strategy and the convertible bond value depend on the endogenous stock value. Again, we obtain these relations by determining the combinations (S_T^*,k_T^*) and (S_T^*,W_T^*) for every firm value V_T^-. *Figure 5* shows these relations for a particular example.

Figure 5: Aggregate Conversion Volume k_T^* and the Value of a Convertible Bond W_T^* under Unrestricted Conversion

The left diagram shows the aggregate conversion volume k_T^* as a function of the stock value S_T^* in the unrestricted case. The right diagram shows W_T^* as a function of S_T^*. The parameter values are n = 100, m = 100, k_0 = 0, N = 100, ND = 10,000, σ = 0.5, r = 0.05, $TD - T$ = 1.



This Figure shows that the optimal conversion volume is uniquely determined by the stock value for all $S_T^* \neq N$. For $S_T^* = N$, a stock value that has a positive probability, the optimal conversion volume k_T^* can take on every value between zero and $m - k_0$. To determine k_T^* for this case it is necessary to know $V_T^-, \underline{V}(k_0) \leq V_T^- \leq \overline{V}$. The value of a convertible bond is equal to N for all stock values $0 < S_T^* < N$; i.e., if the bond is not converted. For stock values $S_T^* > N$, a complete conversion is optimal and $W_T^* = S_T^*$ holds. The stock value $S_T^* = N$ results in a unique convertible bond value of N, even though the aggregate conversion volume is not unique.

In the case of bankruptcy $S_T^* = 0$, the convertible bond value – as under block conversion – can attain every value between zero and N depending on the firm value. We summarize these findings in Result 8.

Result 8 (Conversion Strategy and Value of a Convertible Bond at Maturity as a Function of the Endogenous Stock Value under Unrestricted Conversion): *The optimal aggregate conversion strategy k_T^* as a function of the stock value S_T^* is $k_T^* = 0$ for $S_T^* < N$ and $k_T^* = m - k_0$ for $S_T^* > N$. For $S_T^* = N$ the conversion volume k_T^* can obtain every value between zero and $m - k_0$. The value of a convertible*

bond is uniquely defined by the stock value except for $S_T^* = 0$. *It takes the form* $W_T^* = N + max\,(0, S_T^* - N)$ *for* $S_T^* > 0$.

d) No Additional Debt (ND = 0)

The differences between block conversion and unrestricted conversion stem exclusively from the existence of additional debt. Without additional debt, it follows from equations (7) and (8) for the critical firm values $\frac{\bar{V}}{n+m} = N$ and $\frac{\underline{V} - (k_0) - (m - k_0) \cdot N}{n + k_0} = N$ that $\bar{V} = \underline{V}(k_0) = (n + m) \cdot N$ holds. Therefore, the values $\underline{V}(k_0)$ and $\bar{V}$ coincide for both conversion variants. Thus, partial conversion can only occur for the firm value $\bar{V}$. This property implies that at maturity, the block strategy is also a feasible equilibrium strategy in the unrestricted case[13] and that the value of a convertible bond and the endogenous stock value coincide with the corresponding values in the block case.

Result 9 (No Additional Debt outstanding at Maturity): *Without additional debt, the block conversion strategy also represents an equilibrium strategy in the unrestricted case. The values of both the convertible bond and the stock under block conversion coincide with those in case of unrestricted conversion*[14].

4 Optimal Conversion Strategy and Equilibrium Asset Values before Maturity of the Convertible Bond

We use the properties of the stocks, the additional debt, and the convertible bonds at maturity to determine the optimal conversion volume k_0^* at time t = 0 for both conversion variants block conversion and unrestricted conversion.

At this point, we make four preliminary notes, which we will need to draw on several times in the following sections.

(1) For both conversion variants, the critical firm value $V^{crit} = (m - k_0 - k_T^*) \cdot N$ at maturity equals $V^{crit} = (m - k_0) \cdot N$ as $k_T^*(V^{crit}) = 0$ in both cases. Thus, the endogenous V^{crit} depends on k_0 only[15]. The critical firm value $\underline{V}(k_0)$, below which $k_T^* = 0$ holds, also satisfies this property. On the other hand, the critical firm value $\bar{V}$, above which a complete conversion $k_T^* = m - k_0$ takes place, does not depend on k_0. This is true as the value of additional debt at time T is fully determined by the number of converted convertibles; i.e. it is independent of the point of time when conversion takes place.

(2) k_T^* is a random variable depending on V_T. For every firm value $V_T, \bar{k}_0 + k_T^*(\bar{k}_0) \geq \hat{k}_0 + k_T^*(\hat{k}_0)$ holds, if $\bar{k}_0$ *is* above $\hat{k}_0$. This statement is obvious for firm values $V_T \leq \underline{V}(\hat{k}_0)$, i.e., if no conversion occurs at time T. For firm values with a positive

13 At a firm value of $\bar{V}$, every feasible conversion volume is optimal in the unrestricted case.

14 The second part of this result goes back to *Constantinides* (1984).

15 Consequently, $k_T^* = 0$ holds for $V_T < V^{crit}$. If default is associated with bankruptcy costs, it could be advantageous for the convertible bond holders to avoid a default by a conversion. See *Limratana-mongkol* (1999).

conversion volume k_T^*, this statement results from the fact that only the total conversion volume is relevant for the conversion decision.

(3) The value of additional debt B_0 at time $t = 0$ strictly increases with the conversion volume k_0. This property follows from note (2) and the fact that B_T^* increases with $k_0 + k_T^*$. Moreover, in the unrestricted case W_0 is strictly increasing in the conversion volume k_0. This property results from the fact that the convertible bond value at time T does not decrease with k_0 independent of the firm value V_T^-. However, it strictly increases for firm values that have a positive probability.

(4) For both conversion variants, a premature conversion is only reasonable if a positive dividend is paid off at time τ. If we assume block conversion, this property follows by the same arguments as for exchange traded American stock options. For the case of unrestricted conversion, the analysis in Section 3.2 shows that the value of a convertible bond at maturity W_T^* falls never below the stock value S_T^*, and it is with a positive probability higher than S_T^*. Therefore, the current value of a convertible $W_0(k_0)$ is always above the stock value $S_0(k_0)$. A conversion without a dividend payment cannot be optimal in the unrestricted case.

4.1 Block Conversion

a) Analysis of the Optimal Conversion Strategy as a Function of the Firm Value

In the block case, we choose the conversion volume $k_0 \in \{0, m\}$ so that the wealth of the convertible-bond holders at time $t = 0$ is maximized:

$$\max_{k_0 \in \{0,m\}} k_0 \cdot S_0(k_0) + (m - k_0) \cdot W_0(k_0).$$

For the determination of the optimal conversion volume, we must compare the value $W_0(0)$ of a convertible bond given a conversion of $k_0 = 0$ with the value of a stock $S_0(m)$ after a complete conversion, $k_0 = m$.

The asset values at time $t = 0$ are given by the relations (5) and (6) and the optimal conversion volume $k_T^*(V_T^-)$ at maturity. For $k_0 = m$, it follows for the optimal conversion volume $k_T^* = 0$ and V^{crit} equals zero. In the case of $k_0 = 0$, we have $k_T^* = 0$ for $V_T^- \leq \overline{V}$ and $V^{crit} = m \cdot N$. Substituting these relations into (5) and (6) results in equations (10) and (11) below for the values of a stock and a convertible.

We can also deduce these values in the following intuitive way. The stock is equivalent to $\frac{1}{n+m}$ European call options written on the firm value with strike price ND and maturity TD plus the dividend payment $\frac{D_0}{n+m}$ per stock. Analogously, the convertible bond is a portfolio consisting of a zero bond with face value N and maturity T, a put option short written on the proportionate firm value $\frac{1}{m}V_t$ with strike price N and maturity T, and a European call CC_0 on the stock without dividend payment $\frac{1}{n+m}\ C_0(V_0, ND, TD)$ with strike price N and maturity T.

$$S_0(m) = \frac{1}{n+m} C_0(V_0, ND, TD) + \frac{D_0}{n+m}. \tag{10}$$

$$W_0(0) = N \cdot e^{-r \cdot T} - P_0\left(\frac{1}{m} V_0, N, T\right) + CC_0\left(\frac{1}{n+m} C_0(V_0, ND, TD) N, T\right). \tag{11}$$

For the call value CC_0, which can also be considered as a compound option on the firm value V_0, as well as for C_0 and P_0 exist closed form solutions. These closed form solutions indicate that both quantities $S_0(m)$ and $W_0(0)$ strictly and continuously increase with the firm value V_0(ex dividend D_0). For the conversion decision at time $t = 0$, the sign of the difference

$$\begin{aligned} S_0(m) - W_0(0) = {} & \frac{1}{n+m} C_0(V_0, ND, TD) + \frac{D_0}{n+m} - N \cdot e^{-r \cdot T} \\ & + P_0\left(\frac{1}{m} V_{0,} N, T\right) - CC_0\left(\frac{1}{n+m} C_0(V_0, ND, TD), N, T\right) \end{aligned} \tag{12}$$

is relevant. This sign depends on all parameters in equation (12). In the following discussion, we vary the dividend D_0 and the firm value V_0. Then, for the optimal conversion volume, three opportunities exist:

- For a dividend equal to zero, the optimal conversion volume results in $k_0^* = 0$ independent of V_0.

- For a sufficiently high dividend D_0, the difference (12) is always positive, independent of V_0, and $k_0^* = m$ holds.

  We can intuitively reason this statement by comparing the advantages and disadvantages associated with a conversion at time $t = 0$. The advantage of a conversion is the dividend $\frac{D_0}{n+m}$ obtained per convertible bond. Its disadvantage is the possibility that the stock has a lower value at time T than does the convertible bond. However, the difference of these two values is bounded by the face value N of a convertible bond. If the proportionate dividend $\frac{D_0}{n+m}$ lies above N, then a complete conversion independent of V_0 is optimal.

- For a positive dividend D_0, a block conversion $k_0^* = m$ is optimal for low and high firm values V_0. For sufficiently low firm values, the total firm value predominantly consists of the value of the dividend claim D_0. Thus, a conversion results in a value of at least $\frac{D_0}{n+m}$, but a non-converted convertible has a value close to zero, as W_0 cannot lie above V_0.

  In the case of a very high firm value V_0, the probability for $V_T^- > \overline{V}$ is about one, i.e. a conversion will almost surely occur at time T. Then, a conversion is already optimal at time $t = 0$, because the value of a stock obtained by conversion approximately exceeds the value of a non-converted convertible by the proportionate dividend.

The question of whether a conversion occurs for "medium" firm values, depends – as argued above – on the relation between the proportionate dividend and the difference between the values of a convertible bond and a stock at time T.

Figure 6 provides two examples in which no block conversion takes place for medium firm values. This Figure shows k_0^* as a function of the firm value V_0 for two different values of the dividend D_0. In both cases, the optimal conversion volume has the same structure. $k_0^* = m$ is optimal below a first critical firm value and above a second critical firm value. For all the other firm values, $k_0^* = 0$ holds[16].

To analyze the effect of a changing dividend D_0, we can consider two possibilities. The first varies D_0 given a constant V_0. The second assumes that the total firm value $D_0 + V_0$ is constant, i.e. V_0 decreases if D_0 increases. In the first case, the results are straightforward and correspond to our intuition. Therefore, we focus on the second possibility. In this case, an increase of D_0 is associated with a reduction of V_0 resulting in a lower value of W_0[17]. On the contrary, the stock value S_0 increases with the dividend D_0. Thus, a higher dividend cannot lead to a lower conversion volume when the total firm value is fixed.

When the *debt face value ND* rises, the optimal conversion volume k_0^* either decreases or does not change. This property is due to the fact that the conversion value $S_0(m)$ for $k_0 = m$ decreases with *ND* more strongly than the value of a convertible bond $W_0(0)$. These considerations yield the following result.

Result 10 (Conversion Strategy before Maturity under Block Conversion): *The optimal conversion volume k_0^* can increase with the firm value V_0, but it can also decline. Given a constant total firm value $V_0 + D_0$, both a higher dividend D_0 and a lower ND result in a monotonous increase of the optimal conversion volume k_0^*.*

b) Analysis of the Values of the Convertible Bond and the Stock as a Function of the Firm Value

The value of a convertible bond under the block conversion assumption is the maximum of the two values $W_0(0)$ and $S_0(m)$:

$$W_0^* = \max\{W_0(0), S_0(m)\}$$

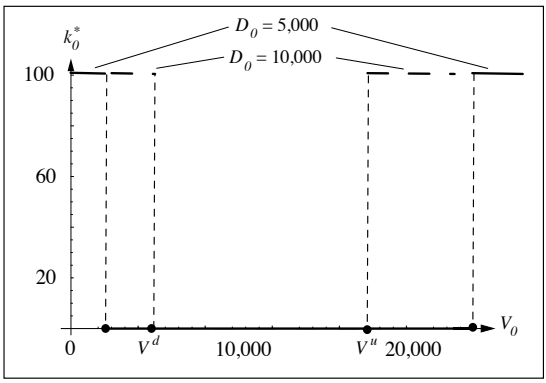
$W_0(0)$ and $S_0(m)$ increase with V_0 and decrease with *ND*, while $W_0(0)$ declines and $S_0(m)$ increases if D_0 increases. These findings give

16 This property of the optimal block conversion at time $t = 0$ can be generally proven if no additional debt exists. If there is additional debt, we were not able to prove this property. If we relax the assumption of a geometric Brownian motion for the firm value, the difference (12) can have more than one change of sign.

17 This property immediately follows from the relation (11).

Figure 6: Optimal Conversion Volume k_0^* under Block Conversion

The Figure shows the optimal conversion volume k_0^* in the block case as a function of the firm value V_0 (without the dividend) for different values of the dividend D_0. The parameter values are n = 100, m = 100, N = 100, ND = 10,000, σ = 0.5, r = 0.05, $TD - T$ = 1. The following critical firm values are related to the two different magnitudes of the dividend: D_0 = 5,000 (solid line), V^d = 2,525.6, V^u = 28,666.6, D_0 = 10,000 (dashed line), V^d = 5,641,8, V^u = 17,670.6.



Result 11 (Value of Convertible Bond before Maturity under Block Conversion): *The value of a convertible bond W_0^* strictly and continuously increases with the firm value V_0 and strictly and continuously decreases with the debt's face value ND. If a conversion is advantageous (k_0^* = m), the convertible bond value increases with the dividend, but for k_0^* = 0, a higher dividend yields a lower W_0^*.*

The endogenous s*tock value* S_0^* ist given by:

$$S_0^* = \begin{cases} S_0(0), & \text{if } k_0^* = 0 \\ S_0(m), & \text{if } k_0^* > m \end{cases}$$

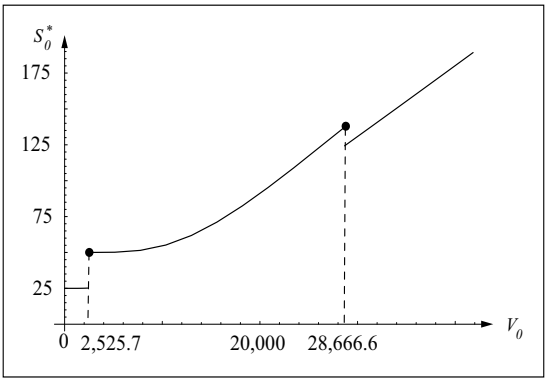
Figure 7 shows an example for the stock value S_0^* as a function of the firm value. We note that in this Figure, stock values below $\frac{D_0}{n+m}$ = 25 are not possible because of the certainty of the dividend payment. For firm values between 0 and V^d = 2.525,7 full conversion is optimal (cp. Figure 6), and therefore the stock value strictly increases from $S_0^*(0) = \frac{D_0}{n+m}$ = 25 to $S_0^*(V^{d-})$ = 25,2[18].

In the case of a further increase of V_0,k_0^* jumps to zero and the stock price jumps to $S_0^*(V^d)$ = 50,0. Therefore, endogenous stock values between $S_0^*(V^{d-})$ and $S_0^*(V^d)$ cannot occur. In the range of $V^d \le V_0 \le V^u$,k_0^* = 0 is optimal and S_0^* strictly increases with V_0 to a value of $S_0^*(V^u)$ = 137.2. At the upper firm value V^u =

18 V^{d-} stands for the left side limit of the firm value V_0 at V^d. Analogously, we define the quantity V^{u+} as the right side limit at V^u.

Figure 7: Stock Value S_0^* under Block Conversion

The Figure shows the stock value S_0^* in the block case as a function of the firm value V_0. The parameter values are n = 100, m = 100, D_0= 5,000, N = 100, ND = 10,000, σ = 0.5, r = 0.05, TD = 2, T = 1.



28,666.6, the conversion volume k_0^* shows a further jump. Related to this jump is a drop of S_0^{**} from $S_0^*(V^u)$ = 137.2 to $S_0^*(V^{d+})$ = 124.3.

