



Department of Economics

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ABSTRACT

of a dissertation for awarding of the educational and scientific degree of “Doctor”

CHALLENGES IN ASSESSING THE FAIR VALUE OF PUBLIC COMPANIES AND ENHANCING ITS REASONABLENESS

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The dissertation comprises a total of 231 pages and consists of a title page, table of contents, list of abbreviations, list of tables, list of figures, introduction, three chapters, conclusion, and references. It contains 54 tables and 22 figures. The bibliography includes 91 academic sources and research articles. In addition, 24 internet sources, 21 regulatory documents, and 15 other sources have been used, including statistical and financial data on the analysed companies, financial statements, and aggregated industry-level data.

The PhD Student is enrolled in an independent doctoral programme in “Finance, Monetary Circulation, Credits and Insurance” at the Department of Economics of New Bulgarian University.

The dissertation has been reviewed and approved for defence in accordance with the Law on the Development of the Academic Staff by the Department of Economics at New Bulgarian University at a council meeting held on April 14, 2026.

The defense of the dissertation will take place in an open meeting of the scientific jury on date at hour in the Meeting Hall of the New Bulgarian University. The defense materials are available at the Department of Economics at New Bulgarian University and <https://economics.nbu.bg/bg/doktoranti>.

I. GENERAL CHARACTERISTICS OF THE DISERTATION WORK

1. Relevance of the research

In the context of an increasingly globalised economy and dynamic capital markets, the issue of fair value measurement of public companies is gaining growing importance for investors, regulators, analysts, and corporate management alike. The concept of fair value continues to generate both academic and practical debate regarding its theoretical foundations, methodological application, and regulatory framework. A key driver of this debate is the changing nature of regulated trading markets in recent years, primarily reflected in the structural shift in the profile of publicly traded companies.

Increasingly, companies at an early stage of their life cycle are being listed on stock exchanges. For such companies, determining future economic performance is particularly challenging, as their cash flows are often negative in the initial stages of development, while market expectations tend to be overly optimistic. Stock exchanges actively facilitate the listing of such companies by creating specialised segments that ease initial public offerings and trading. At the same time, there is a noticeable trend towards lowering listing requirements, including those related to the volume and quality of publicly available information. This forces investors to make decisions under significant information asymmetry, which makes fair value measurement particularly challenging.

Contemporary research and market evidence indicate that traditional valuation models fail to adequately capture this new reality. An analysis from 2023 reports that the average annual deviation of market prices from analysts' target prices amounts to approximately 39%, while the performance of automated valuation models based on the discounted cash flow (DCF) method is even less satisfactory (Andreeva, 2023). Some platforms even generate negative valuations for companies with negative cash flows, resulting in outcomes that lack economic justification. Furthermore, for early-stage companies, appropriate market comparables are often unavailable, which limits the applicability of the market approach. This makes the income approach, and in particular the discounted cash flow (DCF) method, the most logical choice, but also the most vulnerable to uncertainty in the underlying assumptions.

These considerations call into question the reliability of traditional valuation models for public companies and motivate the choice of the dissertation topic. The main research question is

how to enhance the reasonableness of valuations based on DCF models when the input data are uncertain and highly sensitive to underlying assumptions.

The issue of fair value is not only methodological but also regulatory. With the development of international accounting standards and the convergence between IFRS and US GAAP, the concept of fair value has assumed a central role in corporate reporting and financial markets. However, fair value accounting presupposes the existence of reliable estimates based on economically realistic models. In the absence of such conditions, reported values may be misleading, as became particularly evident during the financial crisis of 2008, when some critics identified fair value accounting as a factor contributing to the amplification of market volatility.

This places the methodological robustness of valuations at the centre of both academic and professional debate. The work of Damodaran (2009, 2018) addresses the valuation of companies that are considered “difficult to value” and provides practical guidance for valuing young, start-up, and high-growth firms, as well as companies in financial distress. Nevertheless, even these approaches do not eliminate the uncertainty of input data, which remains a key determinant of the reliability of DCF-based valuations.

This dissertation explores the possibility of integrating Monte Carlo simulations into the discounted cash flow method. This approach allows fixed assumptions to be replaced with probability distributions that reflect the inherent uncertainty in market expectations. Although simulation methods are well established in the financial literature (Baroni et al., 2006; Samis & Davis, 2014), there remains a lack of a clearly defined and consistent methodology that systematically outlines the steps involved in developing a simulation-based valuation model.

2. Object and subject of the dissertation research

The object of the study comprises publicly traded companies for which traditional valuation models fail to provide reliable results due to the high degree of uncertainty and the limited availability of information. The research focuses on two companies – Rivian Automotive Inc. and Vera Therapeutics Inc. – selected with the aim of covering different industries and types of valuation challenges, and of demonstrating the broader applicability of the proposed methodology.

The subject of the research is the integration of Monte Carlo simulations into the application of the discounted cash flow (DCF) method for the purpose of fair value estimation, with the aim of enhancing the reasonableness and transparency of the results.

3. Purpose and Objectives of the Dissertation

The main **purpose** of the research is to develop a methodology for the valuation of public companies that builds upon the classical principles of the discounted cash flow (DCF) method, while extending them through the quantitative modelling of uncertainty.

In order to achieve this purpose, the following research objectives have been formulated:

1. To systematise the theoretical understandings of the concept of “fair value” and to analyse the main economic theories of value – classical, neoclassical, and contemporary critiques of marginalism.
2. To trace the incorporation of the fair value concept from financial theory into accounting standards and to examine the degree of harmonisation between international and US standards.
3. To analyse the fundamental differences between international, European, and US valuation standards and to outline the need for their convergence.
4. To compare traditional company valuation models based on the discounted cash flow method and to identify their limitations.
5. To identify the main problems and challenges in the practical application of established models for determining fair value.
6. To develop and test a methodology for integrating Monte Carlo simulations into valuation based on the discounted cash flow method.
7. To apply the proposed methodology to real publicly traded companies and to analyse the empirical results obtained.

