Black-Scholes Flexibility of European Companies in the Digital Age

Martin Uzik^{1,*}, Christopher Runge¹

¹ Berlin Institute of Finance, Innovation and Digitalization at the Berlin School of Economics and Law, Badensche Straße 50-51, 10825 Berlin, Germany

Abstract

Research background: “How much is flexibility worth?” This question is the title of one of almost countless contributions. In these, procedures are discussed with which existing room for manoeuvres in corporate management can be quantitatively mapped. When Myers recognized in 1977 that decision-making situations in companies have the characteristics of financial options, he laid the foundation for the theory of real options. In the following years, further articles appeared dealing with the problem of the value-based recording of flexibility.

Purpose of the article: The aim of this paper is to empirically test the explanatory variables of Black-Scholes flexibility. A period from 2000 to 2020 is analyzed, as it is assumed that the digital age had already found its way into companies’ business models at that point in time.

Methods: In the following, using the approach described above, the value of flexibility from the Black-Scholes call option is determined for the years 2000 to 2020. The sample comprises the STOXX Europe 600. The aim of the model is to test whether the flexibility determined by Black-Scholes can be explained by selected parameters. These include intangibles, sales growth, debt to equity, market to book value, and earnings in the form of profitability

Findings & Value added: The results show which variables explain the Black-Scholes flexibility as well as how the Black-Scholes flexibility has evolved over the period studied.

Keywords: *financial option; Black-Scholes model; valuation; flexibility*

JEL Classification: *G11; G12; G14*

1 Introduction

“How much is flexibility worth?” (Copeland & Keenan, 1998). This question is the title of one of almost countless contributions. In these, procedures are discussed with which existing room for manoeuvres in corporate management can be quantitatively mapped. When Myers recognized in 1977 that decision-making situations in companies have the characteristics of

* Corresponding author: martin.uzik@bifid.org

financial options, he laid the foundation for the theory of real options (Myers, 1977). In the following years, further articles appeared dealing with the problem of the value-based recording of flexibility. It was recognized that the conventional future success value methods of company valuation (capitalized earnings value and discounted cash flow methods) are not suitable for capturing the inherent flexibility of many investment projects (Amely & Suci-Sibianu, 2001). Due to the value of flexibility always being positive, these valuation methods lead to a systematic undervaluation of the respective companies or individual investment projects. This problem could be addressed with the help of the real options approach by no longer considering investment projects as a one-time and irreversible decision for or against a project, but by taking the asymmetric risk-reward profile into account in the investment appraisal process. Since Myers laid the foundation in 1977, real options have been decisively researched in a wide variety of areas (Kang et al., 2021 ; Balibrea-Iniesta et al., 2021 ; Oh & Yoon, 2020 ; Luo et al., 2021). Nowadays, many different use cases for real options have been and are being researched. Lambrecht (2017) identified four new main areas for future research in real options : real option applications, deeper development of real option methods, empirical studies and tests of real option valuation (ROV) and surveys or studies providing insights real options are exercised. For example, a real option approach for valuing publically funded research, by van Zee & Spinler (2014) or a new fully possibilistic method for real option valuation of investment projects by Stoklasa et al. (2021). Driouchi and Bennett (2011) argue, if real options are explored and exploited appropriately, real options decision making can result in superior performance. The majority of contributions that quantify flexibility deal with so-called asset-side real options. The focus here is on the scope for action embodied in the company's assets. Room for maneuver can arise through expansion (growth), removal (divestment) or alternative deployment (switching). So far, little attention has been paid to the scope for action on the liabilities side. They arise, for example, through self-financing and through their contribution to the value of the company or the value of an investment project (Koch 1999 ; Rams, 1999).

In this paper, corporate flexibility is determined and compared on the basis of the Black-Scholes model and by Myers' model. Subsequently, these flexibility values are explained by selected variables by means of a regression analysis.