An increase of D_0 and a decrease of ND, respectively, either result in an increase of the conversion volume k_0^* or in no change of k_0^*. However, a decrease of k_0^* is not possible. For this reason, an increase of D_0 and a decrease of ND, respectively, are either associated with a drop in the stock value (due to the wealth transfer to the debt holders caused by the conversion) or with a continuous change of S_0^*. This analysis gives

Result 12 (Stock Value before Maturity under Block Conversion): *If the conversion volume is constant, the stock value S_0^* is continuous in the firm value V_0, in the dividend payment D_0, and in the debt face value ND. If a variation of V_0, D_0, or ND results in an increase (decrease) of the conversion volume k_0^*, the stock value S_0^* exhibits a drop (upward jump). Due to the upward jump of S_0^* at V^d, stock values between $S_0^*(V^{d-})$ and $S_0^*(V^d)$ are not possible.*

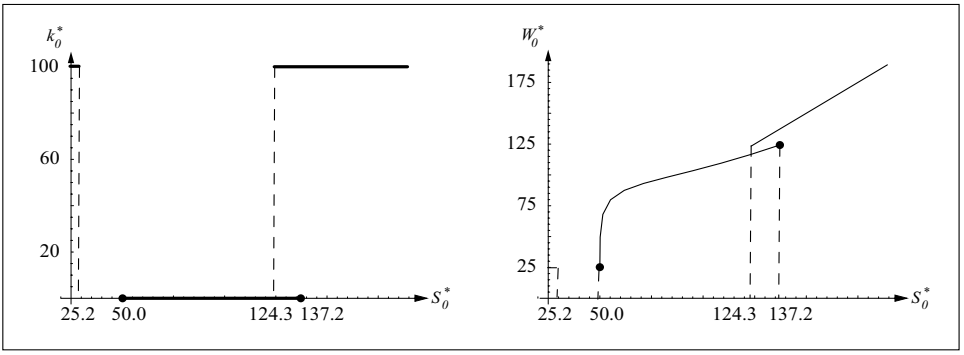
c) Analysis of the Conversion Strategy and the Values of a Convertible Bond as a Function of the Stock Value

Using the same argument as in Section 3, we examine the optimal conversion strategy and the value of a convertible bond as a function of the stock value S_0^*. *Figure 8* presents an example of this analysis.

For firm values in the interval $[0, V^u$ = 2,525.7), k_0^* = m is optimal according to *Figure 6*, and the stock value strictly increases to $S_0^*(V^{d-})$ i.e. the conversion volume k_0^* = m is optimal for endogenous stock values 25.0 = $\frac{D_0}{n+m} \leq S_0^*(V^{u-})$ = 25.2 and the convertible bond value $W_0^*(S_0^*)$ is linear in S_0^*.

Figure 8: Conversion Volume k_0^* and the Value of a Convertible Bond W_0^* under Block Conversion

The left diagram shows the optimal conversion volume k_0^* as a function of the stock value S_0^* in the block case. The right diagram shows W_0^* as a function of S_0^*. The parameter values are n = 100, m = 100, D_0 = 5,000, N = 100, ND = 10,00, σ = 0.5, r = 0.05, TD = 2, T = 1.



A further increase of the firm value results in a drop of k_0^* down to zero, and endogenous stock values between $S_0^*(V^{d-})$ and $S_0^*(V^d)$ = 50.0 cannot occur, as pointed out in Result 12. We note that a reduction of k_0^* does not result in a jump of the convertible bond value, i.e. $W_0^*(25.2) = W_0^*(50) = 25.2$ holds.

For the range $V^d \leq V_0 \leq V^u$, the endogenous stock value $S_0^* = S_0^*(0)$ and the value W_0^* of the convertible strictly and continuously increase with V_0. As S_0^* shows a drop at V^u, stock values in the range $S_0^*(V^{u+})$ = 124.3 and $S_0^*(V^u)$ = 137.2 cannot be mapped with a unique conversion volume or a unique convertible bond value. For stock values above $S_0^*(V_0^{u+})$, we get $k_0^* = m$ and $W_0^* = S_0^*$. This analysis gives the following result.

Result 13 (Conversion Strategy and Value of a Convertible Bond before Maturity as a Function of the endogenous Stock Value under Block Conversion): *Depending on the magnitude of the dividend $D_0 > 0$, the optimal conversion can either be always complete ($k_0^* = m$) or have at least two jumps in S_0^*. For the second case, there is a range of endogenous stock values in which there is no unique relation between the optimal conversion volume and the convertible bond value, on the one hand, and S_0^*, on the other hand. The value of a convertible bond strictly and continuously increases with S_0^*.*

4.2 Unrestricted Conversion

a) Analysis of the Optimal Conversion Strategy as a Function of the Firm Value

In the case of unrestricted conversion, all investors base their decision on a comparison of the two opportunities, "holding the convertibles" or "conversion". Thus,

as we do in Section 3.2, we get the following characterization for the aggregate conversion volume in any *Nash*-equilibrium:

$$k_0^* = \begin{cases} 0, & \text{if } S_0(0) < W_0(0) \\ x, & \text{if } S_0(x) = W_0(x) \\ m, & \text{if } S_0(m) > W_0(m) \end{cases} \tag{13}$$

The optimal *Nash*-equilibrium (13) is unique, because the three different possibilities in (13) are mutually exclusive. This statement can be shown as follows. According to note (3) at the beginning of Section 4, $W_0(k_0)$ and $B_0(k_0)$ are strictly increasing with the conversion volume k_0. Because the firm value $V_0 + D_0 = (n + k_0) \cdot S_0(k_0) + (m - k_0) \cdot W_0(k_0) + B_0(k_0)$ is independent from k_0, the equation $S_0(x) = W_0(x)$ can hold for one particular conversion volume k_0 at most[19]. If $S_0(x) = W_0(x)$ does not have a solution, $S_0(k_0) < W_0(k_0)$ or $S_0(k_0) > W_0(k_0)$ must hold for all k_0. In the first case, $k_0^* = 0$ is optimal, and in the second one, k_0^* equals m.

For the analysis of the dependence of the aggregate conversion volume k_0^* from the firm value V_0, it is sufficient to consider those firm values V_0 for which a partial conversion occurs, i.e. $0 < k_0^* < m$ or $S_0(k_0^*) = W_0(k_0^*)$ holds. It follows from the relation[20]

$$\frac{\partial W_0^*}{\partial V_0} = \frac{\partial W_0}{\partial V_0} + \frac{\partial W_0}{\partial k_0} \cdot \frac{\partial k_0^*}{\partial V_0}$$

$$= \frac{\partial S_0^*}{\partial V_0} = \frac{\partial S_0}{\partial V_0} + \frac{\partial S_0}{\partial k_0} \cdot \frac{\partial k_0^*}{\partial V_0}$$

that the local sensitivity *of* k_0^* for V_0 is given by:

$$\frac{\partial k_0^*}{\partial V_0} = -\left. \frac{\frac{\partial W_0}{\partial V_0} - \frac{\partial S_0}{\partial V_0}}{\frac{\partial W_0}{\partial k_0} - \frac{\partial S_0}{\partial k_0}} \right|_{(k_0^*(V_0), V_0)} \tag{14}$$

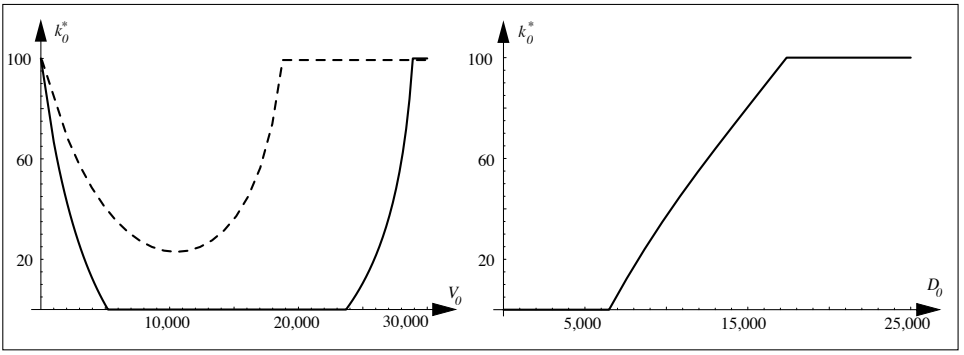
First of all, we again consider a variation of V_0 given a constant dividend D_0. Without a dividend payment, the optimal conversion volume is equal to zero, as in the block case, and a complete conversion is optimal for all firm values V_0 when the dividend is sufficiently high. If, for example, $\frac{D_0}{n+m} \geq N \cdot e^{-r \cdot T}$ holds, then a complete conversion at $t = 0$ together with a risk-free investment of the dividend gives a portfolio value at time T of $\frac{D_0}{n+m} e^{r \cdot T} + S_T(m)$. Since this amount exceeds the value of a convertible bond $W_T^* = \max(N, S_T(m))$ at time T, a complete premature conversion is optimal.

19 If for $\bar{k}_0$ and $\hat{k}_0 (\bar{k}_0 < \hat{k}_0)$ the stock value and the value of a convertible bond coincided, then the firm value for $\bar{k}_0$ would be lower than that for $\hat{k}_0$. This inequality contradicts the property that the firm value is independent of the conversion volume.

20 From the relations (5) and (6) follows that for firm values V_0 with $0 < k_0^* < m$, the optimal conversion volume k_0^* can be differentiated in V_0.

Figure 9: Aggregate Conversion Volume k_0^* under Unrestricted Conversion

The left diagram shows the aggregate conversion volume k_0^* as a function of the firm value V_0 for the dividends D_0 = 5,000 (solid line) and D_0 = 10,000 (dashed line) in the unrestricted case. The right diagram shows k_0^* as a function of D_0 given a constant total firm value of $D_0 + V_0$ = 25,000. The parameter values are n = 100, m = 100, N = 100, ND = 10,000, σ = 0.5, r = 0.05, TD = 2, T = 1.



If the dividend payment satisfies the condition $0 < \frac{D_0}{n+m} < N \cdot e^{-r \cdot T}$, the aggregate conversion volume k_0^* is a strictly decreasing function in V_0 for small firm values and is equal to m for $V_0 = 0$. This property follows from the approximations for the values of a convertible bond $W_0(k_0) \approx \min\left(N \cdot e^{-r \cdot T}, \frac{V_0}{m - k_0}\right)$ and a stock $S_0(k_0) \approx \frac{D_0}{n + k_0}$ if the firm value V_0 is sufficiently close to zero. These approximations imply $W_0(m) > S_0(m)$ and $W_0(0) < S_0(0)$. Therefore, for small positive firm values, a sequential conversion takes place and the slope of k_0^* given by (14) is negative. Moreover, if V_0 equals zero, then by the property of the geometric Brownian motion V_t stays at zero for all future points of time, and a complete conversion $k_0^* = m$ is optimal[21].

The left side of *Figure 9* shows the optimal conversion volume k_0^* as a function of the firm value V_0 for two different dividend payments D_0 = 5,000 and D_0 = 10,000. In both cases, k_0^* decreases with the firm value when V_0 is low. The minimal conversion volume can be positive or zero. The critical firm values, for which a complete conversion occurs, are V_0 = 28,882.0 for D_0 = 5,000 and V_0 = 18,695.4 for D_0 = 10,000.

If we vary the dividend D_0 under the condition that the total firm value $V_0 + D_0$ is constant, the optimal conversion volume monotonously increases, as shown in the right side of *Figure 9*. No conversion takes place up to a critical dividend. Then, the conversion volume strictly increases with D_0 until $k_0^* = m$. We obtain this result

21 In addition, $k_0(V_0)$ is right-continuous at $V_0 = 0$. To show this behavior, we assume that the limit of $k_0^*(V_0)$ is $\bar{m} < m$, if V_0 converges to zero. Then, the minimum in the approximation for W_0 is equal to $\frac{V_0}{m - k_0^*(V_0)}$ for small firm values. This value contradicts the equilibrium condition $W_0(k_T^*) = S_0(k_0^*)$ as $W_0(k_0^*)$ converges to zero, but $S_0(k_0^*)$ converges to $\frac{D_0}{n+\bar{m}} \neq 0$.

if we replace in (14) the derivatives for V_0 with the corresponding ones with respect to D_0. The nominator has a negative sign as an increase of D_0 reduces the value of W_0 and increases the value of S_0. Because the denominator is always positive, the result follows.

As in the block case, an increase of the *face value of additional debt ND* leads to either the same or a decreasing aggregate conversion volume. The assertion can be shown using formula (14) similar to the last result. We must consider only that an increase of *ND* reduces the value of both the convertible bond and the stock. But the sensitivity of W_0 is lower than that of S_0, since at time T, both assets are equally sensitive to *ND* if $k_T^* > 0$ holds and S_T^* is more sensitive if $k_T^* = 0$.

In analogy to Result 10 under block conversion, we find the following result for the conversion volume in the unrestricted case.

Result 14 (Conversion Strategy before Maturity under Unrestricted Conversion): *The optimal conversion volume k_0^* given a constant dividend D_0 is a continuous function of the firm value. It can increase, but also decrease, with V_0. If the total value $V_0 + D_0$ is constant, the optimal conversion volume k_0^* is a continuously increasing (decreasing) function in the dividend D_0 (the debt face value ND of the additional debt). Moreover, the first conversion date with an optimal unrestricted conversion can lie before, but never after, the optimal conversion date in the block case.*

The last part of this result can be illustrated as follows. A comparison of *Figures 6 and 9* indicates that a positive aggregate conversion volume k_0^* under unrestricted conversion is possible, but the convertible bonds are not converted in the block case. The opposite case, in which a block conversion and no conversion in the unrestricted case are optimal, cannot happen. If $W_0(0) < S_0(m)$ holds in the block case, the condition $W_0(0) < S_0(0)$ for the unrestricted case must also be valid to ensure that $k_0^* = 0$ is the equilibrium strategy in the unrestricted case. Because $V_0 + D_0 = (n + m) \cdot S_0(m) + B_0(m) = n \cdot S_0(0) + m \cdot W_0(0) < B_0(0)$ in conjunction with $\frac{\partial W_0}{\partial k_0} > 0$ and $\frac{\partial B_0}{\partial k_0} > 0$, these two inequalities $W_0(0) \leq S_0(m)$ and $W_0(0) \geq S_0(0)$ cannot be satisfied simultaneously[22]. Therefore, a premature conversion under the block assumption implies a premature conversion of competitively held convertible bonds.

b) Analysis of the Values of the Convertible Bond and the Stock as a Function of the Firm Value

If the convertible bond is partially or fully converted, $W_0^* = S_0^*$ must hold. Together with the identity $V_0 + D_0 = n \cdot S_0^* + m \cdot W_0^* + B_0^*$, we have the following representation for W_0^*:

$$W_0^* = \begin{cases} W_0(0), & \text{if } k_0^* = 0 \\ \frac{V_0 + D_0 - B_0^*}{n+m} & \text{if } k_0^* > 0 \end{cases} \tag{15}$$

22 The values of both $S_0(m)$ and $W_0(0)$ in the block case coincide with those in the unrestricted case.

W_0^* is a continuous and strictly increasing function of V_0. In the case of $k_0^* = 0$, this property immediately results from (11). If $k_0^* = m$ holds, it follows from the fact that the sensitivity of B_0^* in terms of V_0 is below one. If the conversion volume k_0^* strictly increases with V_0, the value of a convertible bond benefits from both the higher firm value and the increase of the conversion volume. This property is a consequence of note (3) at the beginning of Section 4.

In the opposite case, if k_0^* decreases with V_0, we have $\frac{\partial B_0^*}{\partial V_0} = \frac{\partial B_0}{\partial V_0} + \frac{\partial B_0}{\partial k_0} \cdot \frac{\partial k_0^*}{\partial V_0} < \frac{\partial B_0}{\partial V_0} \leq 1$ and, therefore, the derivative $\frac{\partial W_0^*}{\partial V_0} = \frac{1}{n+m}\left(1 - \frac{\partial B_0^*}{\partial V_0}\right)$ is always positive. The first inequality follows from the fact that due to remark (3) at the beginning of Section 4, the debt value $B_0(k_0)$ increases with the conversion volume. The second inequality results from formula (4).

The sensitivity of W_0^* to D_0 conditional on a fixed total firm value $V_0 + D_0$ follows again from (11) if $k_0^* = 0$ and from (10) if $k_0^* = m$ holds. In the first case, $W_0(0)$ decreases with D_0. In the second case, it increases with D_0. In the third case of a sequential conversion $0 < k_0^* < m$, W_0^* can increase or decrease with D_0 since two opposite effects are related with a variation of D_0. First, if we increase D_0, the firm value V_0 and W_0^* will decrease. Second, by Result 14, the optimal conversion volume k_0^* increases in D_0. For the total sensitivity of W_0^* to D_0 it matters which of these two effects dominates.

As in the block case, a higher debt face value *ND* cannot lead to a higher convertible bond value. This result is because the convertible bond value at maturity and the optimal conversion volume k_0^* decreases with *ND* for all firm values. Both effects lead to a reduction of the convertible bond value W_0^*.

Result 15 (Convertible Bond Value before Maturity under Unrestricted Conversion): *The value of a convertible bond W_0^* strictly and continuously increases with the firm value V_0 and strictly and continuously decreases with ND. An increase of the dividend D_0 can result in either an increase or a decrease of W_0^*. The value of a convertible bond in the unrestricted case is not smaller than its value under block conversion.*

To justify the last statement, we distinguish between three cases: In the first case, a block conversion could occur, but no conversion would take place in the unrestricted case. Due to Result 14, this case is not possible. In the second case, it is optimal not to convert in the block case and k_0^* is positive in the unrestricted case. As W_0 increases with k_0 by remark (3) at the beginning of Section 4, W_0^* does not lie below the corresponding value in the block case. The third case is characterized by a block conversion and $k_0^* > 0$. Then, it follows from the strict monotonicity of $B_0(k_0)$ in k_0 for $0 < k_0 < \mathrm{m}$ in conjunction with representation (15) of W_0^* for $k_0^* > 0$ that W_0^* is larger than the value of a convertible in the block case.

By applying our previous considerations on the convertible bond values, the *stock value* S_0^* can be represented as follows:

$$S_0^* = \begin{cases} S_0(0), & \text{if } k_0^* = 0 \\ \frac{V_0 + D_0 - B_0^*}{n+m} & \text{if } k_0^* > 0. \end{cases}$$

For this reason, the first part of Result 15 is also valid for the stock value S_0^*.

Result 16 (Stock Value before Maturity under Unrestricted Conversion): *The stock value S_0^* strictly and continuously increases with the firm value V_0 and strictly and continuously decreases with the debt face value ND. An increase of the dividend D_0 can result in either an increase or a decrease of S_0^*.*

If we compare the results of this section with those in the block case, we find three essential differences: First, the stock value cannot decrease with V_0. Second, in the unrestricted case, there is an interval of positive length in which the stock value decreases with D_0 rather than one critical value for the dividend as in the block case. Third, the stock value cannot increase with the debt face value *ND*.