4. Research Thesis

The dissertation advances the thesis that integrating Monte Carlo simulations into the discounted cash flow (DCF) method significantly enhances the reasonableness of fair value estimates of public companies. This is achieved through the incorporation of probability distributions and correlation relationships between key input variables, which enables the measurement and analysis of risk arising from uncertainty in the underlying assumptions. As a

result, the output is not a single fixed value, but a range of possible values, reflecting the inherent economic uncertainty and making the valuation more reliable and analytically useful.

5. Research Methods and Approaches

The study applies a systemic, historical, structural, and normative approach. These are combined with methods of observation, comparative and dynamic analysis, SWOT analysis, and simulation modelling. On this basis, quantitative techniques are integrated into traditional valuation models, enabling a more in-depth understanding of the behaviour of uncertainty within the DCF framework.

The dissertation draws on an up-to-date regulatory framework and empirical data on publicly traded companies and industries at the time the research was conducted. Particular emphasis is placed on modelling uncertainty using **Oracle® Crystal Ball Decision Optimizer** software, through which probability distributions, confidence intervals, and sensitivity analyses of the results are generated.

6. Limitations of the Dissertation

The limitations of the study arise from the relatively small number of companies analysed, which is driven by the complexity of the applied methodology and the requirement for a high degree of precision in the input data. Nevertheless, the results obtained are indicative of the effectiveness of the simulation-based approach in fair value estimation under conditions of uncertainty.

The study is limited to US publicly traded companies listed on Nasdaq. This geographical limitation is justified by the high liquidity of the US capital market and the wide availability of reliable financial and sectoral information, which provides a solid empirical basis for analysis. In addition, when developing and testing a new valuation methodology, it is appropriate to apply it within a market characterised by a high degree of efficiency and transparency, such as the US market, as this allows for a more objective assessment of its applicability.

For Rivian Automotive, financial data covering a three-year historical period (2022–2024) have been analysed, while for Vera Therapeutics a five-year period (2018–2024) has been considered. This reflects the limitations arising from the relatively short market history of the companies and the lack of representativeness of earlier data.

From a methodological perspective, the study is based on the income approach and the discounted cash flow (DCF) method, which provides the most suitable conceptual framework for integrating Monte Carlo simulations. The market and cost approaches are not the focus of the analysis, as they rely primarily on current market prices or accounting measures, which do not allow for a sufficiently flexible and in-depth examination of the impact of risk and probabilistic scenarios on company valuation.

Additional limitations arise from the configuration of the analytical software used, which allows for a limited number of probability distributions. These limitations define the scope of applicability without compromising the validity of the conclusions.

These limitations outline directions for future research, which may include:

- expanding the empirical base by including a larger number of companies from different industries and stages of development;
- applying more advanced software solutions and simulation techniques;
- examining the replicability and the impact of key variables, such as the beta coefficient and profit margins, on the dispersion of results;
- analysing the applicability of simulation-based DCF models to non-public companies, as well as in accounting and auditing practice.

7. Practical Significance of the Research

The proposed methodology has significant practical value, as it provides a framework for conducting more reasonable and analytically robust fair value estimates under conditions of uncertainty and limited data. It can be applied in:

- investment analysis by individual and institutional investors;
- mergers and acquisitions transactions;
- valuations for financial reporting purposes, including impairment testing;
- risk management and stress testing of corporate models.

II. STRUCTURE AND CONTENTS OF THE DISSERTATION WORK

The dissertation comprises a total of 231 pages and consists of a title page, table of contents, list of abbreviations, list of tables, list of figures, introduction, three chapters, conclusion, and references. It contains 54 tables and 22 figures. The bibliography includes 91 academic sources

and research articles. In addition, 24 internet sources, 21 regulatory documents, and 15 other sources have been used, including statistical and financial data on the analysed companies, financial statements, and aggregated industry-level data. The dissertation is structured in line with the research aim and specific objectives as follows:

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CONCLUSION

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III. BRIEF SUMMARY OF THE DISCARTATION

INTRODUCTION

The introduction presents the topic of the dissertation, its significance, and its relevance in the valuation of public companies. It introduces the research thesis and sets out the aims of the dissertation, which are pursued through the analysis of the defined object and subject of the study. The research methods and the associated limitations are also outlined.

CHAPTER I. THEORETICAL AND METHODOLOGICAL ASPECTS OF FAIR VALUE MEASUREMENT AND ANALYSIS OF COMPANIES

Chapter One presents the theoretical and methodological foundations of fair value. It examines the evolution of economic theories of value, the incorporation of the fair value concept into accounting standards, and its relationship with valuation standards.

The first part of the chapter reviews the main economic theories of value. In the historical development of economic thought, different interpretations of value can be distinguished, among which the classical labour theory of value and the neoclassical theory of value, based on the marginalist approach, occupy a central position (Schumpeter, 1954; Blaug, 1997). In more recent literature, critical perspectives have emerged that challenge key assumptions of the neoclassical paradigm and propose alternative frameworks for analysing value (Anderson, 2012; Dixit and Pindyck, 1994; Dempsey, 2013; Grabowski, 2009; Ernst and Gleißner, 2022). These three strands reflect broader philosophical, social, and economic developments and seek to explain the nature of value, its origins, and its measurement. The study and analysis of economic theories provide clarity on the evolution of the concept and its interpretation in light of the factors that have shaped it within specific historical contexts. This contributes to distinguishing between “value” and “price” and to understanding their role in the contemporary economic environment.

