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Gaussian Distributed Shareholder Value As a Tool for Value Based Management: Business Horizon

Jochen Huelss*, Norman Vogel**, Philipp Pohl***, Dietmar Ratz*** and Roland Kuestermann***

A waterproof approach to comprehensively value a business is yet to be accomplished. The central scientific issue to be tackled in the paper is to determine the accuracy of predicted cash flows and to investigate whether a general model of shareholder value distributions belongs to a class of probabilistically known and analyzable distribution functions. This model is based on companies from arbitrary industries and the employment of arbitrary stochastic processes. We rely on the well-known Discounted Cash Flow methodology to finally value a firm. However, the future cash flow prediction and the presentation of the result is achieved differentially. In literature, the predominant methodology is a deterministic prediction. This approach is extended by stochastic processes. Either a Random Walk or a Wiener Process is employed to more realistically forecast future developments based on a time-series of past business figures. Since we prove that both stochastic processes return a set of normally distributed results, the shareholder value is displayed as a Gaussian curve. This normality of shareholder value is plausible due to generalized limit case theorems and depicts a substantially new finding for Value Based Management. The Gaussian can be analyzed fully probabilistically and thus, it is possible to dynamically examine the shareholder value with the Value at Risk metric. A set of twelve sample companies is valued to assess the model's predictive ability and to exhibit the accuracy of the Gaussian distributed shareholder value. Moreover, we introduce the open source software 'Business Horizon' that is capable of executing a business valuation based on the established model.

Keywords: Shareholder Value, Stochastic Processes, Gaussian Distribution, Value at Risk, Business Horizon

JEL Classification: C53, C61, G32

1. Introduction

According to the vast number of published papers and books, value-based management is the leading and most widely spread management strategy. Clearly, Coenenberg and Salfeld's (2007) straight forward opinion that "value-based management has come out on top as the leading term of modern business management" (p.3) is indisputable. The main principle of value-based management refers to adopting the maximization of the shareholder value to a firm's strategy.

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There are more scenarios besides financial reporting, though, where an assessment of the shareholder value is necessary. For instance, it is of interest for an acquisition or merger of a firm, the initial public offering, and investment analysis for big and even small investors. However, one problem remains. It remains complex, costly, and time-consuming, though needed, to value a firm. Many parameters, namely assets, liabilities, taxes, required rate of return, competitors, future trends, etc., have a major influence on the shareholder value.

Historically, the net asset value (NAV) was used to determine a firm's value. It simply understood an entity's value as all assets less its liabilities. This approach is viable for an immediate liquidation of a business but it does not take into account a possible acquisition and its future profits. In response to the increasing dynamic valuation of entities, NAV's importance sank drastically. Starting from the eighties, Ballwieser (1990, 1st Edition from 1983) and Rappaport (1999, 1st Edition from 1986) among others investigated the Discounted Cash Flow (DCF) approach. It bases the shareholder value on present values of future cash flows[i]. Since then, DCF gained more popularity and has been transformed by many valuation methods relying on DCF to the most recognized and applied method. Usually, these methods value either according to the required rate of return on equity or entity and take into consideration a benefiting tax shield as well (Koller, Goedhardt, & Wessels, 2005). All foremost consulting firms have developed their own frameworks. All those have been derived from discounted cash flows (Ryan & Trahan, 1999). More recent research adds another dimension to an as realistic as possible valuation process. Kautt (2003) argues that real options can advance the efficacy of a valuation. A real option is an incident that might actually occur to a business and, during valuation, its impact on the company is scored. This paper, however, focuses on the DCF methodology and in particular on the Adjusted Present Value (APV) model to calculate the shareholder value. The central scientific problem tackled by the present article is to determine the prediction's accuracy to plan businesses' future cash flows. Moreover, the article investigates whether shareholder value distributions of a general model belong to a class of probabilistically known and thus distribution functions. This model is based on companies from arbitrary industries and the employment of arbitrary stochastic processes. The hypothesis derived from this problem is outlined in chapter 3.1.

The paper proceeds as follows. The next chapter reviews relevant literature for the prediction of cash flows and exposes our concept to the reader. Next, the used methods are described in detail and the software 'Business Horizon' which implements those methods is introduced to the reader. A comparison of predicted and actual cash flows of twelve sample firms is drawn. Afterwards, the Gaussian distributed shareholder value of those firms is proven, examined, and analyzed. Finally, the outlook provides further research possibilities.

2. Literature Review

In literature, regression models, stochastic processes, and the ARMA model can be found to forecast cash flows.

Lorek and Willinger (1996) have investigated a multivariate regression which is built on time-series to predict future cash flows. As input parameters for the time-series, they used former values of earning, accruals and cash flows. They argue that their model outperforms the predictive ability of comparable competitive models at that time due to considered accruals. In 2006, the two of them published another paper about the predictive ability of time-series.