We cannot make a general statement similar to that for the value of a convertible bond about the relation between the stock values in the unrestricted case and under the block assumption. When a block conversion is optimal and a partial conversion occurs in the unrestricted case, then the stock value can be higher in the unrestricted case due to the lower wealth transfer to the debt holders. Conversely, a positive conversion volume in the unrestricted case without a conversion in the block case results in a higher stock value in the block case.

c) Analysis of the Conversion Strategy and the Values of a Convertible Bond as a Function of the Stock Value

Contrary to the block case, by Result 16 the stock value in the unrestricted case can attain every value $S_0^* \geq \frac{D_0}{n+m}$. Moreover, every endogenous stock value is uniquely related to both an optimal conversion volume and a convertible bond value. Therefore, we obtain the following result.

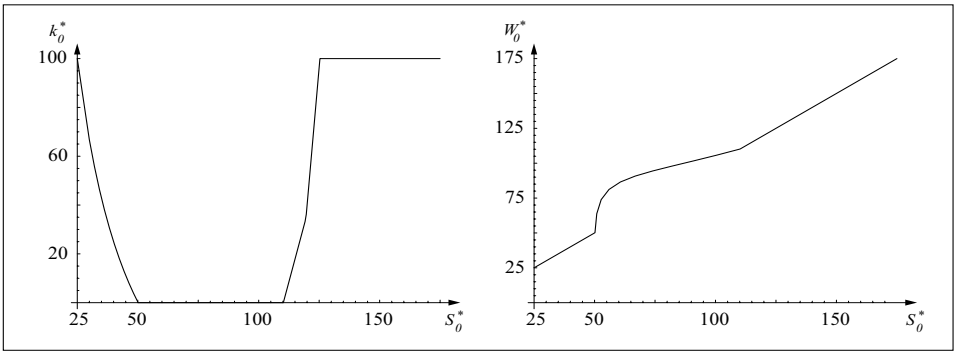
Result 17 (Conversion Strategy and Value of a Convertible Bond before Maturity as a Function of the endogenous Stock Value): *The value of a convertible bond W_0^* strictly and continuously increases with S_0^*. The optimal conversion volume k_0^* can continuously increase or decrease with S_0^*.*

The first part of Result 17 is consistent with our intuition. It follows from the continuity and the strict monotonicity of the stock value S_0^* and convertible bond value W_0^* in the firm value V_0. The behavior of the optimal conversion volume k_0^* as a function of the stock value S_0^* is a consequence of Result 14 (for a constant dividend) and Result 16.

Figure 10 shows the optimal conversion volume k_0^* and the value of a convertible bond as a function of the stock value $S_0^*(S_0^* \geq \frac{D_0}{n+m})$. In the range $\frac{D_0}{n+m} \leq S_0^* \leq 50.2$ the optimal conversion volume strictly decreases with the stock value and gives a value of zero for $S_0^* = 50.2$. In this range, the value of a convertible equals the stock

Figure 10: Aggregate Conversion Volume k_0^* and the Value of a Convertible Bond W_0^* under Unrestricted Conversion

The left diagram shows the conversion volume k_0^* as a function of the stock value S_0^* in the unrestricted case. The right diagram shows W_0^* as a function of S_0^*. The parameter values are n = 100, m = 100, D_0 = 5,000, N = 100, ND = 10,000, σ = 0.5, r = 0.05, TD = 2, T = 1.



value S_0^* as in the range $S_0^* \geq 110.2$. In the medium interval (50.2,110.2), $k_0^* = 0$ holds and the value of the convertible bond lies above the endogenous stock value.

If we compare *Figure 10* with *Figure 9*, we see that k_0^* is a smoothed version of the optimal block conversion policy. Unlike the block case, an increase of the dividend to 10,000 leads to a positive conversion volume for the whole range $S_0^* \geq \frac{D_0}{n+m}$. Thus, the convertible bond value W_0^* always coincides with the stock value S_0^* in this case.

d) No Additional Debt (ND = 0)

The different results for the two conversion variants stem from the existence of additional debt. *Constantinides* (1984) shows that for the case without additional debt, a block conversion occurs if and only if a positive conversion volume is optimal in the unrestricted case. Thus, the case that a positive conversion volume is optimal in the unrestricted case, but no conversion occurs in the block case, can only happen if the firm has issued additional debt. For this reason, if the firm has no additional debt outstanding the value of a convertible bond is independent from the conversion variant.

In the absence of additional debt, the values of both a convertible bond and a stock in the unrestricted case coincide with those in the block case. Further, the stock value S_0^* does not jump with V_0 and D_0 in the block case. Additionally, the relation between W_0^* and S_0^* is for all stock values ($S_0^* \geq \frac{D_0}{n+m}$) uniquely defined. S_0^* cannot decrease with D_0. In the special case of no additional debt, the following result holds.

Result 18 (No Additional Debt outstanding): *Without additional debt, a conversion in the unrestricted case is always related to a block conversion. The values of both a stock and a convertible bond coincide for both conversion variants.*

5 Conclusion

In this paper we characterize the optimal conversion volume and the related asset values of convertible bonds and stocks of firms that have additional debt outstanding. The model framework is given by a frictionless market with a continuous trading opportunity for all financial securities, a lognormally distributed risky value of the firm V_t, no information asymmetries, two possible conversion dates, and two strategic conversion variants: unrestricted conversion and block conversion.

In the absence of additional debt, the values of the convertible bonds in both the block and the unrestricted case coincide, even though the equilibrium strategies differ. Therefore, this result justifies the block conversion assumption that is typically used in the literature for the valuation of convertible bonds which is analogous to the valuation of American call options on stock.

The results we find under the assumption that additional debt exists are driven primarily by a wealth transfer from the stockholders to the additional-debt holders. This wealth transfer can differ for the two conversion variants. In this case, both the values of a stock and the values of the convertible bond also differ. The magnitude of the difference depends on the parameter values and the number of possible conversion dates. A comparative static analysis of these differences is reserved for a further study.

We can summarize the most important properties of the *optimal conversion strategies* in the presence of additional debt outstanding as follows: (1) A partial conversion in the unrestricted case at maturity can be optimal; thus, the block conversion assumption cannot represent an equilibrium strategy for this conversion variant. (2) In the unrestricted case, a conversion can be optimal, but no conversion takes place in the block case. However, a conversion in the block case implies conversions in the unrestricted case.

For the *asset values*, we obtain the following essential properties: (1) The value of a convertible bond in the unrestricted case can be above, but never below, the corresponding value in the block case. Therefore, the convertible bond value under the block assumption serves as a lower bound for the unrestricted case. (2) The stock value under block conversion can decrease with the firm value V_0 or, as in the unrestricted case, it can be partly independent from the firm value. A higher face value of the additional debt can result in higher stock values in the block case, but not in the unrestricted case. (3) Certain values of the stock price S_0^* are not possible in the block case, but in the unrestricted case, all values above the proportionate dividend are attained. Contrary to the block case, the value of a convertible bond W_0^* in the unrestricted case is a unique function of the stock value S_0^*. (4) The stock value can decrease when there is a higher dividend. There-

fore, convertible bonds represent instruments that can protect debt holders against too-high dividend payments.

Our paper can be generalized in several ways. One possibility is to admit conversion at any point of time. However, as long as dividends are paid at discrete points of time, it is sufficient to consider a finite number of conversion dates, which is a direct generalization of the seemingly restrictive case treated in this paper. We can also analyze further conversion variants[23]. The monopolistic case yields several unexpected results. Finally, we can extend our analysis by assuming that the convertible-bond holders also have stocks and additional bonds of the firm in their portfolios.

Our results on the properties of convertible bonds do not directly apply to warrants. Because we allow for a premature conversion, we cannot replicate convertible bonds by a bond plus prematurely exerciseable warrants. This property results in three essential differences in the exercise strategy and the endogenous asset values between convertible bonds and corporate warrants: (1) Even if no dividend is paid, a premature exercise can be optimal in the block case. (2) The debt value of a firm with outstanding warrants does not necessarily increase with the exercise volume, because an exercise leads to an inflow of the strike prices from the exercised warrants in contrast to a conversion of convertibles. (3) The values of warrants in the unrestricted case can lie above or below the corresponding values in the block case.

A Table of Symbols

B_t	Value of additional debt given an exogenous conversion volume k_t
B_t^*	Value of additional debt given the optimal conversion volume k_t^*
$C_t(\cdot)$	Value of a call option at time t
$CC_t(\cdot)$	Value of a compound call option at time t
D_t	Present value of the total dividend at time t
k_t	Exogenous conversion volume at time t
k_t^*	Optimal conversion volume at time t
m	Number of issued convertible bonds
n	Number of stocks outstanding before time $t = 0$
N	Face value of a convertible bond
ND	Total face value of the additional debt
$P_t(\cdot)$	Value of a put option at time t
r	Risk-free rate
S_t	Value of a stock given an exogenous conversion volume k_t
S_t^*	Value of a stock given the optimal conversion volume k_t^*
T	Maturity of the convertible bond
TD	Maturity of the additional debt
V_t	Firm value of the risky part
$V_t + D_t$	Total firm value

23 See *Spatt/Sterbenz* (1988).

V_T^- Firm value at time T immediately before redemption of the non-converted convertible bonds

$\underline{V}$ Critical firm value at time T that leads to a stock value of N when no conversion occurs

$\bar{V}$ Critical firm value at time T that leads to a stock value of N when a complete conversion occurs

V^d Lower firm value where a drop of k_0^* occurs in the block case

V^u Upper firm value where an upward jump of k_0^* occurs in the block case

W_t Value of a non-converted convertible bond at time $t = 0$ given an exogenous conversion volume of k_t

W_t^* Value obtained with one convertible bond with the optimal strategy k_t^*

$W_{t,all}$ Total value of the $m - k_0$ non-converted convertibles

μ Mean of the firm value return

σ Volatility of the firm value return

τ Dividend date

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Information Networks as a Safeguard from Opportunism in Industrial Supplier-Buyer Relationships

Abstract

The network idea has been gaining growing attention in the last decades. We analyse the applicability of networks as a mechanism that protects suppliers from buyers' opportunism. So-called information networks can function as a safeguard for dependent suppliers by reducing information asymmetries among the networking parties and by developing group norms. To confirm this hypothesis, we conduct an empirical study. The results show that information networks can provide protection for a dependent supplier if information about a buyer's unfair behaviour is credible, and if as a result this buyer suffers a considerable loss of reputation.

JEL-Classification: M31.

1 Introduction

To meet the requirements of their industrial buyers, suppliers must often make major investments. A large part of these investments are usually highly specific, i.e., investments that can hardly be put to an alternative use beyond the one they were originally intended for[1]. This situation results in a supplier's dependence on his buyer, which might encourage the latter to behave opportunistically[2]. Thus, suppliers face the problem of how to either reduce their dependence on a buyer, or how to protect themselves from a buyer's unfair behaviour.

The current economic literature deals mainly with two safeguards: intense contractual coordination[3] and investments in good relationship quality[4]. But contracts are appropriate instruments only if suppliers can control whether these contracts are actually adhered to. Because there are information asymmetries between both parties, this condition might not always be a given[5]. Especially in business relationships that have lasted for a short time, only the party who behaves opportunisti-

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1 See *Meyer/Bartelt* (1999), p. 26.

2 See *Williamson* (1975), p. 6; *Provan/Skinner* (1989), p. 205; *Anderson/Weitz* (1992), p. 20; *Freiling* (1995).

3 See e.g. *Heide/John* (1988), p. 22 and (1992), p. 33.

4 See *Diller* (1992); *Röjßl* (1994), p. 260; *Nooteboom* (1996), p. 998.

5 See *Meyer* (1996), p. 91.

cally will know that he is behaving in this way. *Berger/Noorderhaven/Nooteboom*[6] and *Nooteboom*[7] argue that to judge a business partner's behaviour as being opportunistic, the supplier needs a longer period of time to gather enough experience with the new buyer. Furthermore, striving to achieve and maintain a high relationship quality does not necessarily protect the supplier, as the buyer can sidestep these efforts. In addition to these two safeguards, specific suppliers' attributes, such as owning a valuable patent, having an outstanding product quality, or successful ingredient branding can also protect the supplier from opportunism, since in these cases the supplier is highly important to the buyer. However, in many cases these or similar attributes are missing.

Another possible protection instrument from opportunism, so far largely ignored in research, could be the development and maintaining of information networks. Networks are generally considered to have an integrating quality in inter-firm relationships[8]. In this paper we define inter-firm networks as cooperative efforts between legally independent companies that achieve advantages for the networking parties when compared to the firms that do not belong to this network[9].

According to this definition, information networks represent cooperations between firms. These cooperations are based on the partners' common interests[10] and are intended to reduce existing asymmetries among the network participants' mutually important information[11]. By being network members, weak firms can build coalitions against other powerful firms and so improve their relative positions[12].

Suppliers can also develop and profit from information networks. A supplier who is part of such a network can in this way signal to his powerful buyer that information on the buyer's unfair behaviour could spread across his network by negative word of mouth. Therefore, if the supplier informed his network partners that he ended a relationship because of the buyer's opportunistic behaviour, the buyer would face considerable difficulties in finding a substitute for that supplier[13].

In this paper we examine the assumption that integration in information networks protects a dependent supplier from a buyer's potentially opportunistic behaviour. In a first step, we discuss this hypothesis theoretically, and then present an empirical study that confirms this assumption.

6 See *Berger/Noorderhaven/Nooteboom* (1995), p. 200.
7 See *Nooteboom* (1996), p. 1003.
8 See *Grandori/Soda* (1995), p. 197.
9 See *Jarillo* (1988), p. 22; *Siebert* (1991), pp. 293 ff.; *Sydow* (1992), p. 2; *Meyer/Bartelt* (1999), p. 22.
10 See *Grandori/Soda* (1995), p. 184; *Mohr/Fisher/Nevin* (1996), p. 103; *Achrol* (1997), p. 59.
11 See *Powell* (1990), p. 304.
12 See *Emerson* (1962), pp. 36 ff.
13 See *Noorderhaven* (1995), pp. 9–10; *Rousseau* (1995), p. 25; *Barney* (1997), p. 308.

2 Theoretical framework

2.1 Protection quality of information networks

It makes good business sense for suppliers to inform each other mutually about a buyer's opportunistic behaviour, even if they are competitors. This hypothesis is supported by the following arguments.

First, knowledge about a buyer's tendency to behave opportunistically is useful for all network partners, for example, because they can either avoid any cooperation with him in future or handle any dealings very carefully. Therefore, the reduced information asymmetry between the different suppliers[14] leads to a gain of power for an individual supplier in relation to actual or potential buyers[15].

Second, we argue that networking parties will develop common values[16] if there is a regular and intense exchange of information inside the network[17]. *Grandori/Soda*[18] refer to the fact that network partners tend to develop group norms[19]. In the situation considered here, these norms can consist of the partners agreeing by common consent to limit their cooperation with powerful buyers when informed that the buyers' behaviour is unfair[20]. This consensus results in countervailing power[21].

Finally, we assume that because they have invested in developing and maintaining the information network, the networking parties commit themselves to each other, i.e., they are also basically interested in their partners' welfare. This fact leads to reduced competition among the suppliers within the network[22], which is a disadvantage from the buyers' viewpoint.

Clearly, the diffusion of negative information within a suppliers' network can be critical for a buyer, because he could lose his reputation as a customer and have difficulties finding alternative suppliers. It is also obvious that an individual supplier can protect himself from a buyer's opportunistic behaviour by becoming part of an information network. Because a business partner's unfair behaviour will result in economic disadvantages to this firm, we can derive the following hypothesis:

H1: The more intensely suppliers are embedded in an information network, the higher is their economic success.

14 See *Männel* (1996), p. 186.
15 See *Grandori/Soda* (1995), pp. 189–190.
16 See *Sobrero/Schrader* (1998), p. 591.
17 See *Mohr/Nevin* (1990), p. 38; *Uzzi* (1997), pp. 45–46.
18 See *Grandori/Soda* (1995), p. 199.
19 See *Frazier/Rody* (1991), p. 55; *Frazier/Antia* (1995), p. 324; *Gundlach/Achrol/Mentzer* (1995), p. 78; *Achrol* (1997), p. 59.
20 See *Provan* (1993), p. 851.
21 See *Frazier/Summers* (1984), p. 48.
22 See *Ebers* (1999), p. 34.

In the following section conditions are discussed, under which suppliers possibly benefit intensively from being information network members.

2.2 Effectiveness of information networks

As we note above, some of the investments made by industrial business partners are specific in nature. These specific investments become worthless if the business relation is disrupted. In the literature, the thesis is widely accepted that one partner (A) has an economic incentive to behave opportunistically if the other partner (B) has made higher specific investments than A, because B must have a comparatively stronger interest in continuing the business relationship[23]. Therefore, an asymmetry of specific investments to the supplier's disadvantage should have a direct negative effect on the supplier's economic success. Furthermore, these considerations result in the conclusion that if a supplier makes comparatively *fewer* specific investments in a business relationship than does his buyer, the supplier should not have strong reasons for protecting himself from a buyer's opportunistic behaviour. This consideration leads to the hypothesis:

H2: If a supplier has made higher specific investments in the relationship than has the buyer, then information networks protect suppliers from a buyer's opportunistic behaviour.

We can derive additional conditions for highly efficient information networks from a theoretical framework suggested by *Büschken*. *Büschken*[24] discusses five possible factors that influence a supplier's good reputation in a market characterized by customer uncertainty about product quality. These factors are experience, similar situation, up-to-date information, information source credibility, and damage potential. We can apply *Büschken*'s considerations to derive conditions for highly effective information networks among suppliers.

