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Simulation-based Business Valuation

valuing with company specific

Why should we use simulation-based business valuation?

- **Simulation-based business valuation** has been in discussion for some time as an **alternative to the CAPM-based business valuation** (Ernst, 2022; Gleißner and Ernst, 2019).
- The simulation-based business valuation has the advantage of **capturing the company-specific** risk position by means of an **unbiased planning**.
- This makes it possible to derive a company value that reflects the **actual risk situation in the company**.
- The simulation-based company valuation is **especially suitable** for
  - the valuation of medium-sized companies,
  - M&A projects,
  - start-up companies,
  - companies in a crisis situation and
  - for the integration of country-specific risks in the company valuation.

DCF with CAPM has serious weaknesses: alternative valuation concepts are in demand or neccessary

- **The Alternative: Investment theory as foundation of valuation**
  - Principles of (subjective) company valuation: subject reference, future reference principle of overall valuation (cf. Matschke/Brösel (2013)).
- The investment-theoretical valuation conception (readily) uses total-analytical optimization calculi. The investment-theoretical valuation concept is better founded and often clearly superior in terms of purpose adequacy (decision values, e.g. in the case of " "Business decisions" (§93 AktG)
- **But:** the finance-theoretical valuation (**"DCF plus CAPM"**) appears simpler (and therefore more "practicable" to many "valuation practitioners").
  -

Sources: Matschke, M. J./Brösel, G. (2013): Unternehmensbewertung. 4. Aufl., Wiesbaden.

Olbrich, M. (2014): Unternehmungsnachfolge durch Unternehmungsverkauf, 2. Aufl., Wiesbaden.

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Klingelhöfer, H. E. (2009): Investments in EOP technologies and emission trading – Results from a linear programming approach and sensitivity analysis, European Journal of Operational Research, 196. Jg., S. 370–383.

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Toll, Ch. (2018): Zur Bewertung einer Unternehmensspaltung aus Sicht der Anteilseigner des zu spaltenden Unternehmens, ZfbF, 70. Jg., S. 155–204.

Toll, Ch./Kintzel, O. (2019): A Nonlinear State Marginal Price Vector Model for the task of Business Valuation. A Case Study: The Dimensioning of IT-Service Companies under Nonlinear Synergy Effects, Central European Journal of Operations Research, 27. Jg., S. 1079–1105.

The best of both worlds: Semi-investment theory valuation using "imperfect replication" and (μ,R)-principle

Central assumption (base assumption) of the valuation method

- $$E\left(\widetilde{CF}_t^1\right) = E\left(\widetilde{CF}_t^2\right) \; and \; R\left(\widetilde{CF}_t^1\right) = R\left(\widetilde{CF}_t^2\right) \Rightarrow Value\left(\widetilde{CF}_t^1\right) = Value\left(\widetilde{CF}_t^2\right)$$

  Two **cashflows** to the valuation subject (at the same point in time) have the **same value** if they **match** in **expected value** E (or μ) and in the **chosen risk level** R (e.g., R ist standard deviation σ or VaR).

- (μ,R)-valuation functional includes well-known **(μ,σ) axiom** of CAPM as a **special case**.

- The valuation is **not** derived from the **expected utility theory.**

- The valuation is **not** a **heuristic method** as in the built-up models.

- **The Theory is basis for a "Simulation-based Business Valuation"**

Source: Gleißner, W./Wolfrum, M. (2008): Eigenkapitalkosten und die Bewertung nicht börsennotierter Unternehmen: Relevanz von Diversifikationsgrad und Risikomaß, in: FINANZ BETRIEB, 9/2008, S. 602-614. and Gleißner, W. (2011): Risikoanalyse und Replikation für Unternehmensbewertung und wertorientierte Unternehmenssteuerung, in: WiSt, 7 / 11, S. 345 – 352. Dorfleitner / Gleißner (2018), Dorfleitner (2020), Ernst (2022).