It draws the conclusion that regression models are also a reasonable resolution to forecast quarterly cash flows. In 2010, Lorek and Willinger investigated whether restricting firm-specific parameter estimation adversely affects performance of prediction. It was concluded that enhanced and superior predictive performance is obtained by models on a time-series basis compared to cross-sectional regression. Furthermore, strong sensitivity of firm size to predictive ability of cash flows was shown. Francis and Olsen (2011) concluded that time-series regression is as accurate as cross-sectional regression forecast. Additionally, regression model forecasting is compared to a naïve model with the evidence of the same forecasting accuracy.

Many economic forecasting tools rely on Auto Regressive and Moving Average (ARMA) models. For instance, Lorek and Willinger (2011) have carried out research in predicting cash flows. Their new findings reveal that for multi-step-ahead quarterly cash flow prediction an ARMA model is the better approach than a plain time-series analysis. Their research suggests that the deviation of predicted and actual values is 20% less with the ARMA model than with a multivariate regression.

As for stochastic approaches, Casey (2000) discusses a risk-aware stochastic framework for corporate investment and finance. Its central instrument is a frequency distribution of present values of future equity. This present value distribution is stochastically simulated and tries to consider the risk of fluctuation in future cash flow as well as bankruptcy.

Li (2003) proposes a model to value a company according to its stochastically calculated earnings. The model assumes that the earnings follow a time-varying mean reverting process and that the firm has a finite life. Due to these assumptions, the shareholder value is recognized as a boundary value problem and an analytic solution to this problem is presented.

Tallau (2009) has developed a costumer-based model for the valuation of growth companies. It links costumer valuation and the firm valuation. The main value drivers are stochastically determined. The shareholder value is derived from a Monte Carlo simulation.

Arthur (2010) examines whether models incorporating components of cash flows from operations or using simply net cash flows from operations provide lower prediction errors. In his study, the usefulness of the disclosure of non-core cash flow components in favor of the predictive ability of future cash flows is provided. Furthermore, advantage of cash flow component model over aggregate cash flow model is identified.

Other published literature tries to stochastically predict stock prices or the internal rate of return (see Rebello and Reddy (2010) and Hazen (2009)). However, not many researches do the circular reference to use stochastic processes to determine future cash flows as input for DCF methods.

Our contribution uses known models to predict Free Cash Flows (FCF) and ultimately a frequency distribution of shareholder values. We use either a Random Walk or a

Wiener Process to calculate future cash flows. As mandatory input parameters for the APV model, a series of FCFs and debt capital is needed as well as current tax rates. In order to determine the Weighted Average Cost of Capital (WACC), required rate of return is necessary. Our approach stands for a viable cash flow forecast and comprehensive probabilistic analysis of the shareholder value to rationally manage a company. Moreover, the model can simply be applied because of an available open source software implementation.

3. Hypothesis and Applied Mathematical Methods

3.1 Hypothesis

The hypothesis of our work is that the resulting shareholder value distribution based on the mentioned cash flow prediction is normally distributed. The article aims to develop and unveil a methodology to predict cash flows which is superior to other models found in literature in terms of a specific metric. By using statistical tests, it shall be proven that the resulting shareholder value distribution is an approximation of the Gaussian distribution. In case of a valid hypothesis, the entire Value at Risk toolset can be applied to our findings.

3.2 Discounted Cash Flow Methodology

Using the discounted cash flow methods to value a company it is necessary to determine its cash flows. A company's cash flow is the amount of cash that is available for being distributed among its capital providers to satisfy their payment claims like debt capital interests and dividend payouts. Thus, it is derived from the EBIT adjusted by depreciation or amortization, changes in working capital, and capital expenditure.

Various different DCF methods to value a firm are available. Those methods often referred to in literature include Adjusted Present Value, Flow to Equity (FTE), and Free Cash Flow approach. For further reference see Drukarczyk & Schüler (2009), Ballwieser (2011), and Hering (2006).

3.3 Stochastic Processes

Stochastic processes are used to forecast cash flows in period *t+1*. As we assume a discrete state space as well as a discrete set of periods, a Random Walk built on a Markov chain is an option. Random Walk takes successive random steps *n* with probability *p* upwards and *1-p* downwards.
Calculating X_{t+1} follows the simple algorithm:

(1) Set destination value $X_t = A$, (2) determine random number i, (3) decide $i < p$, (4a) increase with d or (4b) decrease with d, and (5) set $A = X_{t+1}$.

In order to achieve a significant X, steps (2) to (4ab) have to be repeated numerously, as well as the steps (1)-(5) n times with following parameters: $n =$

quantity of periods, $A = CF_t$, step size $d = \frac{\sum_{t=-n}^{-1} |x_t + x_{t-1}|}{n}$ and $p = \frac{w}{n}$ where $w =$number of past value risings.

A Wiener Process or Brownian Motion can be recognized as the limit case of a time-discrete Random Walk whose motions at instants of time $n \cdot \Delta t$ for n = 1,2,… in size of $\pm \Delta x$ have the probability of 0.5.