- Experience. A supplier has negative experiences with his buyer.
- Similar situation. In the same situation, if other suppliers had done business with this buyer, they too would have had economic losses.
- Up-to-date information. The supplier who suffers from his buyer's opportunism transmits this information immediately to the other suppliers within his network.
- Information source credibility. The network members assess the information source as being credible, i.e., they judge the supplier who transmits the information as being competent[25] in recognizing opportunistic behaviour. Moreover, the networking partners judge this supplier as trustworthy insofar as he is not spreading this information out of self-interest.

23 See *Heide* (1994); *Nooteboom* (1996); *Barney* (1997).
24 See *Büschken* (2000), p. 10.
25 See *Ganesan* (1994), p. 3.

- Damage potential. As a result of the spreading of negative information within the network, the buyer who behaves opportunistically will have both his present and future ability to work with other suppliers severely impaired.

We can regard the first two factors as givens, because this paper deals with information networks among competing suppliers that are intended to exchange information about individual buyers' opportunism. The speed with which current information about a buyer's opportunistic behaviour is diffused to other network partners depends on the quality of the information channels between the partners. If there are only loose relationships between the networking parties, one member risks providing valuable information while not receiving any relevant information in return[26]. We have described the quality of these channels as the members' network integration intensity, i.e., the level of suppliers' embeddedness, and this discussion has already led to hypothesis H1. Therefore, we need only discuss in detail the two remaining factors, information source credibility and damage potential.

Competing suppliers usually mistrust each other and therefore doubt the credibility of mutually exchanged information. After all, a supplier could spread rumours about a buyer just to keep possible competitors from doing business with this buyer. To be regarded as a credible information source, the informant would have to face severe consequences for giving out false information. Thus, the networking parties will only trust each other if the informant stands to worsen his position by spreading false information[27]. In principle, a supplier has an economic loss if his information policy causes the disruption of a business relationship into which the supplier has made high specific investments, or if potential buyers avoid doing business with him in the future because they believe he acts in a way that is damaging to their business. If other suppliers are not able to judge the amount of a certain supplier's specific investments, they can alternatively assume, that the amount of his specific investments (e.g., in production processes, staff qualification, electronic data exchange, or quality control systems adapted to the buyer's specific requirements) increases with the duration of the relationship. Networking parties can also believe in a member's competence, to truly recognize a buyer's opportunistic behaviour only if the relationship with this buyer has already existed over a long period of time[28]. This assumption accords with *Porter*'s market signal theories. *Porter* postulates that only established, well-known companies within a branch are capable to send highly credible signals[29]. Transferred to the problem considered here, we can assume that a firm's long-term experience within a branch and with an individual buyer serves as a good indicator for the credibility of the information sent to other network members. These considerations lead to the following hypothesis.

26 See *Fichman/Goodman* (1996), p. 319.
27 See *Jarillo* (1988), p. 37.
28 See *Thorelli* (1986), p. 41.
29 See *Porter* (1992), p. 38.

H3: If the supplier's relationship with the buyer has existed over a long period of time, intense network integration protects the supplier from a buyer's opportunistic behaviour.

However, we note that some basic trust must exist among the network members, because otherwise a social system such as an information network could not exist[30].

As we mention above, the extent to which an information network provides protection from an opportunistically acting buyer depends on the amount of damage actually caused to his reputation once the information about his behaviour has spread. If a certain buyer has a negative reputation, his potential suppliers can use this information as an indicator for his abilities and motivations[31]. We can assume that the extent of damage increases with the diffusion of negative information. Therefore, the damage to an unfairly acting buyer depends on the number of network members who can inform other networking parties through negative word of mouth. Moreover, in this context it is important that information network members can also transmit information into other networks they belong to, resulting in multiplier effects of negative word of mouth[32]. Thus, the existence of a large number of competitors embedded in an information network could prevent the buyer from actually behaving opportunistically. There is no doubt that on the one hand the number of competitors has a direct negative effect on a supplier's economic outcome, because with an increasing number of suppliers the buyer's power to negotiate and find alternative suppliers increases. On the other hand, as we can see from the considerations above, a large number of competitors represents a favorable condition for protecting a supplier from a powerful buyer's opportunism through an information network. Thus, we can hypothesize that:

H4: If the supplier can spread the information about a buyer's opportunistic behaviour to many competitors, then the supplier's intense network integration offers protection from this buyer's opportunistic behaviour.

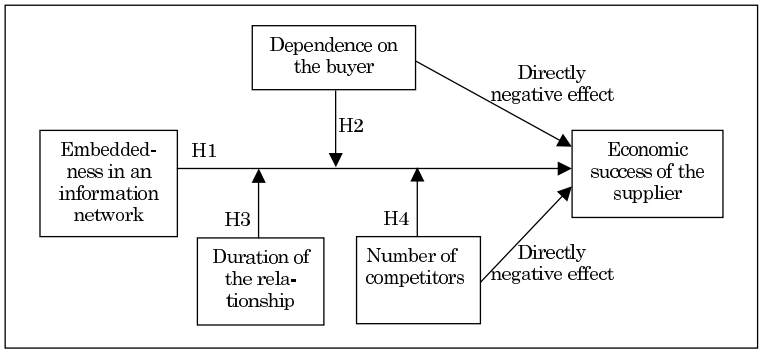
The diagram in *Figure 1* summarizes the hypotheses.

3 Empirical analysis

Our empirical analysis is based on data from a written survey, which we conducted among 232 industrial suppliers. The respondents who completed the questionnaire (in German) either belonged to the general management or the marketing/sales management. The respondents were requested to select a business relationship that is very important to their company and to provide data about this relationship[33]. The sample consists of companies from the following branches: metal industry (34.2%), mechanical engineering (17.1%), electronics (16.7%), auto-

30 See *Ganesan* (1994), pp. 4 ff.; *Lane/Bachmann* (1996), pp. 367–168; *Meyer/Bartelt* (1999), p. 45.
31 See *Wathne/Heide* (2000), p. 46.
32 See *Granovetter* (1972/73), pp. 1361 ff. and p. 1378; *Rogers* (1976), p. 299.
33 For a more detailed description of the sample see *Böhme* (1999), pp. 130 ff.

Figure 1: Conceptual model linking a supplier's embeddedness in an information network with his economic success



motive industry (15.8%), plastics industry (9.2%), precision mechanics (4.4%), and other branches (2.6%).

3.1 Measures

To measure network integration intensity (i.e., embeddedness), the supplier's subjective judgement of his economic success due to the relationship, and the supplier's dependence on his buyer we asked respondents to rate statements on a 7-point scale. We then calculated means for the variables used in measuring each respective construct.

The following two items, which are similar to the measures applied by *Nooteboom/Berger/Noorderhaven*[34], measure the supplier's network integration intensity (correlation 0.712).

- Because of our relations with other companies in our industry, other suppliers would be informed immediately about a buyer's unfair behaviour. As a result, this buyer would lose his reputation.

- If this buyer treated us unfairly, this behaviour would substantially wreck his reputation in our industry.

We used the following three statements, which are frequently applied to similar situations in literature[35], to measure the supplier's perception of his economic success resulting from the relationship (*Cronbach*'s Alpha = 0.751):

- If you consider the most important financial reward you have had in this relationship, to what extent does it meet your prior expectations?

34 See *Nooteboom/Berger/Noorderhaven* (1997), p. 337.
35 See *Dahlstrom/Boyle* (1994), p. 62; *Gassenheimer/Baucus/Baucus* (1996), p. 73; *Mohr/Fisher/Nevin* (1996), p. 116.

- How do you judge the overall success of your relationship compared to your prior expectations?

- Seen as a whole, our cooperation with this buyer can be described as not being very efficient (recoded).

We applied a difference scale[36] to measure the supplier's dependence on the buyer that results from the symmetry or asymmetry of the specific investments in the relationship. The respondents had to judge five aspects of that relationship from both their own and their buyer's point of view: the amount invested in the relationship, the losses to this investment in the event of a breakup in the relationship, the costs for adaptations in the production area incurred so far, the time spent for these adaptations, and the costs for restructuring if the relationship were to be disrupted. The two scale items used for measuring the degree to which the specific investments lost their value in case the relationship was discontinued were, for example:

- If we substituted another firm for this buyer, a high proportion of the assets invested in this relationship would become completely worthless.

- If we were to discontinue the relationship with our buyer, the largest part of the assets invested by our buyer in connection with our relationship would be lost.

We calculate the difference of the scale values for each of these five item pairs. Our calculations represent the degree of the supplier's dependence on the buyer. We also determine the mean of these five differences (*Cronbach*'s Alpha = 0.713). If the five relationship aspects indicate that the supplier has invested more in the relationship than the buyer, we assume that the supplier is engaged in a one-sided position of dependency.

The duration of the considered relationship was easily determined by indicating the year. The number of competitors was obtained from the answer to the question: "Is your company the only one supplying these products to your buyer? If not, how many other companies are able to offer the same or very similar products?"

3.2 Analysis and results

Because we intend to examine whether certain variables (supplier's dependence on a buyer, duration of the business relationship, number of competitors) moderate the relationship between a supplier's embeddedness in an information network and his economic success, we divide the observations into categories based on these variables and examine and compare the strength of the relationship within these categories. If, for example, the values obtained for the three moderating variables are divided into three categories on the basis of their 33%-quantiles, there result 3^3 possible constellations. However, proceeding in this way leads to

36 See *Peter/Churchill/Brown* (1993).

the problem that the number of observations per constellation is comparatively low.

For this reason, we conduct two separate analyses, one with supplier's dependence and number of competitors as moderating variables, the other using the supplier's dependence and duration of the relationship. This procedure is acceptable, considering the low correlations between the three moderating variables, as shown in *Table 1*.

Table 1: Correlations between the moderating variables

	Dependence on the buyer	Number of competitors	Duration of the relationship
Dependence on the buyer	1.0000	0.2011	-0.1013
Number of competitors		1.0000	-0.0116
Duration of the relationship			1.0000
Note: The correlations were calculated for variables measured on a metric level.			

Using this procedure ensures that each of the resulting nine constellations will contain at least twenty observations. The coding of the moderating variables into three dummy variables and the intervals of the other model variables are listed in *Table 2*.

Table 2: Categories and value intervals of the model variables

Construct	Categories	Coding
Supplier's dependence on the buyer due to specific investments' asymmetry	very high	A_1=1, if $SI_S >> SI_B$, 0 else
	high	A_2=1, if $SI_S > SI_B$, 0 else
	low	A_3=1, if $SI_S < SI_B$, 0 else
Number of competitors	none/some	C_1=1, if number from 0 to 4, 0 else
	a few	C_2=1, if number from 5 to 10, 0 else
	many	C_3=1, if number exceeds 10, 0 else
Duration of the relationship	short-term	D_1=1, if duration up to 10 years, 0 else
	average	D_2=1, if duration between 11 and 25 years, 0 else
	long-term	D_3=1, if duration over 25 years, 0 else
Embeddedness in an information network	metric scale	N: 0=very low,..., 6=very intense
Economic success	metric scale	0=very low,..., 6=very high
Note: SI_S = supplier's specific investments; SI_B = buyer's specific investments.		

Based on these variables, we conduct two regression analyses. In each case we use the supplier's economic success as the dependent variable, and use combinations of the dummy variables and their interactions with the embeddedness in the information network as independent variables. The results of these analyses are shown in *Table 3*. These findings are explained in the next section.

Table 3: Statistical explanation of the supplier's economic success by embeddedness in an information network for different combinations of moderating variables

Regression 1				Regression 2			
Independent variable	Regression coefficient	t-value	p-value	Independent variable	Regression coefficient	t-value	p-value
Intercept	1.6394	4.772	0.0000	Intercept	2.9568	8.754	0.0000
$A_1 \cdot C_1$	1.3335	1.819	0.0704	$A_1 \cdot D_1$	0.6682	0.756	0.4506
$A_1 \cdot C_2$	1.3322	2.013	0.0454	$A_1 \cdot D_2$	0.0784	0.131	0.8959
$A_2 \cdot C_1$	2.3516	2.446	0.0153	$A_2 \cdot D_1$	0.8647	1.117	0.2652
$A_2 \cdot C_2$	1.8883	2.544	0.0117	$A_2 \cdot D_2$	0.3674	0.538	0.5915
$A_2 \cdot C_3$	1.3480	1.930	0.0550	$A_2 \cdot D_3$	0.7466	1.576	0.1165
$A_3 \cdot C_1$	3.6417	4.050	0.0001	$A_3 \cdot D_1$	0.9738	1.075	0.2838
$A_3 \cdot C_2$	2.1639	2.386	0.0179	$A_3 \cdot D_2$	1.0905	1.338	0.1822
$A_3 \cdot C_3$	1.7812	2.948	0.0036	$A_3 \cdot D_3$	1.2330	1.724	0.0861
$A_1 \cdot C_1 \cdot N$	0.0226	0.156	0.8760	$A_1 \cdot D_1 \cdot N$	0.0242	0.165	0.8689
$A_1 \cdot C_2 \cdot N$	0.1152	1.297	0.1960	$A_1 \cdot D_2 \cdot N$	0.1887	2.245	0.0258
$A_1 \cdot C_3 \cdot N$	0.3405	5.304	0.0000	$A_1 \cdot D_3 \cdot N$	0.2659	3.666	0.0002
$A_2 \cdot C_1 \cdot N$	0.0354	0.223	0.8236	$A_2 \cdot D_1 \cdot N$	0.0249	0.204	0.8384
$A_2 \cdot C_2 \cdot N$	0.1086	1.080	0.2815	$A_2 \cdot D_2 \cdot N$	0.1340	1.348	0.1791
$A_2 \cdot C_3 \cdot N$	0.2545	2.579	0.0106	$A_2 \cdot D_3 \cdot N$	0.2406	2.052	0.0414
$A_3 \cdot C_1 \cdot N$	0.0664	0.611	0.5421	$A_3 \cdot D_1 \cdot N$	0.0370	0.230	0.8180
$A_3 \cdot C_2 \cdot N$	0.0809	0.688	0.4923	$A_3 \cdot D_2 \cdot N$	0.0496	0.324	0.7466
$A_3 \cdot C_3 \cdot N$	0.1269	1.681	0.0943	$A_3 \cdot D_3 \cdot N$	0.1050	1.440	0.1514
R^2=0.3028				R^2=0.2706			
Note: Significances calculated for 2-tailed tests.							

3.3 The effect of the number of competitors

The first case we discuss is that of lowest intensity of a supplier's network integration (i.e., N = 0). Thus, we must analyse both the intercept and the eight first-order interaction effects in regression equation 1.

The results of regression equation 1 show that those suppliers who depend strongly on their buyers and compete with many other companies that produce equal or very similar products describe their business relations as comparatively

less profitable. In this case the mean success reaches only 1.64 on a 7-point scale (0 = very low success,…, 6 = very high success).

From the supplier's point of view, because of the symmetry/asymmetry of the partners' specific investments in their relationship, the economic success increases with decreasing dependence on his buyer. Furthermore, the results indicate that the supplier's success also increases with a decreasing number of competitors. Business relations in which the buyer has invested more specific assets than the supplier *and* in which the buyer faces extreme difficulties in finding an alternative supplier appear to be comparatively most successful. Given this favorable constellation, the mean success of 1.64 increases by 3.64 to 5.28 (still using the assumption of the lowest information network integration level, i.e., N = 0).

When we also consider the intensity of information network integration as an explanatory variable, the suppliers' economic success increases if many other companies are able to produce similar products (i.e., if $C_3 = 1$). Without exception, all second-order interaction effects $A_1 \cdot C_3 \cdot N$, $A_2 \cdot C_3 \cdot N$, and $A_3 \cdot C_3 \cdot N$ are significantly positive at least at the 5% level in one-tailed tests. It also becomes obvious that the effect of network integration intensity increases with the degree of the suppliers' dependence on their buyers. This result is due to the symmetry/asymmetry of specific investments, because the effect $A_1 \cdot C_3 \cdot N$ exceeds the effect of $A_3 \cdot C_3 \cdot N$ (i.e., $0.3405 > 0.1269$, $t = 3.34$).

The estimates of regression equation 1 show the two differing effects that the number of competitors has on a supplier's economic success. For illustration, in *Table 4* the effect of the network integration intensity (N) on the economic success from the supplier's point of view is shown for the nine constellations that result from combining "supplier's dependence" with "number of competitors".

Table 4: Influence of number of competitors on a supplier's economic success

		Number of competitors		
		none/some	a few	many
Supplier's dependence on the buyer	very high	1.64+1.33+0.02·N	1.64+1.33+0.12·N	1.64+0.00+0.34·N
	high	1.64+2.35+0.04·N	1.64+1.89+0.11·N	1.64+1.35+0.25·N
	low	1.64+3.64+0.07·N	1.64+2.16+0.08·N	1.64+1.78+0.13·N

The intercepts of these equations show that the economic success of suppliers characterised by low embeddedness in information networks (N = 0) decreases with an increasing number of competitors. Simultaneously, their success increases with the number of competitors (i.e., N) because these are potential recipients of information. Therefore, the number of competitors moderates the influence of the network integration intensity on a supplier's economic success.

3.4 The effect of the relationship's duration

The effect of the relationship's duration will also be analysed initially for the case of a very low network integration intensity, i.e., $N = 0$. The effect $A_3 \cdot D_3$, which is significantly positive in a one-tailed test at the 5% level, indicates that a supplier evaluates a business relation as comparatively economically successful if his buyer has made more specific investments in the relationship than has his own company, and if these positive circumstances have already lasted a long time. Thus, the duration of the business relationship cannot be regarded as a success factor by itself, because it has a positive influence only on a supplier's economic success when combined with the buyer's dependence.