Output-oriented view: Replication of the output $E(\widetilde{CF})$ and $R(\widetilde{CF})$

Theory: Valuation of risk-bearing cash flows with the risk-value model: single-period valuation

Project

investment: amount I_0

return: Z

Reference investment

investment: amount $y + z$

risk-free interest rate r_f

high-risk return r_m

$$E(\widetilde{CF}) = E\left(y(1+r_f) + z(1+r_m)\right) = y(1+r_f) + z(1+E(r_m))$$

$$R(\widetilde{CF}) = R\left(y(1+r_f) + z(1+r_m)\right)$$

Two uncertain payments(at the same time)have the same value if they match in expected value and in the chosen risk level.

→ $W(\tilde{Z}) = y + z$ the requested value

Theorem 1

If the risk level R fulfills either the properties PH and TI or PH and PI, then the present value of Ž according to the output-oriented view is given by:

$$Value(\widetilde{CF}_1) = \frac{E(\widetilde{CF}_1) - R\left(\widetilde{CF}_1 - E(\widetilde{CF}_1)\right)\frac{E(r_m) - r_f}{R(r_m - E(r_m))}}{1 + r_f}$$

Market price for one unit of risk

$$\lambda^O := \frac{E(r_m) - r}{R(r_m - E(r_m))}$$

How much additional return per unit of risk would an investment in a stock market portfolio yield compared to a risk-free investment opportunity.

y<0 implies credit taking

A shortfall is excluded, i.e.. $z \geq 0$

The concept of the simulation-based company valuation

- A simulation-based business valuation relies on information about the risks of the company itself, which are determined by means of **risk analysis**.
- Here, a distinction is made between the risks **hedged and non-hedged in the company**. A distinction can also be made between **systematic and unsystematic risks**, as is customary in the CAPM.
- These risks are modelled within the business plan using **suitable distribution functions** and form the basis of an **unbiased business planning**.
- After carrying out a **Monte Carlo simulation**, the risk measures are selected for the aggregated risks within the framework of a risk analysis.
- These risk measures provide the basis for risk processing in a **simulation-based business valuation**.

Advantages of simulation-based valuation over CAPM

- Simulation-based valuation can capture **all perfections and imperfections** of capital markets.
- **Beta** and **Total Beta** are **special cases** that can also be modelled in simulation-based valuation.
- Different degrees of shareholder **diversification** can be taken into account.
- Simulation-based valuation consistently combines **risk management** and **corporate finance**. Data from early risk detection systems can be used optimally.
- Cost of capital includes the **actual risks** in the company. It is not necessary to derive risks from peer groups on capital markets.
- **Market imperfections** such as insolvency risks, country risks, operational risks can be integrated without problems.
- **CAPM-specific problems** such as tax shield, circularity problem, double counting of financing risks in the WACC, etc. do not occur here.
- Risk profiles of relevant **KPIs** can be created.
- Answers in **M&A projects** the questions what risk-adequate value the buyer receives for the price paid.
- Capital costs can be converted into risk-adequate **multiples**.

Advantages and disadvantages of CAPM-based valuation and simulation-based valuation

	CAPM-based Valuation	Simulation-based Valuation
SME-specific risks	X	✓
Insolvency risk	X	✓
Market imperfections	X	✓
Unbiased planning	X	✓
Ease of application	✓	~
Compliance with legal requirements and auditing standards	X	✓

✓ = fulfilled ~ = partially fulfilled X not fulfilled

Figure 2: Advantages and disadvantages of CAPM-based valuation and simulation-based valuation; own source