The development of the classical labour theory of value is examined as the starting point for the systematic study of value in economic theory. This theory, associated with the works of Smith ([1776] 1983) and Ricardo (1817), considers labour as the primary source and measure of value. Particular attention is paid to the concepts introduced by Smith ([1776] 1983) and their subsequent interpretations. A distinction is made between two main types of value: use value, related to the utility of a given good, and exchange value, which reflects its capacity to be traded for other goods. The notion of the “real price”, introduced by Smith and linked to the labour and effort required to

acquire a good, is also discussed, distinguishing it from value measured by the quantity of labour that the good can command. The issue of measuring value is addressed, emphasising the role of labour as a universal measure and source of value.

Ricardo (1817) further develops the labour theory by focusing on the relative values of goods and the role of labour embodied in their production, including labour embedded in capital and raw materials. His main contributions to the labour theory of value are presented, along with his critique of Smith's interpretations. Ricardo extends the theory by emphasising relative prices and the contribution of labour to production across different inputs.

Despite its importance for the development of economic thought, the labour theory of value has several limitations. It does not fully explain discrepancies between labour inputs and market prices, nor does it adequately account for the role of subjective consumer preferences. These limitations laid the foundations for the marginalist revolution of the nineteenth century and the emergence of the neoclassical theory of value. The neoclassical approach shifts the focus from production, labour, and costs as primary determinants of value towards individual preferences, marginal utility, and the equilibrium between supply and demand. Neoclassical economists place the individual at the centre of their analysis, viewing utility maximisation as a key driver of price formation and resource allocation. This part of the analysis examines the contributions of Jevons (1871), Menger (1871), Walras (1874), and Marshall (1890) to the development of the marginalist approach and the subjective interpretation of value. A key feature of the neoclassical framework is that it does not clearly distinguish between value and price, assuming that market price reflects the value of an asset.

Building on neoclassical principles, the theory of investment value, formulated by Williams (1938), emerges. It defines the value of financial assets as the present value of expected future cash flows. This concept forms the basis of modern valuation models for investments and assets, including the discounted cash flow (DCF) method and the net present value (NPV) rule. These ideas later contribute significantly to the development of modern portfolio theory and the capital asset pricing model (CAPM).

Despite their widespread application, neoclassical models have been subject to considerable criticism, particularly regarding their idealised assumptions, such as rational economic agents, perfect markets, and complete and freely available information. In real-world economic

environments, these conditions are rarely met, which necessitates the extension of traditional models with new approaches. Contemporary research proposes incorporating factors such as behavioural characteristics of economic agents, institutional frameworks, and financial market uncertainty. In this context, new valuation methods are being developed, including simulation-based approaches such as Monte Carlo simulations for modelling risk and uncertainty in company valuation.

Despite the growing criticism of neoclassical theory, the analysis shows that no alternative theoretical framework has emerged to replace the established neoclassical paradigm, which continues to hold a dominant position in economic theory, practice, and education. One reason for this is that neoclassical models offer a simplified and analytically convenient representation of economic processes, whereas attempts to incorporate factors such as uncertainty, behavioural characteristics, and firm-specific features lead to significantly more complex models and difficulties in empirical validation. Despite these limitations, exploring ways to further develop and extend existing models remains an important research task. The table below presents a comparative analysis of selected key aspects of classical and neoclassical theory, as well as a modern perspective on what the concept of value should encompass.

Comparative Analysis of Theories of Value (Table 1 of the Dissertation)

Aspects	Classical Theory of Value	Neoclassical Theory of Value	Modern Conceptualisation of Value
Main Idea	Value is determined by the labour required to produce a given good.	Value is based on consumers' subjective preferences and is determined by supply and demand in the market.	Value incorporates behavioural, sustainability, and systemic factors, recognising that traditional models rely on unrealistic assumptions.
Key Factors	Quantity of labour used in production.	Marginal utility, scarcity, and market equilibrium.	Sustainability, behavioural biases, intangible assets, societal trends, and systemic risks.
Assumptions	Assumes that labour alone explains value, disregarding other factors relevant to business valuation.	Assumes publicly available information, rational agents, and perfect markets, which limits its applicability in the real world.	Employs more realistic assumptions, taking into account market inefficiencies and social, environmental, and behavioural dynamics.
Applicability in Business Valuation	Not applicable to business valuation. Does not provide valid valuation models. Ignores the time value of money. Cannot be applied to the valuation of intangible assets.	Useful for traditional financial modelling, but struggles to address new business challenges and dynamic market trends.	Provides a multidimensional framework incorporating financial, social, environmental, and psychological factors.
Examples in Practice	Not applied in business valuation	Financial valuation models such as CAPM, discounted cash flow (DCF) models, market-based models, and others.	Valuation models based on ESG ratings, behavioural models, and Monte Carlo simulations.
Criticism	Does not account for subjective preferences	Based on unrealistic assumptions and fails to capture the complexity of markets.	The complexity and subjectivity involved in incorporating behavioural and sustainability factors may make valuation an excessively complex process.

Source: The autor

The next part of the chapter examines the incorporation of the fair value concept into accounting standards. Historically, accounting has been based on the historical cost principle, under which assets are measured at their acquisition cost. However, with the development of financial markets and the increasing diversity of financial instruments, this approach has come to be regarded as insufficient for reflecting economic reality. As a result, the concept of fair value has gradually gained prominence, based on current market valuations of assets and liabilities. The idea of fair value developed progressively in US practice, particularly following the 1929 crisis,

which led to the establishment of the institutional foundations of modern accounting regulation. Subsequently, the Financial Accounting Standards Board (FASB) systematised the approach through standards aimed at enhancing comparability and transparency in valuation, which was later reflected in International Financial Reporting Standard (IFRS) 13.