Considering the second-order interaction effects in regression equation 2, it is evident that a supplier's increasing network integration affects his economic success positively if the relationship has already lasted a long time (i.e., if $D_3 = 1$). The regression coefficient for the $A_1 \cdot D_3 \cdot N$ effect proves to be significantly positive at the 0.1% level, the coefficient for the $A_2 \cdot D_3 \cdot N$ effect at the 5% level, and the coefficient for the $A_3 \cdot D_3 \cdot N$ effect at least at the 10% level in one-tailed tests. Since the coefficients for $A_1 \cdot D_1 \cdot N$, $A_2 \cdot D_1 \cdot N$, and $A_3 \cdot D_1 \cdot N$ are not significant, we can suppose that network integration intensity does not influence economic success where short-term relationships are concerned. Thus, it is also statistically confirmed that the relationship's duration moderates the effect of the network integration intensity on a supplier's economic success.

3.5 Hypotheses tests

After having commented the statistical results on two chosen moderating variables, the four hypotheses will now be tested.

According to H1, a supplier's economic success should increase in line with his embeddedness in supplier information networks. The estimated coefficients for $A_1 \cdot C_3 \cdot N$, $A_2 \cdot C_3 \cdot N$, and $A_3 \cdot C_3 \cdot N$ in regression equation 1, and for $A_1 \cdot D_3 \cdot N$, $A_2 \cdot D_3 \cdot N$, and $A_3 \cdot D_3 \cdot N$ in regression equation 2, which are, with only one exception, significantly positive at the 5% level in one-tailed tests, support H1 for certain constellations.

Therefore, we examine whether these constellations correspond to the moderating variables described in hypotheses H2 to H4.

According to H2, a supplier's dependence moderates the postulated relationship. As the findings of regression equation 1 demonstrate (i.e., particularly the coefficient relation $0.3405 > 0.2545 > 0.1269$), there should also be a high number of competitors (i.e., $C_3 = 1$), as predicted by H4. The coefficient relation $0.2659 > 0.2406 > 0.1050$ in regression equation 2 also supports hypothesis H2, but only for long-term business relationships. These findings were predicted by H3. In summary, we can state that the results of this study support all tested hypotheses.

4 Conclusions

The idea of inter-firm networks has received a lot of attention in economic literature during the last two decades[37]. Therefore, we took the obvious step of analysing whether networks could also serve as a protection mechanism from a business partner's opportunistic behaviour in industrial supplier-buyer-relationships[38]. Three arguments speak for the protective quality of an information network. First, an information network reduces information asymmetry for the supplier, which means an individual supplier gains power in relation to his buyers. Second, in information networks group norms may emerge. Such norms can result in an informal agreement not to do further business with buyers who behave unfairly. Third, because of their common interest, information networks may lead to reduced competition among the networking parties.

Furthermore, it was argued that a supplier's dependence on his buyer is necessary to be in need of protection from his buyer's opportunism. Finally, we noted how important the credibility of the information source is for a network consisting at least partly of competitors as well as the damage potential of negative word of mouth regarding a buyer's purchasing behaviour. We took the duration of the business relationship and the number of competitors for indicators to test the moderating role of these two variables.

The results of our empirical study support the assumption that suppliers who are intensely embedded in information networks are more economically successful. Thus, it can be advantageous to suppliers to participate in developing and maintaining such networks if they are concerned about their buyers' possibly unfair business behaviour. However, the results also indicate that this safeguarding function only exists under the conditions of high information source credibility and if the buyer's reputation can be severely damaged by negative word of mouth.

According to the authors' experiences in this area, information networks that work successfully are not institutionalised. Companies contributing to and benefiting from such networks instead use the environment of common projects (i.e., developing components, jointly purchasing raw materials, or cooperating in the area of logistics) to establish information networks and use them for information exchange. Furthermore, common committee obligations (e.g., standardization projects, wage negotiations) are also favorable occasions to build channels for exchanging information about opportunistic buyer behaviour. These situations are characterized by a confidential atmosphere and therefore seem to be appropriate occasions to develop and maintain information networks.

37 See e.g. *Johanson/Mattson* (1985) and (1987); *Johannison* (1987); *Ford* (1990); *Iacobucci/Hopkins* (1992); *Sydow* (1992); *Soeters* (1993); *Loose/Sydow* (1994); *Duysters/Hagedoorn* (1995); *Bellmann/Hippe* (1996); *Croft/Woodruffe* (1996); *Park* (1996).

38 See e.g. *Provan* (1993).

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Competitive Strategy for Media Companies in the Mobile Internet**

Abstract

The provision of mass media content over next-generation 3G mobile networks is envisioned as an exciting new application of new media. This paper focuses on the mobile Internet as strategic challenge for media and entertainment companies. It provides an overview of distinctive features of the mobile Internet related to personalization, time and location sensitivity, uncertainties between technology push and market pull, and motivations for engagement in mobile interactivity. The analysis of competitive strategy in the mobile Internet suggests that the changing market structures in the converging media and entertainment and mobile wireless telecommunications industries lead to shifts of bargaining power. The emerging co-opetition challenges media and entertainment companies to re-evaluate their activities in the mobile value chain that provide potential for the creation of sustainable competitive advantage in the mobile Internet. These changes are reflected in the emerging business models for media and entertainment companies in the mobile Internet. The paper presents three strategic options for media companies: a syndication strategy, a portal strategy, and a mobile virtual network operator strategy.

JEL-Classification: D8, L8, M3.

1 Introduction

The provision of mass media content over next-generation 3G mobile wireless networks[1] is envisioned as an exciting new application of new media. But its key success drivers remain uncertain. It is yet to be seen, if serving mobile content will be highly profitable or a money-losing business. The media uses various buzzwords such as m-trading, mobile multiplayer games, and mobile movies and thus creates high expectations. Yet, the demand for mobile content tends to be assumed rather than demonstrated, and reality may disappoint.

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1 The international standards are specified by the *International Telecommunication Union* in its IMT-2000 report.

However, mobile communications have become an integral part of both business and private life. In 2002, for the first time mobile phones worldwide will outnumber fixed-line phones[2]. The diffusion of wireless communications technology, fixed wireless, but in particular mobile wireless, has taken place rapidly, exceeding even that of the Internet. Forecasts predict that by 2010 there will be more wireless phones than PCs or even TVs[3].

Against this background, the mobile Internet will gain in significance and relevance in media companies' strategies to distribute their content via multiple digital platforms. Mobile communication's use and its applications are moving beyond simple point-to-point voice to data applications such as text, pictures, graphs, audio, and video. Creating the appropriate and relevant content may be a key driver for the development of a next-generation mobile infrastructure. Therefore, media content providers are developing strategies for the distribution of mobile wireless content[4]. This development is particularly challenging, since the wireless telecommunications market is characterized by rapid technological change and great uncertainty about the significance and duration of technological standards, as well as consumer demand. Thus, the evolvement of profitability becomes an important challenge in these markets. Convergence processes in media and entertainment and mobile wireless telecommunications industries are leading to changes in industry structure and hence will challenge strategic management of media companies to build and sustain competitive advantages. However, operational effectiveness through better technology will probably not determine how the players sustain a competitive advantage. Delivering a unique type of value to the customers has more potential to become source of competitive advantage. Therefore, the direct channel to contact mobile Internet customers is an important asset and suggests growing importance of customer relationship management as well as brand strategy for media companies in the mobile Internet.

In section 2, the analysis focuses on the mobile Internet as strategic challenge for media and entertainment companies. The section provides an overview of distinctive features of the mobile Internet, and examines uncertainties between technology push and market pull and motivations for engagement in mobile interactivity. Section 3 concentrates on competitive strategy in the mobile Internet. This section discusses changing market structures in the converging media and entertainment and mobile wireless telecommunications industries, media and entertainment companies in the mobile value chain, and the creation of sustainable competitive advantage. Section 4 presents emerging business models for media and entertainment companies in the mobile Internet and suggests three strategic options for media companies: a syndication strategy, a portal strategy, and a mobile virtual network operator strategy. Section 5 concludes.

2 See *International Telecommunication Union* (2002).

3 See *Durlacher Research* (2001); *Boston Consulting Group* (2000).

4 For a critical discussion of mass media content for mobile wireless communications see *Groebel/Noam/Feldmann* (forthcoming).

2 The mobile Internet as strategic challenge for media and entertainment companies

According to *Rogers* (1995) perceived attributes of innovation, the adoption of mobile communications services will be influenced by the relative advantage, compatibility, complexity, trialability, and observability[5]. Parameters of the mobile Internet that may contribute to the first attribute, the perception of a relative advantage, could be the spatial and temporal needs of communication, functional needs of users, an individual cost optimum of communication, and content.

Among these parameters, media content on mobile wireless distribution platforms could become a dominant driver of data traffic. Therefore, content will be an important element in both media and telecommunications companies' business models. The success of mobile wireless media could be largely dependent on the context in which it functions[6]. Ubiquity of content does not necessarily create relevance, and pure availability does not create demand. It is context that creates relevance that can be translated in a further step into transactions.

"Wearable" computing is an example of trying to avoid disruptive experiences with mobile devices. Projects at the MIT Media Lab such as Nomadic Audio[7] or MIThrill[8] experiment with how to smoothly integrate communications technology into clothes and into the context of the individuals' life. IBM introduced pervasive computing in intelligent jewelry, e.g., in watches, rings, necklaces, and earrings. The use of media content is affected through ubiquitous computing as well. Time-sensitive information is being pushed at the consumer; location-based services can be pulled by consumers. Both have the potential to become an integral part of individual and business life. Customer loyalty to certain media offers can be increased by these measures[9]. However, ubiquitous technology can easily harass consumers and turn the vision of a continuous information flow into a permanent intrusion through distractions and sales pitches[10].

2.1 Distinctive features of the mobile Internet

The mobile Internet enhances the use of services in the dimensions time and space. It does so by adding ubiquity of Internet access and immediacy of communication and (inter)activity.

5 For a derivation and discussion of these attributes see *Rogers* (1995).
6 See *Feldmann* (2001).
7 See *Sawhney/Schmandt* (1999).
8 See http://www.media.mit.edu/wearables/.
9 *Anand/Shachar* (2001) analyze brand loyalty to multiproduct firms using data on television viewing choices. Their findings suggest that the profile of a multiproduct firm is an important element in the information set of consumers. Ubiquitous availability may be one attribute across the media firm's products that affects loyalty.
10 See *Gleick* (2001).

Originally, the concept of mobility was rooted in the area of transportation. Now, it has been transferred to communications networks. Mobile communications conquers constraints of location and geography and allows ubiquitous availability[11].

New time management capabilities emerge with real-time pushed and pulled voice and data communications that quicken the pace of both business and personal life in business-to-business and business-to-consumer markets. The mobile Internet's access device also differs from the fixed desktop computer that accesses the Internet. The mobile phone is far more personal than a PC and is likely to be used by only one single person. Personalization of processes and services in the mobile Internet based on the depicted characteristics may be among the most relevant sources of competitive advantages in strategic mobile Internet management.

A characteristic of the mobile Internet is its hybrid structure, which combines the virtual and the real world in a unique way. This hybridisation differs from the virtual worlds of the Internet. Movement and mobility in the physical offline world and surfing in virtual online worlds are no longer exclusive. Instead, they can now be combined. This hybridization of on- and offline media environments as well as of voice and data communications has fostered ideas and expectations for the mobile phone as a transaction device. Integrating the on- and offline experience without shifting the channel becomes possible when interactive rich media applications of the Internet which have already been implemented in e-commerce, are augmented through their use in nomadic environments[12] and the option to link mobile data transaction offers to call centers.

Another interesting process of hybridization will take place in navigation, which may also use the voice to browse mobile Internet offers. Voice-activated services are being developed to adapt mobile Internet usage to the specific usage context[13]. When a person is moving, e.g., walking down a street, voice navigation as a background activity will be the only possible navigation mode that will enable the user to keep on moving and still be able to concentrate on the street as foreground activity.

While it has been argued that the Internet serves mainly as a tool to gather information on a product that will later be bought in bricks-and-mortar stores, the mobile Internet can reverse this relationship. A customer can gather information in a store and, if there are price, quality or service advantages, purchase the good in the virtual world via the mobile device. Whereas the Internet reduces the importance of location, since virtual markets are not bound to it, the mobile Internet emphasizes the importance of location.

Various capabilities and functions are integrated into mobile communications services. One can distinguish communications, real-time content, storage content, and transaction services. The most obvious function is communications. Voice services and complementary data communication services such as Short Message Ser-

11 See *Buderi* (2001); *Townsend* (2000).
12 For a definition of nomadic environments see *Sawhney/Schmandt* (1999).
13 See *Werbach* (2000b).

vices (SMS) are the basic feature of cell phones and today also the main reason for use[14]. This primary use has the potential to expand to using the cell phone as device to access the mobile Internet. Forecasts estimate that data communications will increase in importance for cell phones[15]. The success of SMS and related info services, the possibility to read e-mails, send Multimedia Messaging Services (MMS), and use instant messaging (IM), are raising high expectations on more advanced data services, especially in terms of generating revenues.

The real-time content in mobile devices is time sensitive published data. Examples are stock quotes, weather reports, or traffic information. This data can be provided by media companies like Reuters, the Financial Times, or The Weather Channel; content aggregators like Yahoo; or other wireless portals as well as municipal authorities. Storage content comprises databases such as the "Yellow-Book" phone directory or restaurant guides. This content can also be provided by publishers such as lifestyle magazines, as well as established institutions and brands like the Yellow Pages or the Zagat restaurant guides.

Transactions represent an area that raises as many hopes as it raises doubts. Mobile electronic commerce can develop the cell phone from a communications into a transaction device. However, the adoption of m-commerce transactions is still very low. The limited size of the display, e.g., determines the amount of product information. However, when the device can support convenient use, including one-click m-commerce applications as well as secure and trusted billing systems, adoption rates may be higher. Identification of the user is one clear advantage of cell phones over other mobile devices as well as traditional e-commerce. Yet, before m-commerce can play a significant role in e-commerce, telecoms need to implement secure identification processes and a standardized micropayment system. A central success factor for m-commerce will be its context specificity. Connecting e-commerce offers to the described enhanced dimensions of time and space and embedding it in context-aware services will be crucial for building and sustaining competitive advantages in m-commerce.

Taking into account the discussed distinctive features of the mobile Internet as well as thinking in terms of immediate, fast access to information, customers will have little acceptance and a short attention span when they are surfing the mobile Internet. They will instead rely on information they can find quickly and in trusted brands with which they already have a customer relationship. This potential consumer behavior suggests that the mobile Internet could enhance the importance of brands and of customer relationship management.

2.2 Uncertainties between technology push and market pull

Mobile Internet access does not improve the mobility of its users – (since this is a question of transportation), but information and communications infrastructure

14 Voice over IP is a possibility for future voice communications via these handheld devices. One reason, why this might not become too successful is the unstable connection and inconveniences of IP telephony.

15 See *Durlacher Research* (2001), p. 13; *Boston Consulting Group* (2000), p. 12.

becomes ubiquitously available on personal devices. It will complement, rather than substitute for, conventional Internet services.

However, a sensitive question that still needs to be considered concerns the ratio of technology push and market pull in the emerging mobile wireless telecommunications and content markets. There is much uncertainty on this question, and this uncertainty influences the development of innovative processes, products, and services. Uncertainty appears on two levels, about technological development in highly competitive environments and the establishment of standards[16] that might drive market acceptance and shift competition to services, as well as about consumer demand.

Concerning technological development, the broadband capacity offered by 2.5G networks might be sufficient for services that users demand via their mobile phones and would call into question investments in 3G networks. Positioning technologies, device operating systems, microbrowsers, protocols, gateways, languages, and micropayment systems need to be developed and standardized for the mobile Internet. This list represents only a very small fraction of unsolved technological problems. The choice of the device is also in the technological realm, but may be determined by the context in which the device is used and how well it fulfills the functions that customers demand[17].

It is even less clear what market pull, i.e. consumer demand, will be. Little reliable data is available that deals with demand for 3G services and consumers' willingness to pay for them. To acquire information on the development of the mobile Internet in Europe or North America, telecom researchers are closely watching how the mobile Internet in Japan and the rapid adoption of NTT DoCoMo's i-mode service develop[18].

However, the diffusion of innovative products and services in media communications is always particularly related to their social meaning and use. Innovative services for mobile phones create different usage contexts. Communications are not restricted to the private sphere, but are performed in public spaces. The personal nature of the mobile phone is leading to new usage patterns. It also marks the participation in certain lifestyles and peer groups. The dimension of functional images of the mobile Internet in relation to and in the context of communication and media usage patterns of existing media is relevant for the creation of usage options for consumers. Against this background, the integration of mobile Internet services in existing companies strategies as well as the evolution of new businesses[19] seems both very promising and risky. The key drivers of market development could be personalization of services, ubiquity and immediacy of access, and possibly the reduction of transaction costs. For the specification of key drivers, especially consumers' motivations for mobile interactivity are crucial.

16 See *Funk* (2001b).

17 For a comprehensive discussion of new digital media and devices see *Rawolle/Hess* (2000).

18 See *Funk* (2001a).

19 For research on the origin and evolution of new businesses see *Bhidé* (2001).

2.3 Motivations for engagement in mobile interactivity

Uses-and-gratifications research[20] has identified gratification factors for cellular telephony such as sociability, relaxation or entertainment, instrumentality or acquisition, reassurance, and fashion and status[21]. From the consumers' perspective, motivations for the use of mobile wireless data communications are often grounded in lifestyle criteria and may focus on communications, entertainment, and convenience[22]. Communications, comprising e-mail, text and multimedia messaging, and mobile instant messaging, has the potential to become the "killer application", similar to its function for the Internet. Forecasts for the use of mobile interactivity underline the growing popularity of entertainment services such as multiplayer games or music downloads[23]. Convenience is also a promising factor. Mobile interactivity offers instant gratification. If conducting certain transactions via mobile devices is more convenient, e.g., due to the integration of barcode scanning technology, then mobile commerce could become a key driver for using mobile interactivity. The necessary precondition is mobile usability and ease of mobile Internet navigation.