Process of simulation-based business planning and business valuation

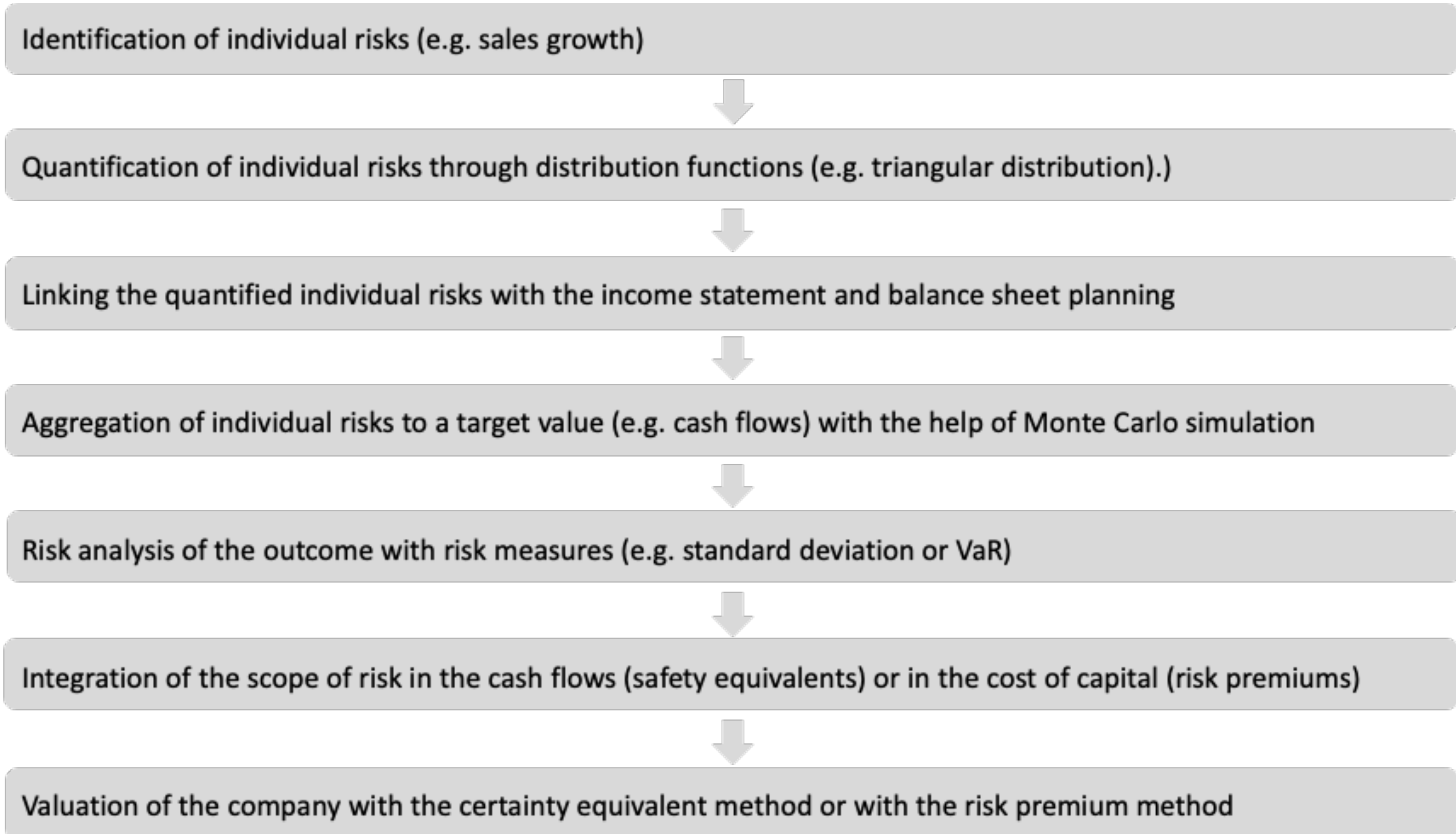


Figure 1: Process of simulation-based business planning and business valuation; own source

Two methods in simulation-based company valuation

- The simulation-based company valuation can now be carried out with
  - the **certainty equivalent method** or
  - the risk **premium method**.
- Valuation with the **certainty equivalent method**

$$Value(\widetilde{CF}_1) = \frac{CE(\widetilde{CF}_1)}{(1+r_f)} = \frac{E(\widetilde{CF}_1) - RD(\widetilde{CF}_1)}{(1+r_f)} = \frac{E(\widetilde{CF}_1) - R(\widetilde{CF}_1) \cdot \lambda \cdot d}{(1+r_f)}$$

  - *CE* = Certainty Equivalent
  - *RD* = Risk discount
  - λ = Price of the risk
  - d = Diversification factor