The literature reflects a long-standing debate between proponents of historical cost and fair value, primarily centred on the trade-off between reliability and relevance of financial information. This study adopts the position that, despite existing criticisms and challenges related to the subjectivity of estimates and the use of unobservable inputs, fair value represents a more appropriate basis for valuation. It provides greater transparency, better reflects market reality, and offers more relevant information for users of financial statements in economic decision-making.

The following part of the analysis focuses on fair value from the perspective of accounting standards, as well as on the degree of harmonisation between International Financial Reporting Standards (IFRS) and US accounting standards (US GAAP). Under US GAAP, the applicable standard is Accounting Standards Codification (ASC) Topic 820 (commonly referred to as ASC 820), while under IFRS it is IFRS 13 Fair Value Measurement. The analysis shows that these standards are largely harmonised, as both define fair value as an exit price in an orderly transaction between market participants and introduce a similar hierarchy of inputs (Levels 1, 2, and 3), as well as comparable valuation approaches. Differences mainly arise in the initial recognition of gains and losses, certain practical valuation techniques, and disclosure requirements. The study concludes that, despite these differences, the degree of convergence between the two standards is high and reflects the broader trend towards global harmonisation of financial reporting. Further alignment, particularly with regard to disclosures and Level 3 measurements, would enhance transparency, comparability, and the reliability of financial information for investors.

Unlike accounting standards, which introduce fair value primarily to improve the transparency of financial reporting, the development of valuation standards is driven by broader valuation practice, encompassing asset transactions, privatisation, litigation, lending, and investment analysis. For this reason, during the 1980s, as financial markets became increasingly globalised and cross-border transactions expanded, the need emerged for a common professional framework to harmonise valuation methodologies and enhance confidence in valuation conclusions. This led to the establishment of the International Valuation Standards Committee and

the development of the International Valuation Standards (IVS). Globally, several major sets of standards are applied in parallel, including IVS, the US Uniform Standards of Professional Appraisal Practice (USPAP), and the European Valuation Standards. The analysis shows that these frameworks share more similarities than fundamental differences, with variations mainly in terminology, documentation requirements, and the content of valuation reports.

A particularly important distinction concerns the different bases of value used in valuation and accounting standards. While fair value under IFRS is determined based on market participant assumptions and excludes entity-specific factors, valuation standards recognise multiple bases of value, including market value, fair value, and investment value, depending on the purpose of the valuation.

The study argues that, despite the high degree of harmonisation in valuation standards, further convergence of principles, ethical requirements, and terminology could enhance transparency and confidence in professional valuations, making them more fair, defensible, reasonable, and relevant on a global scale.

In conclusion, Chapter One demonstrates that the concept of fair value is firmly established in both theory and practice, while its reliability and reasonableness depend on ongoing methodological improvements. The application of tools such as Monte Carlo simulations represents an important direction for overcoming the limitations of traditional models and for achieving greater transparency and confidence in company valuations.

CHAPTER II. VALUATION OF PUBLIC COMPANIES USING THE DISCOUNTED CASH FLOW METHOD: CONTEMPORARY MODELS AND A METHODOLOGICAL APPROACH FOR INTEGRATING MONTE CARLO SIMULATIONS

Chapter Two analyses traditional valuation models for public companies based on the discounted cash flow (DCF) method and outlines their limitations. It develops a new methodology for integrating Monte Carlo simulations into DCF valuation, enabling the quantitative modelling of uncertainty.

The traditional model for equity valuation within the income approach is presented by Williams (1938), who defines the value of a share as the present value of expected future dividends. This laid the foundation for all subsequent valuation models based on discounted cash flows. The model emphasises actual cash flows received by investors rather than accounting earnings. These ideas were further developed by Gordon (1959), who proposed a model for equity valuation under the assumption of a constant dividend growth rate. Although analytically convenient, the model is limited to companies with stable dividend policies and predictable growth.

The analysis of these models shows that, while they have significant conceptual importance for the development of valuation theory, they rely on highly simplified and deterministic assumptions regarding growth, risk, and the stability of cash flows. This study argues that such assumptions limit their applicability in the contemporary economic environment, characterised by high uncertainty, dynamic business models, and companies that often do not distribute dividends. Consequently, dividend discount models are of primarily conceptual value and highlight the need for more flexible methodological approaches in company valuation.

While dividend discount models represent an early form of this approach, in contemporary practice they have largely been replaced by discounted cash flow (DCF) models, which allow for a more comprehensive reflection of a company's economic characteristics. The study presents a methodology for applying the DCF approach based on the framework proposed by Pratt (2007), supplemented by established practices from the contemporary business valuation literature. The aim of this part of the analysis is to provide a framework upon which the methodology for integrating Monte Carlo simulations into the application of the DCF method in the valuation of public companies can be built. Depending on the purpose of the valuation, two main types of cash flows are distinguished: free cash flow to equity (FCFE) and free cash flow to the firm (FCFF). Unlike dividend discount models, which focus solely on distributed dividends, the DCF approach analyses the overall capacity of a company to generate cash flows and takes into account both the interests of shareholders and creditors.

A key element of the approach is the determination of the discount rate, which reflects the required return on investments with similar risk. The study examines the estimation of the cost of equity using the Capital Asset Pricing Model (CAPM), where the expected return is determined by the risk-free rate, the market risk premium, and systematic risk measured by the beta coefficient.

Various approaches to estimating and adjusting beta are analysed, including the Blume adjustment (1971) and the Bayesian model of Vasicek (1973), with the Blume adjustment applied in the empirical part due to its greater practical applicability.

The analysis also considers the impact of capital structure on company risk through the use of levered and unlevered beta, as well as methods for adjusting differences in financial leverage between the company being valued and the selected market comparables or industry averages. This approach is particularly appropriate for companies with an initial public offering history of less than five years, where the company-specific beta is not sufficiently reliable, as is the case with the companies analysed in this study.