The motivations for media companies to expand their services onto new digital platforms and to engage in mobile interactivity are brand and customer relationship management and the creation of multiple revenue streams. Integrating mobile wireless platforms into a digital multiple-platform strategy will build on existing brands' identity and will extend the reach of the digital media brands into markets without significant PC penetration. Thus, a mobile strategy will not only deepen the relationship with existing customers, it will also open the potential to acquire new customers. Mobile revenue streams can have multiple sources, subscription from customers, advertising revenues from cross-promotion, and revenue-sharing agreements with network operators.

Mobile network operators have, in the past, focused primarily on growth and the speed at which they can enlarge their customer base. They must now direct their focus to profitability and rethink their strategic approaches. To define a unique value proposition for their customers, they turn to content providers who in return gain bargaining power. Telecommunication companies are dependent on content providers since they do not have the core competency to create the appealing content that may generate revenue. Media companies are dependent on the new mobile distribution platform and the customer contacts and billing relationship of wireless operators. Since there is the potential for a shift of power from the network operator to the content provider, the next section will discuss the emerging co-opetition[24] between the media and telecommunication companies.

20 The uses-and-gratifications-approach is concerned to identify how people use the media to gratify their needs, in contrast to the previous media effect paradigm that asked what media do to the people.

21 See *Leung/Wei (*2000).

22 See *Nohria/Leestma* (2001).

23 See *Jupiter MMXI* (2002); *Durlacher Research* (2001), p. 96.

24 See *Nalebuff/Brandenburger* (1996).

3 Competitive strategy in the mobile Internet

The digitization of content distribution has lead to structural changes in media and entertainment markets[25]. Online content has become an established component of traditional media companies' offers. It has also led to the emergence of new media companies. The next diversification in the multiple digital distribution strategies of media companies can relate to the provision of personalized mobile wireless media content. However, before analyzing emerging strategic options for media companies, we must observe changes in industry structure, and changes in activities of media companies by using the tool of the value chain in order to seek potentials for building sustainable competitive advantage.

A lesson that media companies have learned from the Internet is that they do not want to follow the Internet rule "follow the free"[26]. The media companies want to charge for mobile Internet services, although it is still unclear if customers are willing and ready to pay for such services after having been used to getting content for free on the Internet. The telecoms have learned from past experience with mobile communications that they must avoid distorted revenues, costs, and share prices. For example, strong subsidies of handsets, in Europe have led to a distortion of telecommunication companies' customer base and the determination of the industries' leading revenue measure, the average revenue per user (ARPU). Subsidizing prepaid phone handsets contributed to this trend. Consumers bought handsets, used the prepaid card and simply bought a new handset instead of buying a new prepaid card. Thus, the telecommunication companies' customer base has grown on paper, but not in revenue. The subsequent distortion of ARPU not only leads to mistakes in internal processes bought forecasting demand and sales, but also misleads shareholders.

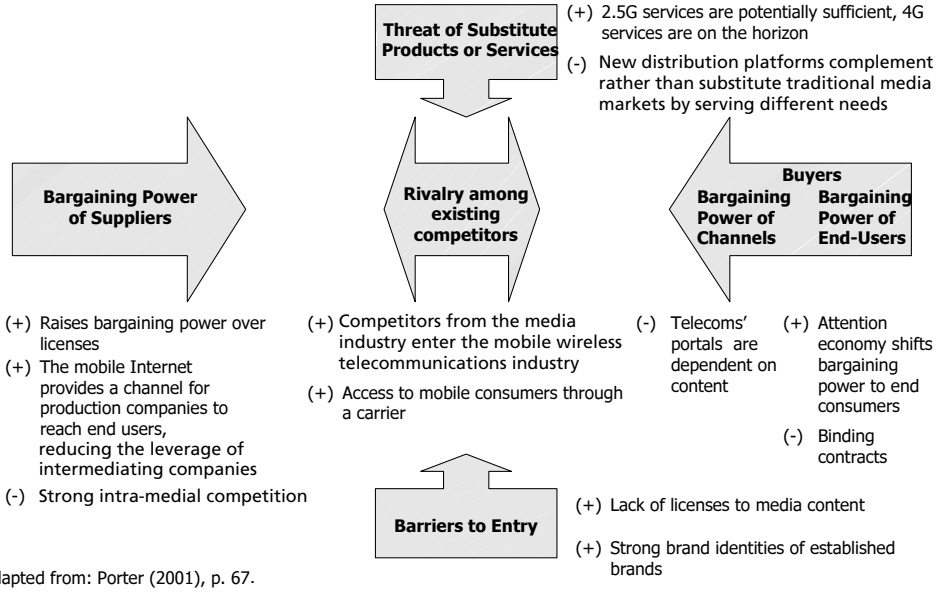
The impact of strategy in mobile Internet markets is extremely high, because gaining sustainable competitive advantage lies in differentiation[27], awareness of customer demand, and good estimation of technological development to overcome the high level of uncertainty of the mobile Internet. These are the elements that will determine if the mobile Internet can create economic value for the players involved in the mobile value chain. Ultimately, this uncertainty will be resolved by the uses and gratifications the mobile Internet will offer to businesses and consumers. When we analyze the industry structure of mobile Internet markets related to the media and telecommunications industries, we see that there is the potential for profitability. However, we have yet to see who is going to capture the economic benefits. This uncertainty is due to potential power shifts in the industry and how much value can be reaped by the customers.

25 See *ECC* (2002); *ECC* (2000).
26 See *Jupiter MMXI* (2002).
27 See *Geng/Whinston* (2001); *Porter* (2001).

3.1 Changing market structures in the converging media and entertainment and mobile wireless telecommunications industries

The rules of competition that determine an industry's attractiveness and influence a firm's competitive strategy are embodied in five competitive forces[28]. The entry of new competitors, the threat of substitutes, the bargaining power of buyers and of suppliers, and the rivalry among the existing competitors determine a firm's profitability. The strength of these five competitive forces can change as an industry evolves.

Table 1: The Mobile Internet influences the Media Industry's Structure



Adapted from: Porter (2001), p. 67.

As the mobile Internet develops, the industry structure of the media and entertainment industry turns into a relationship of co-opetition with wireless operators. Rivalry among competitors extends from the competition among pure media companies to the competition among players in the converging telecommunications and media industries. Media companies gain in bargaining power, because content is suggested to be a main driver of the adoption of mobile communication services in the business-to-consumer (B2C) sector.

With the option to establish mobile virtual network operators (MVNOs) media companies can use their core assets and enter the wireless telecommunications market. From the point of view of wireless operators, the emergence of new players such as MVNOs will be even more crucial, if MVNOs such as media companies or Internet denovo companies, e.g. portals like Yahoo![29], establish strategic

28 See *Porter* (1998).

29 See *Bughin/Lind/Stenius/Wilshire* (2001).

alliances with banks and other content and application providers. These players not only have a lower churn rate than do the mobile carriers, but can also reduce carriers to mere providers of pipes[30]. However, among the carriers' most valuable assets are their existing customer relationships. Barriers to market entry in the wireless telecommunications market for established media companies therefore do not represent major investments for spectrum licenses, network infrastructure, or other physical assets. The carriers' existing customer relationships and media companies' need for access to mobile consumers are instead a barrier to market entry. Moreover, entry barriers include the ability to establish conventional telecommunication services and billing relationships with customers.

For potential new entrants who would like to pursue a similar approach to that of existing media companies the lack of licenses and digital rights to attractive content could be one additional barrier to market entry. For these new entrants, strong brand identities of established brands in the real world as well as in the Internet can be another entry barrier. The brand extension of existing media brands onto the mobile Internet will already attract a lot of the scarce attention dedicated to the mobile Internet. However, the experiences of the mobile Internet in Japan give evidence of competitive advantages for new entrants due to the disruptiveness of the mobile Internet[31].

Substitute offerings are another specific and interesting characteristic of 3G mobile wireless markets, because a potential threat does not come from an enhanced, but from a reduced technology. 2.5G services could be sufficient for business and consumer needs[32]. These services already offer enough bandwidth to deliver new media services. This characteristic means even greater uncertainty for investments in future 3G markets. The cost structure for 2.5G services is far less, and relative price performance of 2.5G services has good potential to outperform 3G services. In Japan, the success of i-mode can so far not be duplicated for NTT DoCoMo's 3G Freedom of Mobile Multimedia Access (FOMA) services. Consumers do not perceive that FOMA offers enough additional value to justify higher prices for handsets and services[33]. In comparison to the 2.5G offers, the increasing adoption of wireless local area networks (WLANs) poses substantial threats to 3G license holders as a possible shortcut to 4G[34], although WLANs are rather seen as a complementary technology. Traditional media as a potential substitute will not threaten mobile Internet offers because of its different usage context and its complementary relationship.

The bargaining power of suppliers will decrease on the one hand, because of strong internal competition in, e.g., handset manufacturers' and telecommunication equipment suppliers' markets. Bargaining power can increase however

30 See *Harrigan* (2001).

31 The concept of disruptive technologies and their implications on incumbents and new entrants has been developed by *Christensen* (1997) and has been applied to the mobile Internet by *Funk* (2001a).

32 See *Knorr* (2001); moreover, applications such as streaming video will not be feasible in 3G networks due to transmission speeds of up to 384 kbps that are far below initial expectations.

33 See *Nishimura* (2002).

34 In Europe, HiperLAN2 is an interesting system that is also designed for wide area networks. See *Dornan* (2002) for the comparison of different 4G systems.

through the differentiation of inputs. Suppliers can negotiate on features, such as built-in cameras, that they are asked to integrate to ensure the usability of applications the telecoms and media companies want to offer. License owners of media content can also increase their bargaining power in renegotiating digital rights of produced content. Production companies, those former suppliers to media companies, can close direct contracts with telecom operators and reduce the leverage of media companies as intermediaries between content producers and consumers.

Buyers will have the highest increase in bargaining power. End users gain in bargaining power, because their scarce attention is highly valued[35]. A lack of product and service acceptance in mobile Internet markets can burn through a huge amount of invested capital. Since the network operators or MVNOs have a strong interest in developing and sustaining the kind of customer satisfaction that can lead to customer loyalty and customer retention, the power of the buyer increases.

One customer lock-in effect that decreases bargaining power and differentiates the Internet from the mobile Internet is the predominance of binding contracts between network operator and customers[36]; the exception to this rule are prepaid models in B2C markets. Media companies can also raise switching costs for consumers through their branded content and regain some of their bargaining power by using exclusive content contracts with certain wireless carriers. Consumers loose bargaining power if they wish access to the exclusive media content and related pushed (advertising) services[37]. However, public policy is concerned with open access to content and will therefore strive for strengthening buyers' bargaining power for mobile wireless content services[38]. The deployment of the mobile Internet will likely put pressure on the profitability of the converging media and wireless telecommunication industries by shifting power to consumers.

3.2 Media and entertainment companies in the mobile value chain

The activities that a media company performs to design, produce, market, deliver, and support its products is represented in its value chain[39]. The value chain reflects a firm's history, its strategy, its implementation, and the underlying economics of the activities themselves.

The value activities can be divided into primary and support activities. To discuss some of the potential changes in the value chain due to the emergence of the mobile Internet, we must further subdivide these activities. The five generic categories of primary activities are inbound logistics, operations, outbound logistics, marketing and sales, and services. Through real-time and advanced demand man-

35 See *Davenport/Beck* (2001).

36 Number portability that has been introduced in Germany in 2002 will lessen the lock-in effects of wireless operators' contracts again in the near future.

37 A EU bill from May 2002 has called for an opt-in system that prohibits the placement of commercial e-mails or SMS without the person's explicit permission.

38 *Noam* (2002) argues for an implementation of regulatory measures to protect consumers' interests of choice and free access to content.

39 See *Porter* (1998), p. 36.

aging and planning, the mobile Internet enhances both inbound and outbound logistics, and services to consumers and advertising clients[40]. Real-time services could be offered on the mobile Internet, from digital content order processing to product development and delivery status and integrated channel management. Virtual mobile Internet services can be linked to telephone voice services and thereby allow interaction with skilled personnel. Contact with staff in call centers or with customer relation managers in companies could be established through a one-click-button so that customer satisfaction with the integrated virtual and real experience advances. Whereas Internet transactions often require physical activities in the value chain such as warehousing and shipping as a result of virtual ordering, the mobile Internet will require virtual activities like SMS-based services as a result of consumers' physical activity and roaming.

The most profound changes in the value chain of media and entertainment companies will be associated with marketing and sales. The means by which consumers can purchase digital content will extend to all devices connected via a wireless network. Media companies can tailor mobile wireless media to personal needs via opt-in marketing that ensures personal relevance of content. Means of persuading consumers to purchase, such as advertising and promotion, can be augmented by using wireless communications tools. Mobile Internet or SMS-based surveys as a means of real-time customer feedback are a promising new tool for mobile marketing efforts. Location-based services may have only restricted potential to create competitive advantage in the near future. Evidence from Japan shows that implementing location-based services is very difficult. It requires enormous capabilities in real-time, third party data, and transaction management, and also exceeds current carrier billing models[41]. However, price-reductions coupons, mobile electronic commerce, and mobile community-building around media content are relevant applications that strengthen customer relations in the media and entertainment companies' value chain.

The value chain as a basic tool for understanding the influence of the mobile Internet on media companies can also be used for the analysis of elements of an industry's value chain. The value chain of the mobile wireless communications industry consists of four distinct segments that can serve consumers and businesses: these are equipment, networks, software, and services. Players in the equipment segment provide components, infrastructure, and devices. Wireless carriers represent the network segment. Enabling software and services contribute among other things portals, communication and transaction services, and content.

Mobile content providers are important drivers in the mobile Internet value chain. Therefore, upstream players make strategic alliances with media companies. For example, Nokia as a handset manufacturer has partnered with the mobile portal of the Financial Times. Vodafone and Vivendi founded their joint venture, Vizzavi, in April 2000. Internet portals like Yahoo! cooperate with "real people"-TV formats such as "Survivor" in order to offer games and entertainment news on mobile

40 The described real-time activities are part of *Porter*'s 5th stage of information technology evolution that optimizes various activities in real-time. See *Porter* (2001), p. 75.

41 See *Funk* (2001a).

devices. Also, new intermediaries emerge, such as AvantGo, which serves as a content aggregator and syndicator on PDAs. Users of the AvantGo service can synchronize the content channels they subscribe to every time they connect their PDA to the (wireless) Internet. Carriers are negotiating to control the content provided via their networks and portals through exclusive content contracts for, e.g., event-driven content such as a hit movies or a sports event. However, for publishers of digital content like ABCNews.com, Cnet.com, or The Weather Channel, exclusive contracts with only one wireless carrier is not a dominant strategy. This development is not only true for media players in the mobile value chain, but for players of any other industry, e.g. the retailing or financial industries, that will seek for mobile Internet strategies to gain competitive advantage.

3.3 Creating sustainable competitive advantage

Analyzing media companies' value chain in the mobile Internet offers one way to examine sources of competitive advantage. Following *Porter*'s (2001) argumentation on strategy and the Internet, sustainable competitive advantage is most likely to be reached through the design of the strategic positioning. Operational effectiveness is a prerequisite for offering competitive pricing structures to customers. Since there is a higher probability for an open platform for content and applications, as it is already practiced in parts in Japan by NTT DoCoMo's i-mode service[42], instead of an exclusive "walled garden" strategy, packaging of products and services gets a greater importance. The aggregation of mobile wireless content has to be personally relevant.

Unlike the fixed Internet, where customers can keep a certain level of anonymity, the subscriber identity module (SIM) card of mobile devices identifies its user. As one result, the potentials of (mass) customization, such as that opened by the Internet, can be enhanced by true personalization of mobile Internet services. The degree of personalization and the degree of usage relevance that a media company will be able to establish will to a large extent determine the degree of its competitive advantage. This importance of personalization will even be enforced through the ability to create an integrated communications system. In such a system, the mobile Internet is one part that complements the whole and supports and develops a user's voice and data communications activities.

The context of how the consumer uses the mobile Internet also comprises the enhanced opportunities to combine virtual and physical activities. Its ubiquity and real-time capabilities and its potential for use with many devices, including microprocessors in clothes or even the body as suggested in concepts of ubiquitous computing, opens new dimensions to customers' everyday experience of information access in the physical world. Strategic positioning of media companies that will exploit this hybrid context of use may create uniqueness and promote indispensability as sources of sustainable competitive advantage.

42 I-mode offers an open platform for content; however, DoCoMo contracts only with a limited amount of preferred content providers for representation in the official menu and billing capabilities. This hybrid approach between open platform and "walled garden" is also pursued for i-mode services in Europe.

Forming strategic alliances with credit card companies, banks, retailers, or municipal corporations for location-based services within a city can lead to distinct services. This formation of business webs will allow media and entertainment companies to enter the mobile transaction business and develop new features for their audience as well as their advertising clients. The mobile Internet will make it possible and easier for the consumer to use media or purchase online while he or she is actually in an inspiring physical environment. This capability also offers potential for network operators to capture parts of profits gained via the mobile Internet by setting up a commission fee for the back-end billing that they would never be able to access through fixed (mobile) e-commerce. Automated payment systems based on the recognition of the customer through the SIM card can also make mobile commerce more convenient than traditional forms of e-commerce. The customer avoids filling in forms on shipping and billing information every time a new product/service provider is used.

For building sources of competitive advantage, the discussed level of high uncertainty means an increased importance of strategy for the mobile Internet that integrates traditional competitive advantage and new sources that exploit the mobile Internet characteristics. These sources are reflected in the changing industry structure, the value chain of the mobile wireless industry, and the value chain of individual media firms and must be translated into media companies' business models.