Stochastic process $W = \lfloor W_{t,} t \ \varepsilon \Re \rfloor_t$ is a Wiener Process with the following attitudes:
(1) Increments $W_{s+t} - W_s$ are stationary and normally distributed as $N(0, \sigma^2 \cdot t)$ for $s, t \geq 0$.
(2) For each $0 \leq t_1 \leq t_2 \leq ... \leq t_n, n \geq 3$ each increment $W_{t_2} - W_{t_1}, ..., W_{t_n} - W_{t_{n-1}}$ is independent.

(3) $W_0 = 0$
(4) Function $t \rightarrow W_t$ is almost certainly continuous (Hassler, 2007).

In practice, to perform a Brownian Motion for periodical cash flows X_t with X_0 as the cash flow in the first period, following formula is common: $X_{t+\Delta t} = X_t + d \cdot \Delta t + \sigma \cdot \sqrt{\Delta t} \cdot \varepsilon$, where step size $d = \frac{1}{n} \sum_{t=-n}^{-1} (X_{t+1} - X_t) = \frac{1}{n} \sum_{t=-n}^{-1} (X_0 - X_{-n})$ and standard deviation $\sigma = \sqrt{\frac{1}{n} \sum_{t=-n}^{-1} (X_{t+1} - X_t - d)^2}$.

It has to be mentioned that cash flow forecasting can be divided into first part of addition to cash flow X_t which refers to the fix part of cash-flow transformation and secondly to the variable part. Thus, the expected value is calculated as $E(X_t) = X_0 + d \times t$.

4. Research Findings

4.1 Business Horizon

'Business Horizon - Focus on Value' is a software tool to calculate shareholder values and was used for all the simulations outlined in the following paragraphs. This open source software has been developed by students of Baden-Wuerttemberg Cooperative State University. It comprises features to calculate a shareholder value deterministically and stochastically. The software relies on annual periodical data of either FCF and debt capital or a complete balance sheet. It implements three different DCF methods (APV, FTE, and FCF). The stochastic calculation only needs a set of past business figures to predict future cash flows (CF) and derive a shareholder value from them. It needs further input parameters such as tax rate and required rate of return. The result pane with probability distribution of shareholder value can be exported. The tool is equipped with multi-language support for English and German. 'Business Horizon - Focus on Value' is deployed as an executable jar file and is available upon request.

4.2 Methodology of Predictive Ability Test

The research carried out proceeds from a comparison of FCF prediction performance to evidence, analysis, and discussion of Gaussian distributed shareholder values. The test is designed to practically assess the predictive ability of a Random Walk and a Wiener Process. Therefore, predicted cash flows are compared to actual data from diverse German enterprises. This data has been collected from the German Bundesanzeiger[ii] which is the nationwide obligatory platform to publish company results. Each sample firm's data packet consists of five past periods of balance sheets (2006 to 2010). The firms' size ranges from annual revenues of 40 million euro to 12 billion euro. Different industries are represented by food, construction, technology, and pharmaceutical companies. Table 1 shows descriptive statistics of the important variables of the sample.

Table 1: Descriptive Statistic for Used Variables of Sample Firms (in Euro)

Variables	Arithmetic Average	Standard Deviation	Min. Value	Max. Value
Revenue	2,936,883,295	4,313,785,860	40,723,105	12,381,537,000
Debt Capital	1,044,209,226	1,971,960,883	4,154,901	5,461,819,000
Total Assets	2,596,959,572	4,020,951,723	47,814,689	10,333,015,000
Cash Flow	355,779,364	779,947,347	3,001,000	2,629,300,000

Two scenarios are compared with both mentioned stochastic models. The first scenario relies on direct input of a manually pre-aggregated FCF and the company's debt capital to forecast a future FCF. The two input figures are stochastically simulated. Whereas the other scenario employs the company's profit and loss statement (P&L) to calculate an adjusted cash flow based on four input figures (revenues, other operating expense, purchases, and personnel expenses). For every scenario three figures are forecasted with both stochastic processes. Firstly, actual CF from 2009 is matched up to forecasted cash flow from 2009 (one-year-ahead). Then, actual cash flow from 2010 is compared to forecasted CF from 2010 based three periods (two-year-ahead). This scenario is referred to as 2010(1). Thirdly, the cash flow from 2010 is matched up to the forecasted one from 2010 based on four past periods (one-year-ahead, 2010(2)). The comparisons of both stochastic processes for both scenarios were conducted with 10,000 repetitions each.

The mean absolute percentage error (MAPE) serves as the metric to assess a forecasted cash flow. It is defined as $MAPE = \frac{1}{n}\sum|\frac{(A-F)}{A}|$, where n = number of predictions; A = actual CF; and F = forecasted CF. However, to avoid distorting forecast errors, all errors greater than 100 percent were truncated to 100 percent. This is a common approach as, for instance, Lorek and Willinger (2011; p. 80) show. For their multi-period ahead quarterly cash flow prediction, they achieved a MAPE of 0.63 with an ARMA model and a MAPE of 0.79 with a regression analysis approach.