Two methods in simulation-based company valuation

- Valuation with the **risk premium method**

$$Value(\widetilde{CF}_1) = \frac{E(\widetilde{CF}_1)}{(1+c)} = \frac{E(\widetilde{CF}_1)}{(1+r_f+r_P)} = \frac{E(\widetilde{CF}_1)}{\left(1+r_f+\frac{R(\widetilde{CF}_1)}{Value(\widetilde{CF}_1)}\cdot\lambda\cdot d\right)} = \frac{E(\widetilde{CF}_1)}{\left(1+r_f+R^{norm.}_{(\widetilde{CF}_1)}\cdot\lambda\cdot d\right)}$$

– $R^{norm.}_{(\widetilde{CF}_1)}$ = is the normalised, aggregated total risk (in % of value = $\frac{R(\widetilde{CF}_1)}{Value(\widetilde{CF}_1)}$), i.e. a measure of the return risk (like the standard deviation of the stock return).

Calculation of simulation-based cost of capital

- Using the before mentioned formulas we can derive the cost of capital.

$$c = \frac{1 + r_f}{1 - \frac{R\left(\widetilde{CF}_1\right)}{E\left(\widetilde{CF}_1\right)} \cdot \lambda \cdot d} - 1 = \frac{1 + r_f}{1 - V\left(\widetilde{CF}_1\right) \cdot \lambda \cdot d} - 1 = \frac{r_f + V\left(\widetilde{CF}_1\right) \cdot \lambda \cdot d}{1 - V\left(\widetilde{CF}_1\right) \cdot \lambda \cdot d}$$

  – V = Coefficient of variation

Case study: Simulation-based planning and business valuation

- In the following, we show in a **case study** how the simulation-based business valuation can be applied **in** practice (Ernst, 2022).
- For this purpose, we use the slightly modified business valuation example by Ernst and Häcker (2017), and based on this, carry out the simulation-based business valuation with the risk premium method and the certainty equivalent method.
- As a DCF-method, we use the equity approach, in which the cash flows to equity represent the relevant cash flows, and the cost of equity represents the relevant cost of capital.

Case study: 1. Creation of the distribution functions of the risk parameters for the Monte Carlo simulation

- In step 1, as a result of a risk workshop, the risks that have not been hedged or can be hedged by the company are identified. These are quantified by assigning them a distribution function (Ernst and Wehrspohn 2022). The cells with the green background colour are input cells for the Monte Carlo simulation and contain random numbers from the specified distribution functions.

Risk Assumptions

	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Triangular distribution	Distribution	Distribution	Distribution	Distribution	Distribution	Distribution
Sales growth	2.00%	2.25%	1.72%	2.51%	0.21%	0.96%
Minimum value	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Most likely value	2.00%	2.00%	2.00%	2.00%	1.00%	1.00%
Maximum value	3.00%	3.00%	3.00%	3.00%	2.00%	2.00%
Normal distribution	Distribution	Distribution	Distribution	Distribution	Distribution	Distribution
COGS	0.27%	2.09%	-5.95%	-4.42%	6.15%	6.99%
Expected value	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Standard deviation	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Selling expenses	5.90%	1.93%	0.38%	-2.46%	-2.83%	-5.71%
Expected value	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Standard deviation	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
General administration expenses	3.13%	-0.27%	-2.29%	-0.06%	-1.07%	-3.21%
Expected value	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Standard deviation	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%

Figure 3: Creation of the distribution functions of the risk parameters for the Monte Carlo simulation; Ernst, 2022.

Case study: 1. Creation of the distribution functions of the risk parameters for the Monte Carlo simulation (cont.)

Risk Assumptions

	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Uniform distribution	Distribution	Distribution	Distribution	Distribution	Distribution	Distribution
Other operating expenses						
Small defaults	76.74%	80.07%	25.20%	60.53%	24.55%	93.64%
Probability of occurence (minimum)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Probability of occurence (maximum)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Likelihood of damage	30.00%	30.00%	30.00%	30.00%	30.00%	30.00%
Amount of damages in % of sales	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Expected amount of damages in % of sales	0.00%	0.00%	0.50%	0.00%	0.50%	0.00%
Medium defaults	83.34%	91.77%	21.75%	85.43%	89.05%	4.11%
Probability of occurence (minimum)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Probability of occurence (maximum)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Likelihood of damage	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Amount of damages in % of sales	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Expected amount of damages in % of sales	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%
Large defaults	75.80%	0.78%	14.83%	85.21%	30.92%	60.91%
Probability of occurence (minimum)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Probability of occurence (maximum)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Likelihood of damage	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Amount of damages in % of sales	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Expected amount of damages in % of sales	0.00%	5.00%	0.00%	0.00%	0.00%	0.00%
Loss of key accounts	16.23%	81.05%	71.39%	50.73%	93.28%	66.49%
Probability of occurence (minimum)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Probability of occurence (maximum)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Likelihood of damage	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Amount of damages in % of sales	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%
Expected amount of damages in % of sales	20.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Figure 4: Creation of the distribution functions of the risk parameters for the Monte Carlo simulation; Ernst, 2022.