4 Emerging business models for media and entertainment companies in the mobile Internet

Business models for media and entertainment companies in the fixed-line Internet comprise, e.g., infomediary, advertising, and subscription models. Under the assumption that marginal costs of reproduction and distribution of digital information goods are close to zero[43], it is rational for a content provider to distribute existing and newly produced content on a plurality of digital platforms. However, it is still difficult to predict what kind of business model will be profitable and sustainable in the Internet.

By analysing the available definitions of business models, we can identify six generic elements: mission, structure, processes, revenues, legal issues, and technology[44]. The mission provides strategic goals and the value proposition, the structure determines the roles and agents of the business community. Processes show the elements of the customer-oriented value-creation process and its coordination mechanism. Revenues analyse the sources of revenues and the business logic. Legal issues and technology have to be considered along all dimensions of the business model.

Business models in the media and entertainment industries often focus on specific elements of a business model, such as the source of revenue. The predominant advertising model in traditional media markets has not proven very successful on

43 See *Bakos/Brynjolfsson* (2000).
44 See *Alt/Zimmermann* (2001).

the Internet. Even if it is combined with subscription models like the Interactive Edition of the Wall Street Journal, WSJ.com[45], it is still difficult to extract rents from the activities and the value the content provides to the targeted customer segments.

The traditional media has seen the Internet as a complement to other distribution platforms, one that offers added value to the customer and that needs to adjust its offers to the characteristics and specifics of the Internet. Mobile media strategies might also complement existing stationary media[46]. Existing content can benefit from the stronger customer loyalty created by ubiquitous, real-time media brand access. Moreover, mobile media can be further personalized. In the mobile Internet, media companies will focus again on the sources of revenue, which will be dependent on the customer's perception of the value proposition.

Revenue-generating business models in the mobile Internet could possibly rely on the advertising model again. Sponsorship of media content is one promising form of mobile advertisement. Integrating media content and time-sensitive and location-based advertising services from media advertising clients that consumers can opt in might be of value. Cross-promotion is an important benefit of mobilizing media brands. For media companies, it can strengthen the media brand through availability on all digital platforms that complement each other. To advertising customers, it offers more cross-media activities, using new packages of cross-promotion and an improved consumer targeting by mobile advertisement.

Wireless advertising is yet another example for the co-opetition between media companies and wireless operators. In Japan, the wireless carrier NTT DoCoMo and the advertising agency Dentsu have formed a joint venture that specializes on wireless advertising and successfully delivers its services, e.g., electronic coupons. According to a study conducted by Jupiter Media Matrix, wireless advertising will be hindered by the limits of the platform and per-minute or per-byte charges[47]. However, the study assigns strong feasibility to the sponsorship of content that builds brands by linking them to useful content. Other data shows that click-through rates in the mobile Internet are more than ten times higher than they are for PC-based web advertising[48]. The high click-through response rates could be attributed to their novelty value, though.

But also subscription models are very successful in Japan. This raises hopes that in Europe, the US, and the Americas similar services will lead to comparable consumers' willingness to pay for digital content[49]. Windowing and versioning strategies[50] can be extended to the mobile Internet to generate multiple revenue streams for media companies. Revenue flows for content providers can come from

45 See *Steinbock* (2000).
46 See *Rawolle/Kirchfeld/Hess* (2002).
47 See *Jupiter Media Matrix* (2000), p. 24.
48 See *Durlacher Research* (2001), p. 95.
49 The adoption of i-mode in Europe is rather modest during its first months of introduction. However, about 30% of the consumers that have decided to subscribe to the i-mode service also use content subscription channels. See http://www.eplus-imode.de/1/de/html/pub/presse/index.html.
50 See *Shapiro/Varian* (1998).

even more sources. Apart from revenues generated at the media companies' two relevant markets, the audience and advertising clients, content providers can negotiate to receive revenue shares of data access charges from network operators. Additionally, mobile wireless transactions made through mobile wireless media content sites might lead to commission fees.

Media content providers in mobile environments include developers of original content for various digital distribution platforms, license holders of digital media content, and pure content aggregators that package and structure content from different sources for delivery over mobile wireless networks. Media content providers have three distinct strategic options to distribute mass-media content via mobile platforms. The syndication strategy distributes existing content to new intermediaries or third party portals. The portal strategy builds on the brand asset media brands can provide. The mobile virtual network operator strategy binds the media company closer to the consumer and emphasizes customer relationship management.

4.1 Syndication strategy

The syndication of content is a well-known concept in the media and entertainment industries. The Internet has re-interpreted this concept[51]. Syndication on the Internet involves the sale of the same product to many customers who integrate it into their offerings and redistribute it. For example, financial news providers syndicate their content to websites, e.g., websites of financial institutions or financial service providers, who in turn can focus on their core competencies. Another model involves intermediaries such as iSyndicate, which bundle branded media content and package and sell it to other distributors.

Syndication has become a widely accepted model of generating multiple revenue streams from digital content. Price differentiation can apply by using different levels of consumer acceptance of timeliness of content and the context in which it is consumed. Digital content is especially useful for that purpose, considering the near-zero marginal costs of reproduction and multiple distributions. On the mobile Internet, publishers can syndicate their existing content to third party portals, e.g., portals of telecom operators. Soneras's Zed, British Telecom's Genie, Deutsche Telecom's T-Mobile all partner with content providers to offer news and entertainment services to their customers and to drive data traffic. New intermediaries such as AvantGo emerge and fixed-line Internet syndicators expand their Internet strategy. AvantGo offers a variety of mobile content channels that consumers can subscribe to on their PDAs. Whenever consumers synchronize their PDA with their desktop, the latest data, such as the mobile edition of The Economist.com, is transmitted. The range of news and entertainment reaches from cnet.com to astrology.com and location-based crime news for wireless. Vindigo is a mobile start-up that provides mobile localized interactive services, syndicating information from branded editorial sources. Mobile service providers like Iobox.com or 1StopMobile.com offer, among a wide range of SMS info services, the download of ring-

51 See *Werbach* (2000a).

tones, display pictures, and screen savers that are in part syndicated from music labels or comic strip producers.

The syndication model proves to be specifically valuable, if media content providers only want to expand their content onto a new platform without investing heavily into the production of new, medium-tailored content. It also provides opportunities to weaker media brands to gain attention and usage.

4.2 Portal strategy

Mobile media portals can only be established by strong media brands that attract substantial attention. Mobile portals are the point of entry to the mobile Internet. Scale will influence the profitability of a mobile portal[52]. To ensure scale, mobile portals must excel in providing ease of access, including technology, pricing, and openness; providing awareness through branding and networking; and by providing the right services that enable them to gain strategic control. Mobile portal operators have the ability to set the default portal and thus determine what menus and what services appear.

In general, branded portals can be established by network operators, handset manufacturers, retail, financial industry, mass media, and Internet companies. There are two different kinds of branded portals, horizontal and vertical portals. In the mobile screen space, personalization and the desire for instant gratification lead to the assumption that vertical portals could be successful. An entertainment brand such as MTV could establish a vertical portal. Yet, its credibility for the delivery of, e.g., political news that might also be of interest to the increasingly hybrid consumer, is doubtable. But also horizontal portals can encounter difficulties. For example, the Internet media company Yahoo! has launched Yahoo! mobile. The Internet portal follows the Yahoo! Everywhere strategy, moving established digital services like site directory, e-mail, and instant messaging on mobile distribution platforms. Yahoo! offers syndicated alerts on news, sports, stocks, and weather. It provides local information such as Yellow Pages listings, restaurant listings, entertainment guides, and travel resources. Yahoo! users can play games like Trivia, Black Jack, or Alien Fish Exchange. In 2001, Yahoo! mobile partnered with the CBS TV program "Survivor". Together, Yahoo! and CBS have created the mobile "Survivor Pick'em" game where the audience can decide over the fate of the players in the real people TV show. However, evidence from Japan shows that new players in the mobile portal business are a lot more successful than Internet portals such as Yahoo! that pursue a diversification strategy of their core businesses[53].

Media company Vivendi has formed the joint venture Vizzavi together with the wireless operator Vodafone. The pan-European company aims at becoming the leading multi-access portal through its mobile portal and entertainment content and services. Vizzavi integrates narrowband, broadband, broadcasting, and wireless,

52 See *Bughin/Lind/Stenius/Wilshire* (2001).

53 See *Funk* (2001a).

creating a portal for the two partners' mobile phone and pay TV subscribers. It combines core competencies in content, aggregation, and distribution[54]. Vizzavi follows a local strategy, acting in markets in France, the UK, Netherlands, Germany, Italy, and Japan. The services they offer in their country-specific portals relate to news, including job listings, and entertainment categories like sports, travel, leisure, finance, games, and shopping. To build an advertising revenue model, Vizzavi plans to implement sophisticated data mining techniques. However, doubts about the multichannel communication portal and difficulties in implementing this concept illustrate the challenges combined with such a portal strategy[55].

Mobile entertainment portals that focus on wireless gaming are appearing and constitute an interesting option for media companies[56]. The community building around such a mobile entertainment portal that is necessary, e.g., for multiplayer games, is one core competence that media and entertainment companies have developed through their online strategies for media content. Loyal gaming communities evolve from portals in the fixed Internet; similary, the wireless gaming industry is developing mechanisms to meet the requirements for building loyal wireless gaming communities. An entertainment portal for mobile wireless multiplayer gaming could also take advantage of emerging mobile wireless peer-to-peer applications[57].

Portals deliver relevant and personalized content, commerce, and community functions. The recent failures of new start-up Internet portals indicate that in mobile environments portals may also encounter difficulties in succeeding as a stand-alone business. Therefore, successful mobile portals may be pushed largely by existing brands[58]. If strong media brands additionally own complementary assets such as experiences in direct customer relationship management, they might go one step further and pursue a mobile virtual network operator strategy.

4.3 Mobile virtual network operator strategy

To recoup the investments operators have made and will make for UMTS license and network costs, mobile network operators have strong incentives to open up their networks to third parties. Mobile network operators can act as wholesalers to virtual operators (VOs) from telecom, retail, media, financial, and automotive industries. VOs have access to the networks of one or more mobile network operators[59]. However, the right to use radio spectrum in GSM and UMTS designated frequency bands stays with the mobile network operators. VOs offer services under their own brand and maintain the contract and billing relationship with the customers. In some markets, VOs are intermediaries that offer integrated communication services. In addition to mobile access services, they provide bundles consisting of cable, fixed-line and mobile access.

54 See *Rose* (2000).
55 See *Gribnitz* (2002); N.N. (2001). The problematic implementation process will become even more critical after Vivendi's strategy shifts planned by its new management, deployed in July 2002.
56 See *Raghu/Ramesh/Whinston* (2002).
57 See *Feldmann* (2002).
58 See *Durlacher Research* (2001), p. 29.
59 For a conceptual and legal distinction between MVNO's and service providers see *Kurth* (2001).

UMTS technologies significantly increase traffic capacity per carrier. Thus, providing third parties with capacity is a means to maintain optimal levels of traffic[60]. It is also a way to generate additional revenue, since revenues from voice services alone are not sufficient for a 3G system. License holders must develop a range of advanced applications for secondary spectrum markets that are marketed and bundled differently for different market segments[61]. To maximize 3G revenues, license holders have a strong incentive to lease parts of their spectrum wholesale to value-added resellers. These MVNOs could target specific customer segments.

Advanced brands may have an interest in buying airtime and bandwidth from network operators, from the retail business, e.g. Tesco in the UK, to Internet companies like E-Bay, mobile portals like Io-box, or traditional media companies. In March 2001, the Financial Times Group and The Carphone Warehouse Group PLC launched a commercial joint venture to a virtual mobile network, offering high quality phones, premium business and financial content, and first-class after-sales service. Virgin Mobile is a strong diversified consumer brand that functions as a mobile virtual network operator. It focuses its efforts on branding and pricing and is currently seeking global expansion.

A clear advantage of a mobile virtual operator strategy for media companies is to hold and build the direct customer relationship and multiply revenue streams, not only by participating further in advertising and subscription revenues, but also by click-through and commission fees, and foremost by airtime and data revenue. MVNOs have complete control over their SIM cards, branding, marketing and promotion, billing, and customer-facing services[62]. Media companies such as Bertelsmann are in a strong position to opt for an MVNO strategy. Due to its book clubs, Bertelsmann already has extensive knowledge and experience in distribution network management and direct customer relationship management. However, for any third party MVNO, it is a challenge to champion the telecommunications management that is not part of MVNO players' core competency. Investment into building this expertise could possibly outweigh the benefits that can be reaped.

5 Conclusions

The mobile Internet offers distinct features related to personalization, and time and location sensitivity that reveal the opportunity for profitability in mobile wireless media markets. Yet, technological standards are as uncertain as is future consumer demand.

There are clear motivations for engagement in the mobile Internet. Consumers are looking for instant gratification, and media companies strive for leveraging their brands, and strengthening their customer relationships to their audience and their advertising clients. Telecommunication companies need content to drive traffic into their networks to recoup past and future investments.

60 See *Valletti* (1999).
61 See *McKnight/Linsenmayer/Lehr* (2001).
62 See *McKnight/Linsenmayer/Lehr* (2001), p. 9.

The strategic challenges alter competitive strategy in the mobile Internet. The mobile Internet leads to co-opetition in the media, entertainment, and wireless telecommunications industries. This development is changing industry structure and bargaining power among the five leading forces that constitute industry structure. Because much bargaining power will shift to the consumers of mobile services, media companies need to re-evaluate their activities reflected by the value chain and their position in the industry's mobile value chain.

Competitive advantage will depend strongly on differentiation and strategy. The strategic positioning must be reflected in the emerging business models. Depending on the strength of their brands, experiences with direct customer relationships, and the willingness to investments, media companies have the option to pursue either a syndication strategy, a portal strategy, or an MVNO strategy.

Outperforming the average competitor will require knowledge and skills of realistic and solid business fundamentals to reap economic value from changes in bargaining power. Media companies must create relevance for businesses' and consumers' everyday life by reinforcing integrated virtual and physical activities to compensate for the mobile Internet's performance limits. The current reluctance of media companies to develop competitive strategies for the mobile Internet demonstrates the wide range of difficulties that are connected with the decisions on the mobile wireless media strategy and calls for further investigation.

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Citation-preferences in "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" and "Schmalenbach Business Review"

Abstract

Over the last decade, the sources cited in papers published in "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" exhibit a strong, continuing trend towards more English-language citations. Furthermore, throughout the whole sample period, the English citations are more likely to be from older sources than are German citations, which could imply that English sources contain more insights of lasting importance. Over time, citations of journal articles have increased, whereas books are cited less often. However, this shift seems to be due to the increasing role of English citations, because English-language sources are much more likely to be journal articles. Finally, in terms of total number of citations, the major English-language journals rival their German counterparts.

JEL-Classification: A140.

1 Scope of this Paper

The world of business science is not a fully integrated one: Although German business scientists take international research into account and do sometimes publish in international journals, most German research is still published in the German language and in German journals.

Nevertheless, anybody working in the field will probably agree that international exposure has been increasing rapidly and that it continues to do so. The decision to introduce the "Schmalenbach Business Review" as a quarterly publication in English is one example for this perceived trend[1].

This paper shows how the outlook of German researchers has changed over the last decade. It does so by analysing the sources cited in articles appearing in "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" (zfbf/sbr) between 1990 and 2001. All sources cited in articles appearing in the years 1990, 1995, 1997, 1999, 2000 and 2001 are counted and analyzed by type of source and language[2].

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1 See *Herausgeber* (1999), p. 1097. Though there are also dissenting voices: *Endres* (1994), pp. 791–792, argues passionately against using English: "Aber das (die Anbetung des Englischen und Amerikanischen in der Betriebswirtschaftslehre) wird sich wieder aendern" (p. 792).

2 The sources are taken from the references section, i.e., if a source is quoted several times in one paper, it is only counted once. In some cases, a primarily German journal chose to publish an arti-

Although the results also allow a ranking of major journals by number of citations, it would not be adequate to interpret the results as a first effort to create a "German citation index"[3]: No attempt has been made to calculate impact factors (i.e., to apply weightings to a citation, depending on the number of articles published in a journal over a defined period of time). Furthermore, only papers from one journal have been analysed: "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" might not be fully representative of German business science as a whole.

2 Data-Set

Table 1 gives an overview over the total number of citations analyzed over time. *Table 2* provides a breakdown by the type of source cited:

Table 1: Total number of citations analyzed

total number of citations	1990	1995	1997	1999	2000	2001	total
books	462	682	631	572	532	525	3,404
collections of articles	120	266	304	180	220	261	1,351
working papers	22	66	57	50	94	85	374
journal articles	575	861	1,082	1,221	1,063	1,243	6,045
total	1,179	1,875	2,074	2,023	1,909	2,114	11,174
number of articles analyzed	39	49	48	51	50	52	289

Table 2: Citations by type of source

% of all publication-types	1990	1995	1997	1999	2000	2001	total
books	39.2 %	36.4 %	30.4 %	28.3 %	27.9 %	24.8 %	30.5 %
collections of articles	10.1 %	14.2 %	14.7 %	8.8 %	11.5 %	12.4 %	12.1 %
working papers	1.9 %	3.5 %	2.7 %	2.5 %	4.9 %	4.0 %	3.3 %
journal articles	48.8 %	45.9 %	52.2 %	60.4 %	55.7 %	58.8 %	54.1 %

The number of citations has risen considerably over the years: Although there were only 1,179 citations in 1990 (quite a number of the articles featured in this year did not even have a list of references), the annual average for 1997–2001 was 2,030. On a per-article basis, the number of citations went up from 30 (1990) to 38 (1995), peaked at 43 in 1997, and then remained at 38–41 for the years

cle in English. These cases were counted as "German citations", because the main orientation of the journal was considered to be the decisive factor (and also for reasons of practicality). However, the overall number of such cases was very limited, and different treatment would not have materially affected the results.