2 Approach to Quantifying the Scope for Action through the Black-Scholes Model

The approach presented for assessing flexibility draws on an option price-based theoretic model. Using the well-known Black-Scholes equation (Black & Scholes, 1973), the value of a call option on equity can be determined with a strike price composed of the amount of money surrendered and the return demanded by the equity investors. This value can be interpreted as the value of flexibility. The starting point of the underlying considerations is that an investment project has a limited term. After its expiry, the assumption of recapitalization already indicated above is made. Recapitalization is understood to mean that the equity raised to finance the project is repaid to the equity investors after completion of the project. New equity is then raised for a subsequent investment project. The Black-Scholes option valuation formula for a call option is as follows:

$$C = S \times N(d_1) - X \times e^{-r_f \times t} \times N(d_2) \quad (1)$$

with

$$d_1 = \frac{\ln \frac{S}{X} + r_f \times t + \sigma^2 \times \frac{t}{2}}{\sigma \times \sqrt{t}} \quad (2)$$

and

$$d_2 = d_1 - \sigma \times \sqrt{t} \quad (3)$$

where

S corresponds to the price of the underlying at the current time $t=0$,

t is the time remaining until the maturity date,

X is the strike price,

$N(d_1)$ is the cumulative distribution function of the standard normal distribution,

$N(d_2)$ is the probability of realizations smaller than d,

r_f represents the continuous interest rate, and

$\exp(-r_f \times t)$ is the discount factor.

Real options theory enables management decisions and corporate processes to be identified and analyzed as options on future corporate success (Daum, 2002).

3 Approach to Quantifying the Scope for Action through Myers' Model

The term growth potentials is used in this thesis to refer to the ability of companies to generate future profitable growth. From a scientific theoretical perspective, the concept of growth options developed by Myers and real options, which go back to Trigeorgis, are identified as suitable approaches. Both will be discussed in the following.

The concept of growth opportunities can be traced back to Myers. Myers (1977) defines that the value of growth opportunities is based on the required return on future investments to exceed the firm's cost of capital. In addition, tangible assets are described as units of productive capacity, while intangible assets are considered as options to expand additional units. The sum of the option values is defined as the present value of growth. Investments in future opportunities, which Myers refers to as the present value of PVGO's growth opportunities, contribute largely to the firm's equity value (Brealey et al., 2010). The growth options explain the price of a share and thus its valuation in a twofold approach when referring to growth: The first component is defined as the capitalized value of average earnings under a no-growth policy, which is consequently expressed as a perpetuity formula with EPS and then discounted by the market capitalization rate r . The second element PVGO is defined as the present value of growth options. These represent the value of all expected future cash flows that originate from internal projects with a positive net present value and exceed the return r required by the investor. Growth options are calculated recursively from the share price and the present values of existing assets (PVEA), which capture the present value of earnings per share.

$$S = \frac{EPS_{t_0}}{r_E} + PVGO \quad (4)$$

An extension of the concept of growth options can be traced back to Trigeorgis. He defines investments as real options, which can be postponed, abandoned, extended, shortened, switched, and compounded. This structuring of option characteristics according to Trigeorgis suggests that the corporate finance literature agrees on the basic principles of

the real options approach, which serves as the basis for more complex quantitative empirical models. According to the evidence, Koller & Copeland (2010) describe the main variables that correlate with flexibility value. While high investment costs and cash flows lost to competition are negatively correlated, other factors are positively associated with flexibility and thus growth options: The longer the time until the option expires, the higher the uncertainty about the present value and the higher the risk-free interest rate. Finally, the level of the present values of the cash flows also determines the flexibility value of the option.

In line with other authors, Trigeorgis (2002) considers uncertainty and flexibility as key factors, therefore the value of options benefits from greater variability in outcomes. He extends the concept of NPV by decomposing the value into a sum of passive NPV, flexibility value and strategic value. In this context, Trigeorgis resolves the limitations of the NPV concept under uncertainty: He defines the part that Myers (1977) calls "intangible" as flexible and strategic. In his view, flexibility value is the real option value that increases with high uncertainty, long investment horizons, high interest rates, and compound options. Flexibility is viewed as the option to postpone, reverse, stop, restart, or switch investment projects (Trigeorgis, 2002).