Case study: 2. Integration of the risk parameters into the planning of the income statement and the balance sheet

- In the second step, the Monte Carlo parameters are built into the income statement and balance sheet planning. This results in unbiased planning.

€ million	Actual t_{-2}	Actual t_{-1}	Actual t_0	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Total sales (random)				39,625	40,493	41,149	41,882	42,184	42,702
Total sales (plan)	34,943	35,015	39,586	40,378	41,185	42,009	42,849	43,278	43,710
Total sales (risk)				−753	−692	−860	−967	−1094	−1008
− COGS (random)				14,211	12,818	15,013	14,825	14,611	16,446
− COGS (plan)	11,756	11,382	17,010	14,687	14,980	15,280	15,586	15,741	15,899
− COGS (risk)				476	2,162	267	761	1,130	−547
Gross profit on sales (random)	23,187	23,633	22,576	25,414	27,675	26,136	27,057	27,573	26,256
− Selling expenses (random)				13,005	12,672	13,479	13,894	13,128	12,921
− Selling expenses (plan)	11,148	11,116	12,751	12,902	13,160	13,423	13,692	13,829	13,967
− Selling expenses (risk)				−103	488	−56	−202	701	1,046
− Research and development expenses	4,405	4,504	5,246	5,212	5,316	5,422	5,531	5,586	5,642
− General administration expenses (random)				2,369	2,399	2,416	2,459	2,462	2,509
− General administration expenses (plan)	1,804	2,026	2,728	2,401	2,449	2,498	2,548	2,574	2,599
− General administration expenses (risk)				32	50	82	89	112	90
+ Other operating income	787	864	5,057	2,355	2,402	2,450	2,499	2,524	2,549
− Other operating expenses (random)				1,689	1,726	1,754	1,785	1,798	1,820
− Other operating expenses (plan)	879	948	2,994	1,721	1,755	1,790	1,826	1,845	1,863
− Other operating expenses (risk)				32	29	36	41	47	43
Operating result (EBIT) (random)				5,494	7,964	5,515	5,887	7,123	5,913
Operating result (EBIT) (plan)	5,738	5,903	3,914	5,810	5,926	6,045	6,166	6,227	6,289
Operating result (EBIT) (risk)				−315	2,038	−530	−279	896	−376

Figure 5: Integration of the risk parameters into the planning of the income statement and the balance sheet; Ernst, 2022.

Case study: 3. Calculation of the probability of insolvency probability

- In step 3, the insolvency risk is linked to the planning model and the insolvency probability is calculated via a heuristic function using the equity ratio and the return on equity employed (ROCE). The cells with the yellow background are output cells of the Monte Carlo simulation.

Insolvency Risk	t_1	t_2	t_3	t_4	t_5	TV
Insolvency likelihood	1.42%	1.35%	1.38%	1.14%	1.23%	1.20%
Likelihood of survival	98.58%	98.65%	98.62%	98.86%	98.77%	98.80%
Equity ratio	38.22%	38.40%	38.59%	39.54%	39.84%	40.33%
Return on capital employed (ROCE)	4.16%	4.50%	4.12%	5.34%	4.39%	4.31%

Figure 6: Calculation of the probability of insolvency probability; Ernst, 2022.

Case study: 4. Calculation of cash flows to equity as a target values of the Monte Carlo simulation

- In step 4, the cash flows to equity are calculated as the target values of the Monte Carlo. The result of the Monte Carlo simulation is a frequency distribution of the cash flow to equity (which is the basis for the following risk analysis.