When applying the DCF approach to the firm, it is also necessary to estimate the cost of debt, which together with the cost of equity forms the weighted average cost of capital (WACC). Various approaches to estimating the cost of debt are reviewed, with the synthetic rating approach proposed by Damodaran (2012) applied in the empirical analysis. The synthetic rating represents an approximate credit rating derived from the ratio of earnings before interest and taxes (EBIT) to interest expenses, i.e. the interest coverage ratio. Based on the position of this ratio within defined ranges, a corresponding credit rating category can be inferred, similar to those assigned by rating agencies. This approach is considered most appropriate, as the analysed companies do not have publicly rated debt. Moreover, the cost of debt estimated in this way is based on the most up-to-date available data.

The study further examines in detail the sources of uncertainty in the application of the DCF method, with the primary aim of identifying and structuring them in order to enable their subsequent integration within the proposed Monte Carlo-based methodology. Two types of factors affecting company valuation are distinguished: endogenous and exogenous. Endogenous factors relate to firm-specific characteristics such as the stage of the life cycle, business model, profitability, and capital structure. DCF models are highly sensitive to these factors, as valuation is based on assumptions regarding future growth, profitability, and the discount rate. For young and high-growth companies, the lack of a stable history of revenues and earnings makes it difficult to formulate reliable assumptions. These limitations affect both the forecasting of cash flows and the estimation of systematic risk through the beta coefficient, as well as the selection of an appropriate capital structure.

Exogenous factors arise from the macroeconomic environment and include changes in interest rates, phases of the economic cycle, and the regulatory framework. Changes in interest rates directly affect the discount rate and thus the present value of future cash flows, while economic cycles may lead to systematic deviations in growth and profitability forecasts. Regulatory changes and the increasing importance of environmental, social, and governance (ESG) requirements also affect both company costs and the level of risk, thereby influencing the cost of capital.

The uncertainty arising from these factors imposes significant limitations on the classical DCF method. In this context, the methodological framework of Damodaran (2009, 2018) is examined, addressing the valuation of companies that are considered “difficult to value” and providing approaches for valuing young, start-up, and high-growth firms, as well as companies in financial distress. Even within such structured frameworks, uncertainty is not eliminated but instead shifts to key assumptions that dominate the valuation. The analysis shows that the main limitation of the traditional DCF method is not the absence of a conceptual framework, but the way uncertainty is treated within the model itself. Fixing key parameters as point estimates leads to results that are highly sensitive to assumptions and difficult to interpret from a risk perspective. This necessitates the adoption of a methodological approach that explicitly incorporates uncertainty into key input variables.

The following section presents a new methodology for integrating Monte Carlo simulations into the application of the DCF method. A review of the literature shows that while there are studies outlining individual attempts to incorporate Monte Carlo simulations into DCF models, these are often limited to specific industries such as real estate and mining (Baroni et al., 2006; Samis and Davis, 2014). However, there is a lack of a sufficiently detailed and generalised methodology applicable to the valuation of companies characterised by a high degree of uncertainty. Damodaran (2018) also suggests Monte Carlo simulations as a possible approach, but without a comprehensive methodological framework addressing the selection of distributions, the number of simulations, or the validation of results. Similarly, Rangelov (2022) discusses the benefits of simulation-based valuation models but does not provide a detailed methodology. DeFusco et al. (2001) introduce simulations as a tool in investment analysis. Overall, the literature review indicates the absence of a clear and consistent framework that can be systematically applied in practice. The objective is

therefore to develop a structured methodology for valuing public companies that explicitly accounts for risk and uncertainty. Such an approach is particularly valuable for companies characterised by high volatility and risk, such as start-ups with negative cash flows.

The methodology for applying Monte Carlo simulations within the DCF framework involves several steps: defining and identifying key variables, generating input data randomly based on probability distributions, performing deterministic calculations of outputs, and summarising and interpreting the results. All calculations in Chapter Three are carried out using Oracle® Crystal Ball Decision Optimizer, software specifically designed for conducting and processing Monte Carlo simulations. For the purposes of the study, the key formulas underlying the software are derived based on its documentation and used to analyse the results presented in Chapter Three. These include the calculation of firm value under multiple simulated scenarios using the DCF method, as well as the statistical analysis of the resulting distributions. Key characteristics of the distribution are examined, including expected value, median, dispersion measures such as variance and standard deviation, and distribution shape indicators such as skewness and kurtosis. On this basis, the probability distribution of valuation outcomes is analysed, with the software also providing graphical representations such as histograms, cumulative distribution functions, confidence intervals, correlation matrices, and the contribution of individual factors to variance.

The most critical part of the methodology concerns the identification of input variables and their appropriate mapping to probability distributions. Not all assumptions need to be modelled as probabilistic variables; some are more appropriately treated as fixed values. In selecting the variables to be included in the Monte Carlo simulation, it is necessary to assess both their degree of uncertainty and their impact on the valuation outcome. Inputs based on contractual arrangements or regulatory requirements (such as tax rates) typically exhibit lower uncertainty and do not need to be treated as stochastic variables. Some variables, although uncertain, may have minimal impact on the valuation, and introducing randomness in such cases may create unnecessary noise and lead to inconsistent scenarios. When too many variables are modelled as uncertain, it becomes difficult to derive meaningful conclusions and interpret the results properly. Therefore, it is essential to identify the variables that contribute most significantly to uncertainty before incorporating them into the simulation. To this end, the methodology proposes conducting sensitivity analysis of the valuation outcome with respect to key inputs. The use of Microsoft

Excel’s “Data Table” functionality is recommended, allowing for systematic modelling of different values for two key parameters simultaneously. These parameters should be interrelated (for example, revenue growth and operating margin, or terminal value assumptions). This approach helps identify which parts of the forecast period are most sensitive and which assumptions have the greatest impact. Assumptions that are not characterised by uncertainty, such as revenues based on contractual arrangements, do not require sensitivity analysis. This also implies that, at the stage of developing base forecasts, it is important to distinguish between different revenue streams, as they may carry different levels of uncertainty and relate to different markets and market shares.