4 Empirical Analysis

4.1 Methodology and Data

In the following, using the approach described above for the years 2000 to 2020, the value of flexibility is determined by the Black-Scholes call option. The sample comprises the STOXX Europe 600. IBM's SPSS software is used for statistical analyses. The data are taken from the EIKON database. The aim of the model is to test whether the flexibility determined by Black-Scholes can be explained by selected parameters. These include intangibles, sales growth, debt to equity, market to book value, and earnings, which enter the model as profitability. Profitability is calculated by weighting net income by sales. Intangibles are further divided by total assets to eliminate the influence of any size effects. The PVGO (Present Value of Growth Opportunities) is included as a further model variable. This is calculated by deducting the PVEA (Present Value of Existing Assets) from the share price. The latter is determined by weighting the earnings per share with the CAPM cost of capital. The test is whether the PVGO is consistent with the Black-Scholes value. However, it should be noted that the Black-Scholes value is only defined in the positive range, whereas the PVGO can also assume negative values.

The valuation parameters included in the Black-Scholes option price formula are to be interpreted as follows: The current price of the underlying value S is equal to the current market value of the equity (stock market value/market capitalization). The exercise price X is also set equal to the current market value of the equity. The term of the option t is assumed to correspond to the period calculated by Balzer (2020), which is required to allow the flexibility and growth potential to be incorporated into the operating business in the form of the PVEA. The volatility σ can be derived from the historical volatility of the shares of the company in question or, if not listed itself, from the volatility of the shares of the company. The risk-free interest rate r_f is replaced by the company-specific CAPM rate. The CAPM return uses the risk free rates and the market returns from the website marktrisikoprämie.de. The beta value is determined based on daily returns in an interval of one year before the CAPM return is calculated. The resulting value of the call after applying the formula to the parameters is understood here as the value of flexibility, as mentioned above.

The PVEA is calculated as a perpetual annuity from the companies’ earnings per share and the company-specific CAPM. The PVEA is then deducted from the share price to calculate the PVGO. All values were calculated at the respective year-end date.

4.2 Empirical Analysis

The STOXX Europe 600 sample was adjusted for missing values to 269 companies. Subsequently, panel data with 5,649 data records were prepared for the analysis. It should be noted that two time periods were examined. For the period between 2000 and 2020 of this investigation, intangibles were disregarded, as they are only sufficiently published by the sample companies from 2004 onwards. Thus, a second data set that takes intangibles into account was prepared for the study period from 2004 to 2020.

The correlation between Black-Scholes values and PVGO is negative, which can be attributed to the fact that PVGO values can also become negative, unlike Black-Scholes. Sales growth shows no relationship to either variable. While the profitability and market-to-book variables are negatively correlated with the PVGO, they show a positive correlation with the Black-Scholes value.

Shortening the study period by four years leads to the reduction of the study sample to 4,573 records. A similar picture emerges here, with both flexibility variables (Black-Scholes and PVGO) positively correlated with intangibles.

In the next step of the statistical evaluation, the hypothesis is tested whether the difference between the PVGO and the Black-Scholes value is given. The hypothesis is: The mean values of the flexibilities calculated with Black-Scholes and PVGO do not differ.

$$H_0: \mu_{Black-Scholes} = \mu_{PVGO}$$

$$H_1: \mu_{Black-Scholes} \neq \mu_{PVGO}$$

Table 1. Paired samples t test 2000 to 2020

Paired Samples Statistics				
	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 Black-Scholes_	86.94	5649	205.98	2.74
PVGO_	-120.01	5649	1337.51	17.80

Paired Samples Correlations			
	N	Correlation	Sig.
Pair 1 Black-Scholes_ & PVGO_	5649	-.0162	0.000

Paired Samples Test							
Paired Differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	Sig. (2-tailed)
				Lower	Upper		
Pair 1 Black-Scholes_ - PVGO_	206.95	1385.80	18.44	170.80	243.09	11.224	0.000