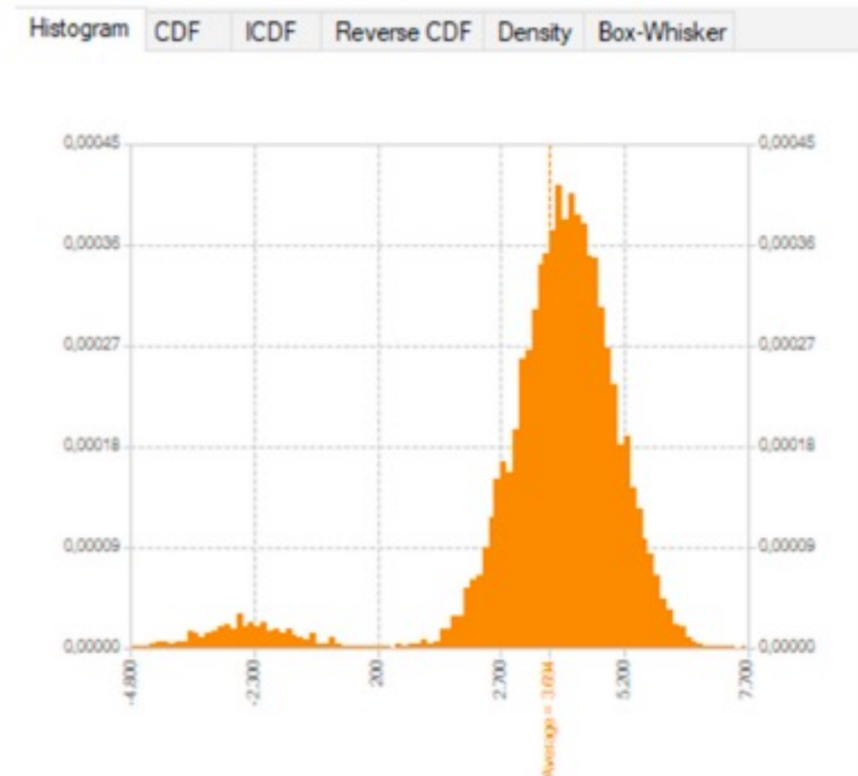
Cash flow to Equity

€ million	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Operating result (EBIT) (random)	5.522	5.359	5.505	5.548	4.622	4.750
– Financial expenses	978	986	1.016	1.036	1.052	1.062
Earnings before taxes (EBT)	**4.544**	**4.372**	**4.490**	**4.512**	**3.570**	**3.688**
– Income taxes	1.190	1.145	1.176	1.182	935	966
– Change in deferred taxes (asset side), deferred taxes (liabilities side), and income tax liabilities	0	0	0	0	0	0
Earnings after taxes	**3.354**	**3.227**	**3.314**	**3.331**	**2.635**	**2.722**
+ Depreciation and amortization	2.908	2.920	2.932	2.945	2.950	2.954
+ Change in other provisions	0	0	0	0	70	71
– Capital expenditures	3.296	3.320	3.344	3.370	3.095	3.101
– Change in net working capital	−1449	726	272	222	236	559
+ Change in Provisions for pensions and other post–employment benefits	523	370	192	196	100	101
+ Change in Refund liabilities (noncurrent)	−167	0	0	0	0	0
+ Change in Contract liabilities (noncurrent)	−986	0	0	0	0	0
+ Change in Noncurrent financial liabilities	6.034	1.750	910	928	473	478
+ Change in Financing gap	0	0	0	0	0	0
+ Change in Refund liabilities (current)	−3622	0	0	0	0	0
+ Change in Contract liabilities (current)	−3235	0	0	0	0	0
+ Change in Current financial liabilities	221	156	81	83	42	43
Cash flow to Equity (random)	**3.183**	**4.377**	**3.813**	**3.892**	**2.939**	**2.709**
Cash Flow to Equity from CF statement (random)	**3.183**	**4.377**	**3.813**	**3.892**	**2.939**	**2.709**
Check	OK	OK	OK	OK	OK	OK
Cash Flow to Equity (expected)	**3.026**	**4.589**	**3.659**	**3.716**	**3.683**	**3.694**

Figure 7: Calculation of cash flows to equity as a target values of the Monte Carlo simulation; Ernst, 2022.