4.3 Test Results

Table 2 presents the resulting figures of the test conduction for Random Walk. All presented numbers are the deviation from the actual value in percentage. The first column depicts the company's branch and name as well as its type of enterprise. The following three columns present a detailed annual forecast performance. The column on the right outer hand is the arithmetical average of the company's forecast accuracy. The table's bottom row depicts the annual error. The cell at the bottom right is the total forecast error of the assessed companies.

In Table 2, the annual average MAPEs of 2009 and 2010(1) are approximately 85% and thus, almost equal. Their difference only amounts to 3.2 percentage points. However, among these results are many scoring 1.0. I.e. their companies' FCF forecast exceeded or undercut the actual value by more than 100%. The result of 2010(2) is considerably better. Its percentage error is close to 30 percentage points lower. But yet, there are four companies having a mean error of 1.0. Throughout the result pane, there is not a single industry that markedly scores better than others. Eventually, Random Walk with two stochastically simulated input parameters generates FCFs that deviate from the actual FCFs by 74.9% in the periods from 2009 to 2010.

Table 2: Test Scenario Random Walk with Direct Input; (F) = Food, (C) = Construction, (T) = Technology, (P) = Pharmaceutical

Scenario 1.1: Random Walk with two input parameters				
Firm	2009	2010 (1)	2010 (2)	Firm MAPE
(F) Rothaus AG	0.103	0.142	0.054	0.100
(F) Coca Cola DE AG	1.000	1.000	1.000	1.000
(C) Strabag AG	1.000	1.000	1.000	1.000
(C) Eurovia GmbH	1.000	1.000	1.000	1.000
(C) Zueblin AG	1.000	0.989	0.021	0.670
(C) Bilfinger Berger AG	0.816	0.856	1.000	0.891
(T) Datev eG	0.394	0.738	0.180	0.437
(T) Vodafone D2 GmbH	0.712	0.677	0.291	0.560
(T) Microsoft DE GmbH	1.000	1.000	1.000	1.000
(P) ACINO AG	1.000	1.000	0.836	0.945
(P) Biotest Pharma GmbH	1.000	1.000	0.134	0.711
(P) Serumwerk Bernburg AG	1.000	1.000	0.005	0.668
Annual MAPE	0.835	0.867	0.543	0.749

Table 3 presents the findings for a Wiener Process as FCF forecasting model. Generally speaking, the results' characteristics are more homogenous compared to those from a Random Walk. The figures in the periods 2009 and 2010(1) are less accurate than those from 2010(2). Moreover, the difference between 2009 and 2010(1) is below 1 percentage point. The distance to the mean error of 2010(2) is, however, substantially smaller than in Table 2. There are five firms with an average score fallen below 30% deviation now. The Wiener Process predicts FCFs with a mean error of 57.8%. Taking the result table drilled down to the different branches, the resulting ranking is Food in front of Technology, pharmaceutical companies and Construction

Table 3: Test Scenario Wiener Process with Direct Input

Scenario 1.2: Wiener Process with two input parameters				
Firm	2009	2010 (1)	2010 (2)	Firm MAPE
(F) Rothaus AG	0.024	0.092	0.030	0.048
(F) Coca Cola DE AG	1.000	1.000	0.608	0.869
(C) Strabag AG	1.000	1.000	1.000	1.000
(C) Eurovia GmbH	1.000	0.592	1.000	0.864
(C) Zueblin AG	0.545	0.096	0.178	0.273
(C) Bilfinger Berger AG	0.281	1.000	1.000	0.760
(T) Datev eG	0.006	0.038	0.227	0.090
(T) Vodafone D2 GmbH	0.378	0.194	0.301	0.291
(T) Microsoft DE GmbH	1.000	1.000	1.000	1.000
(P) ACINO AG	0.754	0.680	0.566	0.667
(P) Biotest Pharma GmbH	0.145	0.369	0.362	0.292
(P) Serumwerk Bernburg AG	1.000	1.000	0.336	0.779
Annual MAPE	0.594	0.588	0.551	0.578

The second scenario is presented in Tables 4 and 5. The cash flow predictive ability test was conducted using time-series of profit and loss statements as input parameters. These values are revenues, other operating expense, purchases, and personnel expenses. They serve as input for the stochastic processes and result in an adjusted cash flow that is subsequently employed for the firm valuation. This approach is adequate because the used figures represent basic and crucial indices of a firm’s performance. Due to an anticipated more uniform set of results, the comparison of different industries becomes more relevant. In order to reflect this higher importance, the result tables show a Branch MAPE. Table 4 presents the results of the test execution for Random Walk. The forecasts of 2009 and 2010(1) indicate a worse result for their annual MAPE than 2010(2). This is a similar observation than in the previous tests. The latest comparison of 2010(2) has only got an average forecast error of 38.4%. Additionally, no company scores over 100% and the majority peaks around 50%. The total deviation from actual values of forecasted CF sums up to 48%. Given the industries, a highly polarized result can be determined. On the lower end, there are food and technology companies performing strongly. On the other hand, there are construction and pharmaceutical companies which are remarkably more volatile. Their results more than double that of the technology industries. In case of the food branch, the results are even four times worse.