Source: own calculation

Table 2. Paired samples t test 2004 to 2020

Paired Samples Statistics						
	Mean	N	Std. Deviation	Std. Error Mean		
Pair 1 Black-Scholes_	86.94	5649	205.98	2.74		
PVGO_	-120.01	5649	1337.51	17.80		

Paired Samples Correlations			
	N	Correlation	Sig.
Pair 1 Black-Scholes_ & PVGO_	5649	-.0162	0.000

Paired Samples Test								
			Paired Differences		95% Confidence Interval of the Difference			
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 Black-Scholes_ - PVGO_	206.95	1385.80	18.44	170.80	243.09	11.224	5648	0.000

Source: own calculation

The paired samples t-test shows that the H_0 hypothesis must be rejected for both periods. Thus, the mean values of the flexibilities calculated with the two different methods are not equal.

The next question is what explains the individual flexibilities. For this purpose, a multivariate linear regression is performed with the selected parameters.

The first model tested defines the PVGO as the dependent variable and the second model the Black-Scholes value. Debt to equity, profitability (net income to sales), sales growth, intangibles to assets, and market to book are included in the model as explanatory variables. The results of the regression are shown in the following tables for the two periods.

Table 3. Regression with PVGO as dependent variable for 2000 to 2020

Model Summary^a

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.040 ^a	0.002	0.001	1336.921	2.005

a. Predictors: (Constant), Sales-growth_, Profitability_, Market-to-Book_, Debt-to-Equity_

b. Dependent Variable: PVGO_

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16042495.587	4	4010623.897	2.244	.062 ^b
	Residual	10087847686.229	5644	1787357.847		
	Total	10103890181.815	5648			

a. Dependent Variable: PVGO_

b. Predictors: (Constant), Sales-growth_, Profitability_, Market-to-Book_, Debt-to-Equity_

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-94.184	20.106		-4.684	0.000		
	Debt-to-Equity_	-6.587	4.614	-0.019	-1.427	0.154	0.991	1.009
	Profitability_	-74.310	34.558	-0.029	-2.150	0.032	1.000	1.000
	Market-to-Book_	-2.677	1.881	-0.019	-1.423	0.155	0.992	1.008
	Sales-growth_	2.249	22.372	0.001	0.101	0.920	1.000	1.000

a. Dependent Variable: PVGO_

Source: own calculation

Overall, the model has very low explanatory power and only slight model significance. The variable Profitability is the only significant variable at 5 %, but has a negative effect on the PVGO.

Table 4. Regression with Black-Scholes value as dependent variable for 2000 to 2020

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.091 ^a	0.008	0.008	205.193	1.822

a. Predictors: (Constant), Sales-growth_, Profitability_, Market-to-Book_, Debt-to-Equity_

b. Dependent Variable: Black-Scholes_

ANOVA^a

Model		Sum of Squares	df	Mean Square	F
1	Regression	1993459.894	4	498364.974	11.837
	Residual	237634829.842	5644	42103.974	
	Total	239628289.736	5648		

a. Dependent Variable: Black-Scholes_

b. Predictors: (Constant), Sales-growth_, Profitability_, Market-to-Book_, Debt-to-Equity_

Coefficients^a

Model		Unstandardized Coefficients	Standardized Coefficients	t
		B	Beta	
1	(Constant)	84.377		27.343
	Debt-to-Equity_	-2.469	-0.046	-3.487
	Profitability_	13.698	0.034	2.583
	Market-to-Book_	1.616	0.075	5.597
	Sales-growth_	-0.858	-0.003	-0.250

a. Dependent Variable: Black-Scholes_

Source: own calculation

Despite the only slight increase in explanatory power, the second model shows that all variables are significant with the exception of sales growth. It is noticeable, however, that profitability, market to book, and sales growth have opposite signs and thus influence the Black-Scholes value in the opposite direction compared to the PVGO.