Case study: 4. Calculation of cash flows to equity as a target values of the Monte Carlo simulation (cont.)

- The tail risks in the frequency distribution are striking. They show that the combined occurrence of risks can threaten the existence of the company. These tail risks would be overlooked in the absence of simulation-based planning.



Options | Statistics

	'[Company Valuation on Imperfect Capital Markets_(2).xlsx] CF Calculation with Insol. Risk'!K104
Average	3.694
Standard Deviation	1.728
Variance	2.985.606
Skewness	0
Kurtosis	3.051
Coefficient of Variation	0
Range	12.477
Range5_95	6.332
Minimum	-4.784
Expected Tail <= 0,1%	-4.521
0.01% - Quantile	-4.784
0.02% - Quantile	-4.740
0.03% - Quantile	-4.580

Figure 8: Calculation of cash flows to equity as a target values of the Monte Carlo simulation (cont.); Ernst, 2022.

Case study: 5. Risk analysis of the cash flows to equity

- In step 5, the cash flow to equity risk analysis is carried out. The risk measures, standard deviation, and coefficient of variation are calculated. The further calculations refer to the standard deviation for the certainty equivalent method and the coefficient of variation for the risk premium method.

Risk Parameters

	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Standard Deviation	969	1,632	1,614	1,661	1,641	1,728
Coefficient of Variation	0.32	0.36	0.44	0.45	0.45	0.47
Control	0.32	0.36	0.44	0.45	0.45	0.47

Figure 9: Risk analysis of the cash flows to equity; Ernst, 2022.

Case study: 6. Pricing of the risk

- In step 6, the risk parameter - in our case the standard deviation - is adequately priced in order to determine risk-adjusted cash flows for the certainty equivalent method. In addition to the risk parameter itself, this requires the market price of the risk and the diversification factor. The parameter lambda λ describes the "market price of the risk" and expresses the risk aversion. The lambda is calculated by setting the market risk premium in relation to one unit of market risk. The diversification factor d depends on the investor's diversification factor. In order to be able to take into account the entire risk scope of the company, the diversification factor is set at the value of one; however, the diversification factor can be adjusted individually.

Price of the Risk for the Risk Parameter Standard Deviation

	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Standard deviation	969	1632	1614	1661	1641	1728
Lambda	26.55%	26.55%	26.55%	26.55%	26.55%	26.55%
Diversification factor (d)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Price of the risk	**257**	**433**	**429**	**441**	**436**	**459**

Risk-free rate of return	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%
Expected return of the market	6.01%	6.01%	6.01%	6.01%	6.01%	6.01%
Market risk premium	5.31%	5.31%	5.31%	5.31%	5.31%	5.31%
Standard deviation of the market return	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%
Lambda	**26.55%**	**26.55%**	**26.55%**	**26.55%**	**26.55%**	**26.55%**

Figure 10: Pricing of the risk; Ernst, 2022.

Case study: 7. Derivation of the cost of equity for the risk premium method

- In step 7, the cost of capital for the risk premium method is derived from the certainty equivalents according to above shown equations. For the risk premium method, the risk is expressed in the cost of capital, in this case the cost of equity. The risk itself is the result of a risk analysis of the company, for which the coefficient of variation is calculated as the risk parameter. Figure 9 shows the cost of equity derived with the help of the coefficient of variation, the market price of the risk (lambda), and the diversification factor.

Cost of equity

	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Risk-free rate of return	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%
Coefficient of variation	32.02%	35.57%	44.10%	44.69%	44.56%	46.78%
Lambda	26.55%	26.55%	26.55%	26.55%	26.55%	26.55%
Diversification factor	100%	100%	100%	100%	100%	100%
Cost of equity (levered)	**10.06%**	**11.20%**	**14.05%**	**14.26%**	**14.21%**	**14.98%**

Figure 11: Derivation of the cost of equity for the risk premium method; Ernst, 2022.