Table 4: Test Scenario Random Walk with P&L Input

Scenario 2.1: Random Walk with four input parameters					
Firm	2009	2010 (1)	2010 (2)	Firm MAPE	Branch MAPE
(F) Rothaus AG	0.043	0.024	0.132	0.066	
(F) Coca Cola DE AG	0.347	0.235	0.013	0.199	0.133
(C) Strabag AG	0.843	1.000	1.000	0.948	
(C) Eurovia GmbH	0.479	0.560	0.282	0.440	
(C) Zueblin AG	1.000	1.000	0.278	0.759	
(C) Bilfinger Berger AG	1.000	0.326	0.403	0.576	0.681
(T) Datev eG	0.554	0.766	0.299	0.540	
(T) Vodafone D2 GmbH	0.133	0.149	0.317	0.200	
(T) Microsoft DE GmbH	0.122	0.116	0.124	0.121	0.287
(P) ACINO AG	0.576	0.602	0.289	0.489	
(P) Biotest Pharma GmbH	0.456	1.000	1.000	0.819	
(P) Serumwerk Bernburg AG	0.525	0.825	0.468	0.606	0.638
Annual MAPE	0.507	0.550	0.384	0.480	

Table 5 shows the findings for the last test conducted. As in the previous result panes, the one-year-ahead prediction value of 2010(2) is the best with an average annual MAPE of 21.8%. The gap to 2009 and 2010(1) is around 12 and 6 percentage points, respectively. Across all recorded scores, there is solely one forecasting result that deviates by more than 100% and only one firm average exceeds the threshold of 50%. As a consequence, the total MAPE amounts to 27.5%. The distribution of Branch MAPEs draws a more equally spread picture than in the previous tests. The ratio between the best value (13.7%) and the worst one (39.4%) is only 1:3. Again food and technology industries are the best.

Table 5: Test Scenario Wiener Process with P&L Input

Scenario 2.2: Wiener Process with four input parameters					
Firm	2009	2010 (1)	2010 (2)	Firm MAPE	Branch MAPE
(F) Rothaus AG	0.076	0.057	0.119	0.084	
(F) Coca Cola DE AG	0.323	0.224	0.021	0.189	0.137
(C) Strabag AG	0.335	0.418	0.125	0.293	
(C) Eurovia GmbH	0.220	0.135	0.053	0.136	
(C) Zueblin AG	0.545	0.096	0.178	0.273	
(C) Bilfinger Berger AG	1.000	0.076	0.336	0.471	0.293
(T) Datev eG	0.043	0.015	0.038	0.032	
(T) Vodafone D2 GmbH	0.006	0.519	0.472	0.332	
(T) Microsoft DE GmbH	0.186	0.446	0.297	0.309	0.225
(P) ACINO AG	0.635	0.680	0.568	0.628	
(P) Biotest Pharma GmbH	0.481	0.467	0.219	0.389	
(P) Serumwerk Bernburg AG	0.138	0.162	0.196	0.165	0.394
Annual MAPE	0.333	0.275	0.218	0.275	

4.4 Discussion and Interpretation

The two investigated scenarios result in a common finding. For the Scenario 1 (direct input) only two input parameters were simulated, whereas, Scenario 2 (P&L input) relies on four ones. This advantage in quantity is mirrored in the quality of prediction. The improvement of total MAPE for the Random Walk is -36% (0.749 to 0.48). For the Wiener Process the improvement is even better. The total MAPE went down from 0.578 to 0.275. This is a relative advance of -52%. To conclude, the utilization of four instead of two parameters turns out to vastly enhance CF prediction.

A similar behavior can be observed, when taking the two different stochastic processes into consideration. As depicted in Chapter 3.2., a Wiener Process is the more complex stochastic method and thus more accurate outcomes are expected. In the first scenario, the shift from Random Walk to Wiener Process results in a reduced forecast deviation of -23% (0.749 to 0.578). On the other hand, given the second scenario causes a decrease in the deviation of -43% (0.48 to 0.275). The two stochastic processes compared to each other result in a tremendously better predictive ability of Wiener Process. These findings provide empirical evidence that a more complex stochastic process tied up with a higher number stochastically simulated input parameters results in a more realistic prediction for forecasted business figures.

Discussing the different industries, precise interpretation is hard to draw. Conversely to the scenarios and methods, a common development is not noticeable. Nevertheless it is easy to find the industry with the highest accuracy across all tests. This branch is the food industry with a continuous demand regardless of the economic condition of a society. This is because food and beverages are considered as basic needs. Surprisingly enough, the findings for the technology industry expose a cyclically independent growth as well. Moreover, all result sheets unveil the construction industry as the hardest to predict. This indicates that the construction business is strongly volatile, seasonal, and dependent on the current economic condition as well as on a high public demand. Similar to construction is the development of the pharmaceutical branch. On first sight, the volatility of pharmacy products appears to be confusing because drugs and medicine are basic needs like food as well. However, in economic hardship, consumers can purchase products of lower quality or in fewer quantities. Or they can even stop buying dietary supplements. Moreover, public health insurance companies monitor their spending more precisely and reject more insurant’s claims. This is due to a smaller budget for pharmaceutical products caused by a higher unemployment rate and a subsequent funding gap. From these findings we derive that those two branches are not adequately modellable.