Given that the methodology focuses primarily on companies inherently characterised by higher uncertainty, it is recommended that sensitivity analysis be conducted on company-specific inputs. Variables reflecting broader market conditions, such as the market risk premium and the risk-free rate, are not the primary focus of this analysis, as they are typically based on stable external data. The parameters used in the analysis must be realistic and grounded in prior analysis rather than arbitrarily selected, in order to ensure meaningful and well-founded conclusions. Based on this analysis, the key input variables with the greatest influence on valuation are identified and assigned appropriate probability distributions.

The next step in the methodology involves analysing suitable probability distributions for the key input variables, selecting those most appropriate for company valuation within the DCF framework. The table below presents the main input variables, the factors influencing them, the selected probability distributions, and the rationale for their use.

Summary Table of the Variables Analysed and Their Modelling (Table 3 of the Dissertation)

Key Variable	Factors Influencing It	Appropriate Distribution	Rationale for the Choice of Distribution	Sources of Information
Revenue (based on growth and market share)	Regulatory environment, technology, production capacity	Triangular distribution, beta distribution	Based on market conditions and competitor analysis, it is easier to define worst-case, base-case, and best-case scenarios	Financial statements, industry reports, competitor analysis, and production capacity analysis

Margins (gross, operating, net)	Technological advantages, competitive environment	Lognormal distribution	Limits the possibility of values below 0% (or shifts the minimum bound upward)	Industry averages and comparable company data, standard deviation of aggregated industry data covering at least one economic cycle
Capital Expenditures (CapEx)	Growth strategy, technological cycle, size and scale, financial resources, asset efficiency	Triangular distribution	Allows modelling of base-case, conservative, and aggressive scenarios	Financial statements, earnings calls, company development plans, industry averages, and competitor analysis
		Uniform distribution	Suitable for start-up companies with insufficient historical data that do not exhibit a clear probabilistic pattern	
Beta coefficient	Financial leverage, company size, industry cyclicality, overall market volatility	Normal distribution	Discount rates fluctuate symmetrically around the expected mean value	Sample of comparable companies, historical variability
		Lognormal distribution	Limits the possibility of values below zero in cyclical industries	
Cost of Debt (default spread)	Financial leverage, interest coverage ratio, existing debt agreements, interest rate levels	Triangular distribution	The default spread falls within defined bounds	Interest coverage ratios and company ratings based on Damodaran data
Debt-to-Equity Ratio	Company size and stage of development, asset structure, industry characteristics, interest rate levels	Triangular distribution	Bounded between 0 and 100%, preventing negative values and extreme tails	Company financial statements, industry averages, and comparable companies
Terminal Growth Rate	GDP growth, inflation	Triangular distribution, beta distribution, uniform distribution	The terminal growth rate typically falls within a range of 2% to 4%	Macroeconomic data

Source: The Autor

As part of the proposed methodology, the identification of correlation relationships between key input variables in the model is incorporated, as ignoring such relationships may lead to

unrealistic behaviour of the simulated scenarios. In determining these relationships, historical data are used where available, together with aggregated industry information. However, all such relationships should be considered in the context of the specific subject of valuation and the industry in which it operates. This approach is consistent with the practice described in the simulation literature (Hertz, 1964; Savvides, 1994; Mun, 2006), according to which, in the absence of reliable data for statistical calibration, it is acceptable to introduce low, expert-judgement-based correlations between key variables.

Following the identification of input variables, probability distributions, and correlation relationships, a procedure for configuring and executing the Monte Carlo simulation model in Oracle Crystal Ball is presented. Within the study, 10,000 simulation runs are conducted, and the results are interpreted through descriptive statistical analysis, including mean, median, and measures of dispersion, as well as through examination of the distribution shape using skewness and kurtosis. In addition, percentile analysis and confidence intervals are applied in order to quantify the range of possible valuation outcomes and the degree of uncertainty. In analysing the simulation results, confidence intervals are used to indicate the range of probable value estimates. A 90% confidence interval is adopted in the study, as it is more appropriate for model testing and allows for more effective identification of potential relationships. The methodology also includes correlation analysis and variance contribution analysis, through which the key variables exerting the greatest influence on result variability are identified.

The integration of Monte Carlo simulations into the base DCF model requires that the model be structured in a way that ensures internal logical consistency and methodological robustness. In this regard, the next part of the methodology outlines several guiding principles. It is recommended that key input variables be interlinked through economically justified relationships, so that changes in one variable are reflected in related indicators. The use of aggregated assumptions and linear approximations of long-term values is encouraged, while excessive detail should be avoided, as it may complicate the integration of simulations. The choice of forecast period should reflect the characteristics of the company and the industry, with longer periods increasing the level of uncertainty. The determination of input assumptions is based on an analysis of the company's corporate profile, industry context, financial performance, and comparable firms.

The developed methodology for integrating Monte Carlo simulations into DCF-based valuation has applications across various areas of practice. It enables a more in-depth analysis of uncertainty in determining investment value by providing a probabilistic range of possible estimates and supporting investment decision-making. The methodology can also be applied in mergers and acquisitions transactions, where it facilitates the assessment of potential synergies and reduces the risk of overvaluation or undervaluation. In addition, it can be used in fair value measurement for accounting purposes and in asset impairment testing, enhancing the transparency and reasonableness of the underlying assumptions.