Table 5. Regression with Black-Scholes value as dependent variable for 2004 to 2020

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.064 ^a	0.004	0.003	1448.259	2.004
a. Predictors: (Constant), Sales-growth_, Market-to-Book_, Profitability_, Intangibles-to-Sales_, Debt-to-Equity_					
b. Dependent Variable: PVGO_					

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	38871174.745	5	7774234.949	3.707	.002 ^b
	Residual	9579068625.172	4567	2097453.170		
	Total	9617939799.916	4572			
a. Dependent Variable: PVGO_						
b. Predictors: (Constant), Sales-growth_, Market-to-Book_, Profitability_, Intangibles-to-Sales_, Debt-to-Equity_						

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-106.769	27.283		-3.913	0.000		
	Debt-to-Equity_	-9.416	7.093	-0.020	-1.328	0.184	0.942	1.062
	Profitability_	-73.628	37.875	-0.029	-1.944	0.052	0.999	1.001
	Market-to-Book_	-7.296	3.555	-0.031	-2.053	0.040	0.943	1.060
	Intangibles-to-Sales_	645.213	244.928	0.039	2.634	0.008	0.999	1.001
	Sales-growth_	2.912	24.700	0.002	0.118	0.906	0.999	1.001
a. Dependent Variable: PVGO_								

Source: own calculation

The inclusion of intangibles in the second regression model leads to only a slight increase in the explanatory power of PVGO as the dependent variable. Overall, intangibles have a significant positive influence on PVGO. At the same time, both market-to-book and profitability show a slight significant influence.

Table 6. Regression with Black-Scholes value as dependent variable for 2004 to 2020

Model Summary^a

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.139 ^a	0.019	0.018	221.514	1.834

a. Predictors: (Constant), Sales-growth_, Market-to-Book_, Profitability_, Intangibles-to-Sales_, Debt-to-Equity_

b. Dependent Variable: Black-Scholes_

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4446222.947	5	889244.589	18.122	.000 ^b
	Residual	224096028.631	4567	49068.541		
	Total	228542251.578	4572			

a. Dependent Variable: Black-Scholes_

b. Predictors: (Constant), Sales-growth_, Market-to-Book_, Profitability_, Intangibles-to-Sales_, Debt-to-Equity_

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	85.867	4.173		20.577	0.000		
	Debt-to-Equity_	-5.380	1.085	-.0075	-4.959	0.000	0.942	1.062
	Profitability_	11.607	5.793	.0029	2.004	0.045	0.999	1.001
	Market-to-Book_	4.619	0.544	.0128	8.494	0.000	0.943	1.060
	Intangibles-to-Sales_	79.038	37.462	.0031	2.110	0.035	0.999	1.001
	Sales-growth_	-0.121	3.778	.0000	-0.032	0.975	0.999	1.001

a. Dependent Variable: Black-Scholes_

Source: own calculation

The explanatory power can also be slightly increased in the last model with the Black-Scholes value as the dependent variable. Intangibles are also a significant factor here, as are all other variables with the exception of sales growth.

5 Conclusion

In the present paper, the focus was on presenting two option price theory approaches to the valuation of flexibility and to explain them statistically by selected variables. It was found that in the period under consideration, 2000 to 2020, the Black-Scholes equation corresponds to the value of flexibility according to Myers’ model. This was done by matching the PVGO, which is the difference between the stock price and the PVEA, reflecting the exact value of flexibility potentials expected by the market at a point in time. On average, the Black-Scholes equation overstated the value of flexibility compared to the PVGO, taking into account the calculation procedure. Furthermore, intangibles could be statistically determined as a relevant and significant parameter for the value of flexibility. At the same time, profitability, market to book and debt to equity were also found to be significant variables. Overall, it can thus be recommended to company management to invest in intangibles in order to create flexibility values and thus advantages for the company. The limitations lie in the model setup. It may be necessary to define further variables or other correlations and calculation procedures in order to obtain a better understanding of the statistical relevance of flexibility.

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