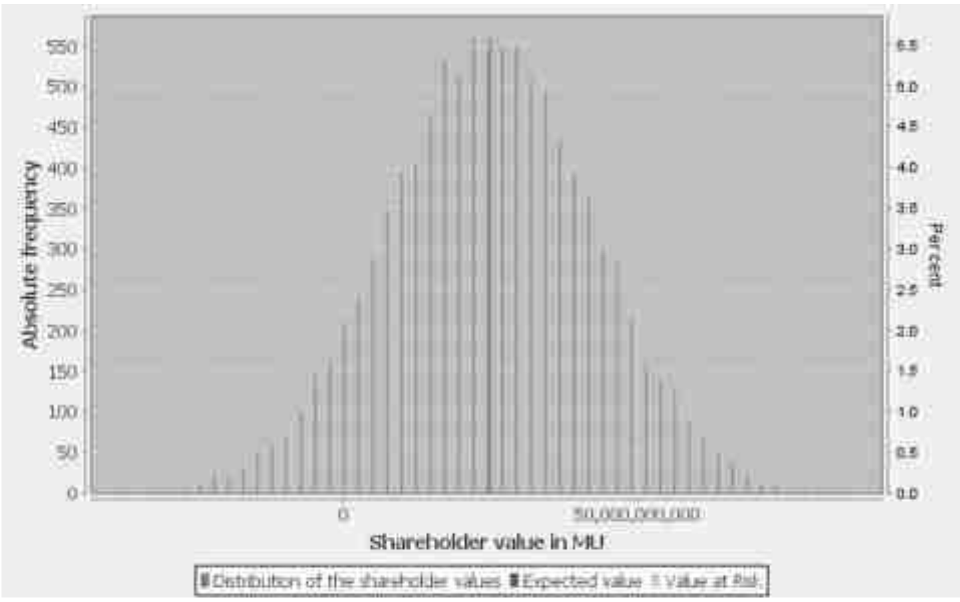
In all test cases the 2010 one-year-ahead prediction has got a higher accuracy compared to the multi-year-ahead predictions. This finding might be explained by the economic downturn and the following double digit growth many companies underwent from 2007 to 2010. This auxiliary condition gave many companies really biased key figures and therefore a distortive impact on the forecast results.

These viable cash flow predictions are utilized as input parameters for a stochastic firm valuation. All the assessed cash flows are expectation values of a probability distribution. Apart from the expectation value, there are 10,000 repetitions of multi-step-ahead forecasted FCFs. Each single FCF time-series is used to run a DCF firm valuation. Therefore, the firm valuation result is not a single value but pools all n firm valuations to a probability distribution. In order to gain a comprehensively probabilistically analyzable distribution, the probability distribution needs to be a Gaussian.

4.5 Normally Distributed Shareholder Values

From the pool of investigated firms, Vodafone DE GmbH is picked to serve as research sample to prove that the results of DCF firm valuation are normally distributed. At first, the visual evidence of a Gaussian distribution is provided for each scenario and method employed above. Figure 1 displays the probability distribution for Scenario 2.2, the firm valuation with a Wiener Process and four stochastically simulated figures. The normal distribution is clearly visible and the concentration of distributed values peaks around the expectation value (thick pillar). This can be regarded as a visual proof for a Gaussian.

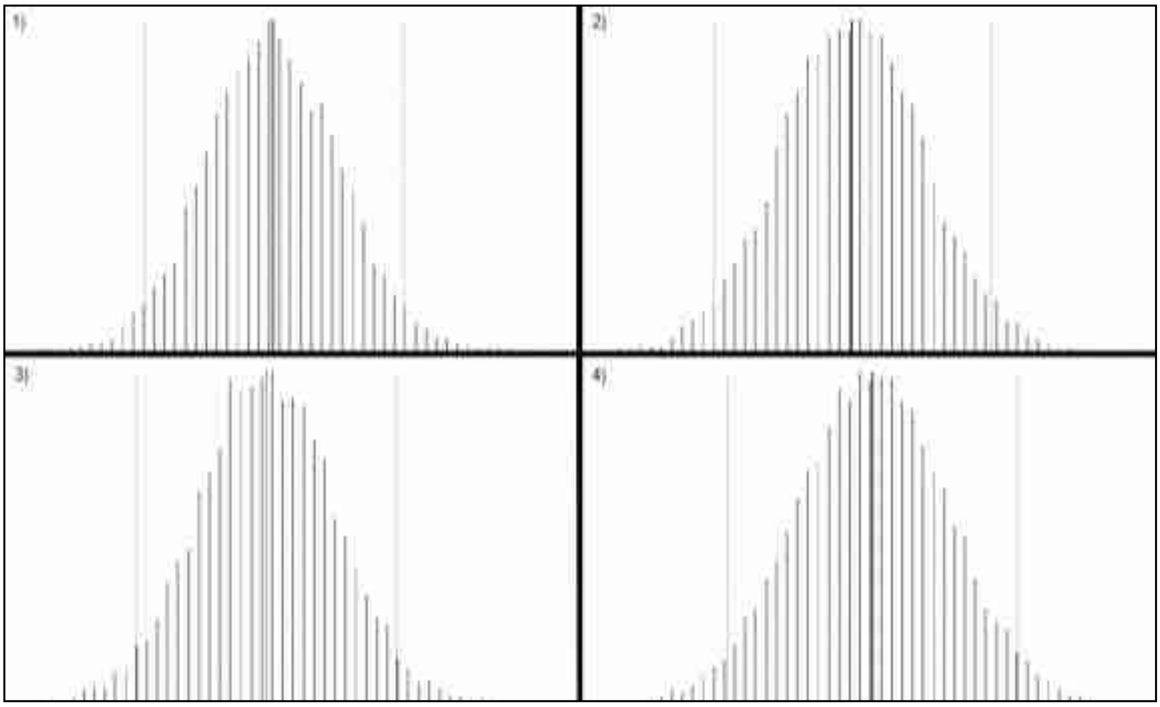
Figure 1: Probability Distribution for Scenario 2.2