The application of the proposed methodology is associated with several limitations. First, the results are highly dependent on the quality of input data, as inappropriate selection of probability distributions or failure to account for correlations between variables may lead to unrealistic valuations. Furthermore, excessive model complexity and the inclusion of too many stochastic variables may hinder interpretation and reduce the reliability of results. There is also a risk of misinterpretation when focusing on individual metrics (such as mean or median) rather than the overall distribution of outcomes. The methodology also involves an element of subjectivity, as the selection of parameters, distributions, and relationships is based on expert judgement. Its application requires a substantial volume of data, in-depth preliminary analysis, and the use of specialised software, which may limit its applicability in situations requiring rapid decision-making and may increase implementation costs.

As a result of the analysis, it is concluded that traditional DCF-based valuation models are widely applicable but are associated with significant uncertainty arising from the need to fix multiple assumptions. In this context, the proposed methodology based on Monte Carlo simulations provides a means of probabilistic modelling and analysis of uncertainty in valuation.

CHAPTER III. APPLICATION OF THE DEVELOPED METHODOLOGY FOR INTEGRATING MONTE CARLO SIMULATIONS IN DCF-BASED VALUATION

Chapter Three aims to demonstrate the practical application and analytical value of the proposed methodology through its application to real publicly traded companies. The selection of companies is intended to illustrate the flexibility and adaptability of the simulation-based approach across different industries, stages of the life cycle, and profiles of uncertainty.

The analysis focuses on two companies that may be characterised as “difficult to value” within the framework of traditional models. The first, Rivian Automotive Inc., is a high-technology manufacturing company in the electric vehicle sector, currently in a phase of rapid growth, but generating significant operating losses and facing substantial capital requirements. The second, Vera Therapeutics Inc., is a biotechnology company still in the clinical stage of development, with no realised revenues and a high dependence on regulatory decisions and research outcomes.

These companies are selected as they represent two distinct types of valuation challenges. For Rivian, the primary risk arises from high capital expenditures and uncertainty regarding the achievement of operational profitability, whereas for Vera Therapeutics uncertainty is associated with the probability of successful product development, regulatory approval, and market entry. In both cases, however, the traditional valuation approaches - market, cost, and income face significant limitations.

For Rivian Automotive, the lack of sufficiently comparable market peers and persistent losses limits the applicability of the market approach, while for Vera Therapeutics the diversity of therapeutic areas and differing stages of development make peer comparisons inherently constrained. The cost approach fails to capture the value derived from innovation and growth potential, while the traditional income approach is highly sensitive to underlying assumptions.

In this context, the combined methodology developed in Chapter Two provides a means of addressing uncertainty through the use of probability distributions instead of fixed values. This allows valuation to be expressed not only as a single expected fair value, but also as a range of possible outcomes, accompanied by sensitivity analysis and quantitative risk assessment.

This chapter pursues two main objectives. First, to demonstrate in practice how the integration of Monte Carlo simulations can enhance the reasonableness of DCF-based valuations when input parameters are uncertain and interdependent. Second, to assess the practical applicability and reliability of the proposed methodology in a real market environment.

The first case study (Rivian Automotive Inc.) applies a free cash flow to equity (FCFE) model, which is appropriate for companies with dynamic capital structures and significant investment needs. The second case study (Vera Therapeutics Inc.) applies a free cash flow to the

firm (FCFF) model, allowing for a broader examination of the effects of both operating and financial variables.

Through these two examples, it is demonstrated that the proposed methodology has broad applicability and can be adapted to different industries and stages of development. Moreover, the use of simulation-based models is shown to be a valuable tool not only for valuation professionals and financial analysts, but also for investors operating under conditions of high market uncertainty.

The application of the methodology involves several stages. The first stage consists of an analysis of the company's corporate profile, including its history and development, product portfolio, key contractual relationships with customers and suppliers (where disclosed), technological strengths and weaknesses, and management structure. The second stage involves a financial analysis of key performance indicators, including horizontal analysis of revenues, costs, and production volumes, as well as analysis of financial results, margins, profitability, and ratios related to leverage, solvency, and liquidity. These two stages precede the valuation and serve as a basis for identifying the company's stage of development, selecting comparable companies, identifying key drivers of assumptions, and distinguishing between variables characterised by uncertainty and those with limited variability (e.g. contract-based revenues).

The third stage involves deriving the assumptions for the base DCF model, including the selection of the forecast period, revenue projections based on expected market share across product segments, estimation of margins, capital expenditures, changes in working capital, determination of the discount rate, and terminal value assumptions. At the same time, the parameters to be used in the probability distributions are identified. The parallel identification of assumptions and parameters ensures internal consistency between the deterministic and probabilistic models, preventing inconsistencies between analytical and simulation results.

For Rivian Automotive, a three-stage DCF model is applied, comprising five years of high growth, with a positive net margin achieved by the end of the fifth year, followed by a five-year normalisation period, and subsequently a stable growth phase, also assumed to last five years. This structure is based on the analysis of the company's financial performance, which indicates improving margin trends alongside the need for a transition period during which assumptions converge towards industry averages, taking into account the historical development of comparable companies within the sector.

For the purpose of revenue projections, three main product lines are identified. Based on an analysis of production capacity, competitive environment, pricing, contractual arrangements, and market expectations, a scenario-based approach is applied, incorporating base, pessimistic, and optimistic scenarios for expected market share within each segment. This approach allows for the formulation of assumptions for the base model while also providing a basis for defining triangular distributions in the Monte Carlo simulations. At the end of the transition period, a growth rate of 15% is assumed, reflecting the achievement of planned production capacity, with a deviation of +/- 5% under optimistic and pessimistic scenarios.

To simplify the model, a direct assumption for net margin is adopted. By the end of the high-growth period, a minimum positive margin of 3% is assumed, supported by comparison with a peer company. During the normalisation phase, a linear convergence towards a sustainable margin is applied, based on a hybrid approach combining data from a comparable company (Tesla) and industry averages with equal weighting. Outlier values from the comparable company are excluded in order to derive a representative long-term margin. Standard deviation is estimated based on industry-level time-series variability, capturing cyclical risk rather than structural differences between firms.