Case study: 8. Calculation of the risk-adjusted cash flow to equity for the certainty equivalent method

- In step 8, the calculation of the risk-adjusted cash flow to equity for the certainty equivalent method, according to Equation (1), takes place. For the certainty equivalent method, the risk is calculated at the level of the cash flows. Following figure shows the riskadjusted cash flows to equity underlying the valuation, which are also referred to as certainty equivalents.

Certainty Equivalent = Risk adjusted Cash flow to Equity (CFtE)

	Plan t_1	Plan t_2	Plan t_3	Plan t_4	Plan t_5	Plan TV
Unbiased CFtE with insolvency likelihood	3,026	4,589	3,659	3,716	3,683	3,694
Standard deviation	969	1,632	1,614	1,661	1,641	1,728
Lambda	27%	27%	27%	27%	27%	27%
Diversification factor	100%	100%	100%	100%	100%	100%
Risk adjusted CFtE = Certainty equivalent	**2,769**	**4,156**	**3,230**	**3,275**	**3,247**	**3,235**

Figure 12: Calculation of the risk-adjusted cash flow to equity for the certainty equivalent method; Ernst, 2022.

Case study: 9. Calculation of the company value with the risk premium method

- In step 9, the company value can be calculated retrogradely for the risk premium method starting from the terminal value. The formulas derived above for the terminal value and the period-specific company value are used.

Equity Aproach for Standard Deviation as Risk Parameter

Risk Premium Approach

	Plan t_1 = 31.12.t0	Plan t_2 = 31.12.t1	Plan t_3 = 31.12.t2	Plan t_4 = 31.12.t3	Plan t_5 = 31.12.t4	Plan TV
Cost of equity (levered)	10.06%	11.20%	14.05%	14.26%	14.21%	14.98%
Cash Flow to Equity - CFtE (t+1)	3,026	4,589	3,659	3,716	3,683	3,694
Terminal Value						24,451
Equity value (operating)	26,897	26,576	24,963	24,831	24,634	
Equity value and TV (operating)	26,897	26,576	24,963	24,831	24,634	24,451
Equity value (operating)	26,897					
+ non-operating assets	-					
Equity Value	26,897					

Figure 13: Calculation of the company value with the risk premium method; Ernst, 2022.

Case study: 10. Calculation of the company value with the certainty equivalent method

- In step 10, the simulation-based business valuation for the certainty equivalent method is carried out. Again, the formulas above are used. It can be seen from the figures that the certainty equivalent method and the risk premium method lead to identical company values.

Equity Aproach for Standard Deviation as Risk Parameter

Certainty Equivalent Approach

	Plan t_1 = 31.12.t0	Plan t_2 = 31.12.t1	Plan t_3 = 31.12.t2	Plan t_4 = 31.12.t3	Plan t_5 = 31.12.t4	Plan TV
Risk-free rate of return	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%
Risk adjusted Cash Flow to Equity - CFtE after Risk (t+1)	2,769	4,156	3,230	3,275	3,247	3,235
Terminal Value (TV)						24,451
Equity value (operating)	26,897	26,576	24,963	24,831	24,634	
Equity value and TV (operating)	26,897	26,576	24,963	24,831	24,634	24,451

Equity value (operating)	26,897.00
+ non-operating assets	-
Equity Value	**26,897**

Figure 14: Calculation of the company value with the certainty equivalent method; Ernst, 2022.

Conclusion

- Simulation-based business planning makes it possible to model imperfections in capital markets in the business valuation.
- This is done by means of unbiased planning that integrates the risks that are not hedged in the company into the business plan.
- Through a Monte Carlo simulation, the risks are aggregated to a target value (e.g., the cash flow).
- The frequency distribution of the cash flows serves as the basis for the company's risk analysis.
- From this risk analysis, statements can be derived from risk ratios, the rating, the probability of insolvency, and the cost of capital.
- The approach presented in this article makes it possible to supplement the CAPM based DCF valuation with a DCF valuation that calculates risks not from the capital market, but from the risk potential that is actually present in the company.
- The approach presented here makes it possible for valuation experts to transfer their valuation know-how to simulation-based business valuations, without having to overcome too many methodological hurdles.
- This is central for acceptance and application in valuation practice.

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Thank you very much for your attention

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