As a second step, normal distribution shall be proven for each scenario by a Kolmogorov-Smirnov test conducted in IBM SPSS. This test assumes a significance level sigma of 0.05 as an evidence for normality. Applying Scenario 2.2, null hypothesis is not refused due to sigma level of 0.860 for Wiener Process. Thus, it can be assumed that findings are not in contrast to the hypothesis.

Apart of Scenario 2.2 that scored the best forecasting results, the other test candidates are investigated, too. Figure 3 presents the schematic probability distribution of all four scenarios. It is easy to observe that all the charts follow a normal distribution. Additionally, a slight improvement of accuracy from Scenario 1.1 to Scenario 2.2 is distinguishable.

Figure 2: Gaussian distributed Shareholder Values. 1) Scenario 1.1; 2) Scenario 1.2; 3) Scenario 2.1; 4) Scenario 2.2



Further Kolmogorov-Smirnov tests for the three remaining scenarios behave statistically similar to the findings presented for Scenario 2.2. The null hypothesis is not refused and evidence for the normality is given for significance level of 0.05. For a mathematical derivation of Limit Case Theorem for dependent randomly distributed values and a resulting normality see Pohl (2008).

4.6 Value at Risk Examination

As a result, a normal distribution provides the basis for continuative analysis of valuation, i.e. by using Value at Risk approaches to make a qualified statement of the enterprise value under risk approximations.

Table 6 presents a Value at Risk examination for three sample enterprises using a Wiener Process considering its risk values in correlation to sigma deviation which is defined as $\frac{|Min\ or\ Max - Expected\ \ Value|}{Standard\ \ Deviation}$.

Table 6: Value at Risk in Correlation to Sigma Level (Wiener Process); Apart from the Deviations, All Figures are given in Euro; (F) = Food, (T) = Telecommunication, (C) = Construction, SV = Shareholder Value

Figure		(F) Rothaus AG	(T) Vodafone D2 GmbH	(C) Zueblin AG
Expected Value		236,844,115	32,820,378,281	-3,025,043,732
Standard Deviation		14,822,740	2,998,110,894	3,634,585,342
Value at Risk: 99,99%	Min. SV	183,569,418	21,300,820,122	-16,365,424,840
	σ-Deviation	3.59	3.84	3.67
	Max. SV	297,236,089	44,304,338,193	11,264,852,297
	σ-Deviation	4.07	3.83	3.93
Value at Risk: 50%	Min. SV	227,064,318	30,832,755,837	-5,461,548,868
	σ-Deviation	0.66	0.66	0.67
	Max. SV	246,844,256	34,835,122,249	-617,993,343
	σ-Deviation	0.67	0.67	0.66
Value at Risk: 20%	Min. SV	232,871,258	32,067,490,425	-3,895,134,739
	σ-Deviation	0.27	0.25	0.24
	Max. SV	240,306,151	33,526,734,873	-2,099,625,598
	σ-Deviation	0.23	0.24	0.25

Wiener Process creates for each enterprise an expected firm value with standard deviation. Applying a Value at Risk level of almost 100 %, sigma level oscillates around 3.83 for maximum shareholder value of Vodafone D2 GmbH and 4.07 as the maximum of the brewery Rothaus AG. Increasing the Value at Risk level to 50 %, sigma decreases to a nearly homogenous level of 0.67. Adopting a higher risk level of 20 % reduces total variability range to a half of the standard deviation. This verifies the applicability of valuing a company with stochastic processes and a subsequent Value at Risk examination which necessarily builds on Gaussian distributed shareholder values. Furthermore, this indicates that one-sided Value at Risk examination can be applied, too, by adopting only a lower border.