3 *Dilger* (2001) argues in favor of creating a German citation index, because the international Social-Science Citation Index (SSCI) does not take German journals into account (apart from a few exceptions).

1999–2001. Consequently, from 1995 onwards there is no discernible trend towards ever longer reference lists.

When we examine the types of sources, there seems to be a strong trend away from citing books and towards citing journal articles: Although the proportion of books has gone down in every year throughout the sample period, the proportion of journal articles has gone up (although to a lesser extent).

3 Analysis and Results

The analysis in this paper discusses the following issues:

- How important are English-language citations in comparison to German-language citations, and how has this importance changed over time?
- Do English-language citations come from other sources than German-language ones?
- Do English-language citations have a different age-structure, i.e. are English citations more likely to be recent or old than citations of German sources?

Table 3 shows the percentage of English-language citations over time (English citations as a percentage of all citations in a category), according to the type of source:

Table 3: Citations by language

% of citations in English	1990	1995	1997	1999	2000	2001
books	26.2 %	20.4 %	23.6 %	34.1 %	37.8 %	44.4 %
collections of articles	35.0 %	22.6 %	25.3 %	45.0 %	46.4 %	44.1 %
working papers	13.6 %	36.4 %	36.8 %	60.0 %	69.2 %	77.7 %
journal articles	39.5 %	51.0 %	62.8 %	59.5 %	72.9 %	71.4 %
total	33.3 %	35.3 %	44.7 %	51.1 %	59.9 %	61.5 %

Over time, the percentage of English citations has gone up continuously, nearly doubling between 1990 and 2001. In the last two years alone, 6 out of 10 citations are from English-language sources. For journal articles and working papers, the proportion is 7 out of 10, even though books and collections (i.e., "Sammelwerke und Lexika") still maintain a slight majority of German-language citations[4]. The higher proportion of German citations for books, compared to journal articles, is

4 It may be argued that the increase in English-language-citations is the primary reason for the declining overall importance of books and the increasing importance of journal-articles, as English sources are more likely to be journal articles: When only German citations are counted, the proportion of books decreases only slightly over time (from 44% in 1990 to 39% on average in 1999–2001), while the proportion of journal articles remains constant (44% in 1990 as well as on average in 1999–2001).

most likely due to different traditions of publishing research results: While German PhD dissertations are in most cases published as books, excerpts of Anglo-Saxon dissertations are much more likely to be published in journals. Although the percentage amount of English citations differs depending on the type of source for any given year, the trend towards English citations is clearly discernible for all types of sources.

There may have been a structural change in 2000, because from 2000 onwards, 4 out of 12 annual copies of "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" are published in English. It is reasonable to assume that papers published in English have a stronger focus on English-language literature. To capture this potential effect, *Table 4* differentiates between the German and the English edition of the journal. As it turns out, even when we exclude the English-language papers published in "Schmalenbach Business Review" and focus only on the papers in the German-language edition, we see that the share of English citations goes up every year[5].

Table 4: Citations in "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" (zfbf) vs. citations in "Schmalenbach Business Review" (sbr)

% of citations in English	total	zfbf		sbr	
	1999	2000	2001	2000	2001
books	34.1 %	34.5 %	39.8 %	48.1 %	61.1 %
collections of articles	45.0 %	40.4 %	39.6 %	60.9 %	68.3 %
working papers	60.0 %	52.1 %	71.4 %	87.0 %	86.1 %
journal articles	59.5 %	68.7 %	69.4 %	78.4 %	78.9 %
total	51.1 %	53.0 %	58.2 %	71.8 %	74.0 %

Tables 5a and 5b differentiate between "recent" and "older" citations. More precisely, they show what percentages of all citations of sources up to 5 years old are in English, and what percentages of all citations of sources aged 20 years and older[6].

The share of English citations goes up continuously for recent citations as well as for citations of older, 'classic' sources. It is particularly interesting to note that citations of older sources are, and have been, much more likely to be in English than are citations of recent sources: For example, it is striking that during the last two

5 Perhaps looking only at the German edition is not an appropriate way of capturing the structural change that occured in 2000: The availability of an English-language platform might have induced German researchers with an Anglo-Saxon research-orientation to publish in English what they would otherwise have published in German. In this case, the introduction of the English edition would have lowered the percentage of English-citations in the German edition. Nevertheless, the data show that the proportion of English-citations went up in the German edition alone as well as overall.

6 Percentages for 1997 are not available, as 1997 results are taken from *Albrecht* (1999), and unfortunately the age-related raw-data used for that study is no longer available.

Table 5a: Citations from sources up to 5 years old

% of citations in English - sources up to 5 years old -	1990	1995	1997	1999	2000	2001
books	20.9 %	15.3 %	na	26.9 %	28.2 %	35.4 %
collections of articles	32.4 %	8.6 %	na	30.0 %	37.9 %	28.9 %
working papers	12.5 %	36.7 %	na	61.1 %	66.7 %	78.0 %
journal articles	31.5 %	32.5 %	na	53.3 %	52.3 %	52.6 %
total	27.0 %	22.3 %	na	42.4 %	44.3 %	46.9 %

Table 5b: Citations from sources at least 20 years old

% of citations in English - sources 20+ years old -	1990	1995	1997	1999	2000	2001
books	50.0 %	25.0 %	na	56.5 %	51.7 %	65.4 %
collections of articles	33.3 %	69.2 %	na	70.0 %	64.3 %	69.0 %
working papers	--	--	na	--	100 %	100 %
journal articles	39.7 %	76.1 %	na	69.7 %	92.5 %	82.9 %
total	43.5 %	50.8 %	na	66.0 %	73.8 %	76.4 %

years, 80–90% of cited journal articles 20+ years old are in English, but only 50% of cited journal articles are less than 5 years old.

One way of interpreting this result might be that recent German research has gained in relevance compared to older research, so it is being cited more intensively. However, this interpretation is not convincing.: Throughout all the years analyzed, recent German research is *always* more likely to be cited than older German research. At the same time, the importance of English citations increases continuously, irrespective of age. So the plausible interpretation of these results seems to be that while authors are intensively surveying and discussing recent German research done by their peers, 'lasting' research is more likely to be published in international journals. The alternative, that German researchers need several years to properly digest English-language research, seems unlikely, since we can expect that relevant research is being followed in major journals. In both English and German.

The result holds not only in the aggregate, but also when we look at individual journals: Of the 15 most-cited journals throughout the whole sample period (excluding 1997, as the detailed raw data was unavailable), 5 are German, 10 English[7]. *Table 6a* shows citations for each journal grouped by age of citation. *All* Eng-

7 The five other journals that received more than 50 citations are, ordered by number of total citations: Harvard Business Review (70), Betriebs-Berater (69), Die Wirtschaftspruefung (64), Quarterly Journal of Economics (63) and Bell Journal (52). The Bell Journal stands out for not receiving any citation that is less than 10 years old. This is due to a renaming into Rand Journal that took place in 1984. However, Rand Journal received only 19 citations, most of which also older than 10 years.

Table 6a: Citations by journal and age-group: major journals[8]

journal	total citations (number)	of which years old (%): -5	5-10	10-20	20+
zfbf / sbr	325	62 %	22 %	11 %	5 %
Zeitschrift für Betriebswirtschaft	254	50 %	25 %	17 %	8 %
J. of Finance	196	23 %	31 %	30 %	16 %
J. of Financial Economics	143	19 %	19 %	46 %	16 %
J. of Marketing Research	129	13 %	33 %	37 %	17 %
American Economic Review	121	9 %	15 %	36 %	40 %
Die Betriebswirtschaft	118	60 %	24 %	13 %	3 %
Management Science	107	17 %	26 %	43 %	14 %
J. of Political Economy	102	11 %	26 %	31 %	32 %
Econometrica	97	9 %	13 %	46 %	32 %
Strategic Management Journal	95	22 %	37 %	39 %	2 %
Betriebswirtschaftliche Forschung und Praxis	83	51 %	28 %	19 %	2 %
J. of Marketing	78	26 %	33 %	28 %	13 %
J. of Consumer Research	76	20 %	29 %	48 %	3 %
Der Betrieb	73	59 %	18 %	20 %	3 %
All English journals	3.055	26 %	27 %	31 %	16 %
All German journals	1.894	51 %	22 %	19 %	8 %

lish journals have a far lower proportion of 'up to 5 years' citations than *all* German journals – the highest proportion for an English journal is 26% (Journal of Marketing), compared to the lowest proportion for a German journal at 50% (Zeitschrift für Betriebswirtschaft). All English journals except for two have a higher proportion of '20+ years' citations than all German journals. The highest proportion for a German journal is 8% (Zeitschrift für Betriebswirtschaft), the lowest proportions for English journals are 2% (Strategic Management Journal), 3% (Journal of Consumer Research) and 13% (Journal of Marketing).

One possible reason for a low proportion of older citations (20+ years) is that a journal has not been in existence long enough. However, a closer look at the major German journals shows that this is not generally the case: "Zeitschrift für Betriebswirtschaft" (ZfB) dates back to 1931, "Der Betrieb" to 1948, "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" (zfbf/sbr) and "Betriebswirtschaftliche Forschung und Praxis" (BFuP) to 1949[9]. Only "Die Betriebs-

8 The five German journals in Table 6a account for 45% of all German journal citations, the ten English journals make up 37% of all English journal citations.

9 In addition, zfbf was published from 1906–44. Along the line, there was a name-change from „Zeitschrift für handelswissenschaftliche Forschung" (ZfhF) to „Zeitschrift für betriebswirtschaftliche Forschung". However, citations of ZfhF are nearly negligible over the sample-period.

wirtschaft" (DBW) started publication comparatively recently, in 1977[10]. On the other hand, both English journals with the lowest proportion of older citations began publishing late: The Strategic Management Journal was first published in 1980 and the Journal of Consumer Research dates back to 1974, so it is not surprising that there are hardly any citations of 20+ years of age in the sample.

While *Table 6a* lists specialised English journals for finance and marketing as well as more general English journals, all German journals in the list have a general orientation. Also, there are no specialised journals on accounting/auditing in the list. For comparison, *Table 6b* shows the results for some less-cited specialised German and English journals in accounting/auditing and marketing[11]:

Table 6b: Citations by journal and age-group: specialised journals

journal	total citations (number)	of which years old (%): -5	5-10	10-20	20+
Accounting/Auditing:					
Die Wirtschaftsprüfung	64	48 %	17 %	19 %	16 %
J. of Accounting Research	44	27 %	16 %	41 %	16 %
The Accounting Review	36	14 %	36 %	36 %	14 %
Marketing:					
J. of Marketing Research	129	13 %	33 %	37 %	17 %
J. of Marketing	78	26 %	33 %	28 %	13 %
Marketing ZFP [12]	43	49 %	16 %	35 %	0 %

4 Summary and Conclusions

Over the last decade, the papers published in "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" have shown a continuous trend towards more international (i.e., English-language) citations. In the last two years of the sample-period, 60% of all citations were in English (roughly 55% in the German-language edition, as compared to more than 70% in sbr). This percentage compares to only 33% in 1990.

Furthermore, throughout the whole sample period, English citations are more likely to be from older sources. This result could imply that English sources contain more insights of lasting importance. In the last two years of the sample-

10 The journal existed already from 1908–43 (though only from 1930 onwards under its present name), but then ceased publication until 1977.

11 A similar comparison is not possible in finance, as there are no specialised German journals with a significant number of citations that have a sufficiently long record of publication. The only exception, Kredit und Kapital, received a total of just 10 citations, making a further analysis statistically meaningless.

12 Marketing ZFP was first published in 1979, i.e., very few citations of 20+ years of age were possible over the sample period.

period, roughly 75% of all citations 20+ years old were in English (for journal articles, the number was even higher at 87%), compared to less than 50% of all citations up to 5 years of age.

In terms of total number of citations, the major English journals rival their German counterparts: The most-cited English journal (The Journal of Finance), received nearly as many citations as the second-ranked German journal (Zeitschrift für Betriebswirtschaft), even though it only covers the area of finance. Only three of the ten most-cited journals are German, though "Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung" and "Zeitschrift für Betriebswirtschaft" occupy ranks one and two. However, for sources 20+ years old, English journals are dominant with the highest ranked German journal (Zeitschrift für Betriebswirtschaft) reaching only rank seven.

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McGrath, Rita Gunther/MacMillan, Ian, The Entrepreneurial Mindset: Strategies for Continuously Creating Opportunity in an Age of Uncertainty, Harvard Business School Press, Boston (Mass.), 2000, 380 pages, $ 29.95.

As the title suggests, this book addresses the fundamental question of how to manage a company when uncertainty and rapid change are the norm. Starting with the observation that uncertainty is often perceived as negative by established firms, *McGrath,* who is an associate professor at the Columbia University Graduate School of Business, and *MacMillan,* who is professor of entrepreneurship at the Wharton School, University of Pennsylvania, advocate that uncertainty should be approached as an opportunity for generating and exploiting new business ideas. This notion is core to the domain of entrepreneurship and follows the tradition of prominent scholars such as *Knight, Schumpeter, Kirzner,* and *Hayek.* The authors argue that established organizations irrespective of their size can learn from successful entrepreneurs how to capitalize on opportunities, and even need to do so, as traditional planning methods reach their limits in circumstances where opportunities are fleeting and where it is necessary to quickly evaluate sketchy information without being able to extrapolate from a well-understood and predictable platform of previous experience.

In order to develop their concept of an "Entrepreneurial Mindset", *McGrath* and *MacMillan* draw from research on the skills of habitual entrepreneurs – a rare breed of entrepreneurs who have founded multiple successful businesses. It is the understanding of the authors that many one-time entrepreneurs were successful because they were lucky, and that their second new venture often failed. Hence, studying habitual entrepreneurs and finding out about their templates for decision making seems to be particularly promising for research. Building on empirical insights on habitual entrepreneurs and results from *McGrath*s Ph.D. dissertation, the authors organize their book into five logically consistent parts which follow the entrepreneurial process from setting a challenging goal to opportunity identification and selection to execution.

In part 1, *McGrath* and *MacMillan* depict how to create an "entrepreneurial frame" which outlines the criteria that make a business opportunity worthwhile to pursue, e.g., in terms of profits the business needs to deliver. These fundamental considerations allow managers not only to get a clearer picture of their own aspirations, but also enable them to clearly communicate their ambitions to others.

In part 2, which is called "Stocking the opportunity register", the authors discuss a range of techniques that are helpful for identifying business opportunities. E.g., they describe the process of "attribute mapping" which can be used for examining the features of a product by an analysis of the customer's perception of these features. Knowledge on the desirability of features can then be applied to discover opportunities for redesigning a product, thereby creating more value for the firm and its customers. Other techniques for finding opportunities build on a resegmentation of the market, a redifferentiation of products, or the development of innovative competences.

Part 3 of the book deals with ways of selecting the most promising opportunities. The underlying premise of this part is that managers need to achieve an unrelenting focus in their activities and therefore should include only very select opportunities in their set of initiatives. The authors suggest that managers should view their endeavours as a portfolio of options and apply real-options reasoning, because many highly uncertain prospects for investment cannot be adequately valued by net-present-value calculations. As with financial options, the advantage of such an option is that it preserves a firm's claim on an opportunity without making a full commitment, thereby limiting the downside risk. Each option is then pursued or abandoned as conditions warrant and resources allow.

Part 4, which is called "Adaptive execution", deals with ways of capitalizing on an opportunity. Amongst others, this part builds on real-options reasoning and introduces a method called "discovery-driven planning" which reflects the habitual entrepreneurs' propensity not to over-analyse competitive situations and to get started. The goal is to plan adaptively while you proceed with your project, and effectively convert assumptions to knowledge at low cost at each milestone of the project, thereby gradually reducing the inherent uncertainty of innovative projects. Other considerations in this part deal with the definition of promising entry strategies and the prognosis of likely competitive responses as well as the assessment of project progress by developing leading indicators.

The final part 5 focuses on exercising entrepreneurial leadership. The authors write: "Your most important job as an entrepreneurial leader is not to find new opportunities or to identify the critical competitive insights. Your task is to create an organization that does these things for you as a matter of course." These tasks fall into three categories: setting the work climate, orchestrating opportunity-seeking and selection, and moving particular ventures forward personally.

This is a book which combines theoretical and empirical insights with pragmatic approaches. The book is rooted in theory, e.g., in the resource-based view of strategic management, in resource-dependence theory and in entrepreneurship theory, yet always stresses the applicability of theoretical insights. Examples of dozens of companies, ranging from Citibank to General Electric to Sonera and the NASA further enhance the applicability of the presented concepts. As with every tool in management, complexity is being simplified in the concepts presented in this book. Following *Levinthal*'s reasoning that people and organizations can deal only with a limited amount of complexity and therefore should try to scale down complexity to a level that can be absorbed, *McGrath* and *MacMillan* present tools that are used by repeatedly successful entrepreneurs in order to support managers in asking the right questions and finding the appropriate answers in spite of complexity and uncertainty. I particularly liked the real-options reasoning as it seems to be a very promising approach in the area of entrepreneurship and therefore should be the subject of more research.

Through its action-oriented approach – each chapter ends with a summary of action steps – this book is mainly targeted at practitioners, namely the corporate management audience and independent entrepreneurs, but is nonetheless well-suited for class rooms of management schools. Because this book is primarily not about being an entrepreneur, but rather about the creation of an entrepreneurial organization, it can be insightful for students in general management and students in entrepreneurship alike.

In summary, the book conveys a tremendous amount of entrepreneurial insights to its readers. And unlike many other textbooks in entrepreneurial management, it succeeds in capturing the spirit of entrepreneurship. The authors, who also have real-world experience in starting new businesses, conclude in their final paragraphs: "It's a lot of fun to create something new and see it develop. It's a lot of fun to outwit and outmaneuver your competitors. (…) It's a lot of fun to win." And I might add: It's a lot of fun to read this inspiring book.

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