Table 7 takes a given normally distributed Wiener Process and analyses the percentage deviation of shareholder values for an increasing number of periods measured by the coefficient $\frac{|Min\ or\ Max - Expected\ \ Value|}{Expected\ \ Value}$ using a value at risk approximation of almost 100 %.

Table 7: Analysis of Percentage Deviation for Increasing Periods (Vodafone D2 GmbH); bn = Billion Euro

Periods	Standard Deviation	Expected Value	VaR = 99.999%			
			Min	% - Deviation	Max	% -Deviation
n = 5	2.998bn	32.820bn	21.300bn	35.10%	44.304bn	34.99%
n = 10	1.984bn	32.808bn	25.738bn	21.55%	40.733bn	24.16%
n = 20	1.109bn	32,842bn	27,322bn	16,81%	36,802bn	12,06%

The expected value of the sample enterprise Vodafone D2 GmbH nearly constantly flows around the same value for each number of periods with a measurement inaccuracy of less than 1 %. The more periods ahead are forecasted, the more decrease of percentage deviation is notable. Doubling the number of periods from five to ten results in a 34.8 % smaller range of distributed values. Doubling again diminishes distribution to a percentage deviation level of 12.06% to 16.81%, which is below 50 % of the initial stray area. For this reason, a better approach is to apply a higher number of periods and shifting the application of perpetuity model towards future to compress range of values.

5. Conclusion

The present paper utilizes stochastic processes to predict future Free Cash Flows. Thereby, it provides evidence that a Free Cash Flow forecast with Brownian Motion is appropriately resilient and feasible. This feasibility is practically proven with the application of the MAPE metric. The findings indicate that the more past business figures available the better is the forecasting accuracy. The resulting set of shareholder values calculated according to the APV model is normally distributed. This visually easily reviewable occurrence was proven by a Kolmogorov-Smirnov test and a reliable level of significance. These findings enable us to analyze a shareholder value probabilistically. Therefore, not only the shareholder value’s expectation is known but also the location of the probability mass. Hence the Value at Risk metric is applicable. It excludes impossible peaks or low points of calculated shareholder values of a chosen percentage of the probability mass. In case of a higher number of forecasted CFs, the stray area of the probability mass reduces. This fully analyzable graph is a novel tool to rationally manage an enterprise. So it coincides with the Value Based Management theory and significantly advances its utilization for businesses.

The extent of a possible user group for such a tool is broad. As mentioned in the introductory part, valuing a firm is not only of interest for huge consulting firms. Many chairpersons of small and medium enterprises (SME) are also keen to know about their shareholder value. Therefore Estes and Savich (2011) compared available financial analysis software for SME. Their findings indicate that few software packages offer a shareholder value analysis. Consequently, there is a use case scenario for software that offers the possibility to determine the shareholder value solely based on past figures and common Discounted Cash Flow methods. The approach outlined in this paper is implemented as a software tool called ‘Business Horizon’ that is powerful and sufficiently fast to be adaptable for company executives.

5.1 Further Research

As our approach has been proven valuable according to sample enterprises in Germany, further research includes widening up the spectrum of enterprises by adopting our test approach and findings to different economic situations and countries.

Starting from these research findings, new fields of studies are opened up. A first focus is the further improvement of shareholder value accuracy. One possibility to achieve this could be to abandon the Markov attitude and apply a time series analysis model. Well-known approaches like auto-regression and moving-average models have to be considered to refine forecast reliability referring to a set of past values *t-1* to *t-p.* They are even more important, if they yield a set of normal distributed values. A second opportunity is the examination of forecasted values in the entire industry of a business. For this reason, an economical index for corrective intervention is of interest. This industry specific representative, determined for example by regression analysis, attempts to tie the development of the branch to a single company.

Further Value at Risk calculations are another interesting area of research. In this environment, normal distributions are often used to determine value-driving parameters. This paper theoretically establishes the use of these stochastic processes with a detailed examination. Therefore a variation of e.g. a share price can simply be related to a variation of a business value so that the result is approximately normally distributed. Building upon this, all instruments of Value at Risk calculations are ready-to-use. For further Value at Risk considerations, please refer to Fricke (2006) and Jorion (2007).

Eventually, further research might also include interval approaches based on interval arithmetic operations (see Alefeld and Herberger (1983) for an introduction). The basic operations and methods are already implemented in Business Horizon, aiming at an interactive treatment of uncertainties in cash flows. Enclosing uncertain values within precise bounds using interval techniques brings up the opportunity to supply even more powerful decision support to the management. Here, the approach might be similar to the one described in Hyvönen and Pesonen (1996) for Monte Carlo methods.

Endnotes

[i] This model is based on the Miller-Modigliani enterprise valuation formula, published by Merton Miller and Franco Modigliani in the Journal of Business in 1961.

[ii] https://www.ebundesanzeiger.de; All German companies that are legally obliged (according to the German Commercial Code) to publish their balances, must publish them in the Bundesanzeiger. This comprises all corporations and limited companies starting from a certain size.

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