Capital expenditures and changes in working capital are modelled as a function of revenue growth, increasing proportionally during the high-growth phase and subsequently aligned with cumulative business development, while maintaining a capital structure consistent with industry characteristics.

The cost of equity is estimated using the CAPM. During the high-growth phase, a company-specific beta is used, estimated through linear regression of stock returns against a market index and adjusted using the Blume (1971) method. In subsequent phases, an industry beta derived from a sample of automotive companies is applied, with extreme observations filtered using percentile thresholds. The standard deviation is calculated based on the adjusted sample, providing a more realistic estimate of sector-level variability. The transition between the two beta estimates is modelled gradually, reflecting the reduction of company-specific risk and the transition towards a stable phase.

During the stabilisation period, earnings growth is assumed to decline gradually towards a sustainable level linked to long-term macroeconomic factors. The model transitions from detailed

revenue forecasting to a simplified approach for efficiency. In the terminal period, a constant growth rate is assumed, and reinvestment needs are determined as a function of this growth and the return on equity, derived using the DuPont framework, ensuring internal consistency of the valuation.

In the next stage, the discounted cash flow to equity (FCFE) model is applied, yielding the following results:

Summary of Valuation Results Using the Discounted Cash Flow to Equity (FCFE) Model (Rivian Automotive) (Table 19 of the Dissertation)

Present Value – High-Growth Period	-\$13,87
Present Value – Transition Period	-\$0,95
Present Value – Stabilisation Period	\$2,48
Present Value of Terminal Value	\$19,27
Value per Share of Rivian Automotive	\$6,93
Share Price as at 31 December 2024	\$13,30
Difference	-47,90%

Source: Author’s calculations and Nasdaq

Based on this model, the fair value per share of Rivian Automotive as at 31 December 2024 is estimated at USD 6.93, which represents approximately 48% relative to the market price on the same date. This suggests that the market significantly overvalues the company.

With regard to the second company analysed, Vera Therapeutics, the forecast period is determined based on the development stage of the company’s two main products and a comparison with the market introduction of similar products. A horizon of one plus ten years is adopted, including a base year with no commercialised product, followed by a five-year period of accelerated growth and a subsequent normalisation phase leading to terminal values.

Revenue assumptions are developed separately for the two products, based on an analysis of the potential patient population, pricing levels, and expected market share, with pessimistic, base-case, and optimistic scenarios constructed. The two revenue streams are treated independently, allowing for a more precise application of sensitivity analysis and integration of Monte Carlo simulations.

Operating margins in the initial years reflect substantial losses driven by high research and development expenditures, followed by an assumption of positive profitability within three years of the launch of the first product, based on an analysis of comparable products. In the long term, margins converge linearly towards industry-average levels in the pharmaceutical sector, used as reference values, while standard deviation is calculated based on time-series data to capture sector cyclicity. The hybrid approach applied in the case of Rivian Automotive is not applicable here due to the lack of sufficiently comparable peers and the significant differences in product characteristics.

Reinvestment requirements are determined as a function of revenue growth through the use of a sales-to-invested capital ratio based on industry data, ensuring consistency between growth and required investment. Tax effects are modelled by taking into account accumulated operating losses, which reduce the tax base in the initial years.

The cost of equity is estimated using the CAPM, with the beta coefficient derived through linear regression of stock returns against a market index and adjusted using the Blume (1971) model. In the terminal period, an industry beta is applied, derived from a sample of comparable companies and adjusted by excluding extreme values, consistent with the approach used for Rivian Automotive, with standard deviation calculated on the adjusted sample. The cost of debt is estimated using a synthetic credit rating based on the interest coverage ratio, to which an appropriate risk spread is added, while accounting for the tax effect. The weights of debt and equity are determined based on market values, with a gradual convergence towards an industry capital structure assumed in the long term. This enables the construction of a consistent framework in which the weighted average cost of capital (WACC) reflects both company-specific risk in the early stages and stabilisation in the terminal period.

In the terminal period, a sustainable growth rate is assumed, while reinvestment requirements are determined based on the return on invested capital derived internally within the model, ensuring consistency across all input parameters and reducing the need for additional external assumptions.

In the next stage, the discounted cash flow model is applied, yielding the following results:

Summary of Valuation Results Using the Discounted Cash Flow to the Firm (FCFF) Model (Vera Therapeutics) (Table 47 of the Dissertation)

Sum of Present Value of FCFF	\$ 1 976 490
(-) Debt	\$ 54 638
(+) Cash and Cash Equivalents	92 646
Equity Value	\$ 1 096 692
Number of Shares	55 236,680
Value per Share	\$ 19,85
Share Price as at 31 December 2024	\$41,41
Difference	-52%

Source: Author's own calculations

The final value per share obtained from the model is USD 19.85. This represents a deviation of approximately 52% from the market price at the valuation date, which was USD 41.41. As at 29 August 2025, the company's shares are traded on the NYSE at a price of USD 21.64, representing a significant convergence towards the estimated value.

The next stage for both companies involves the practical application of the methodology for integrating Monte Carlo simulations into discounted cash flow valuation. The first step is to conduct a sensitivity analysis and identify the assumptions that have the greatest impact on valuation. The assumptions introducing uncertainty into the model relate to expected market share by product, margins, reinvestment-related ratios, the beta coefficient, and terminal growth. Assumptions considered to be relatively certain, such as the market risk premium, the risk-free rate, and the tax rate, are not subjected to sensitivity testing, as they are based on stable external data and are not subject to significant subjective judgement. These parameters are not company-specific and are defined consistently in both theory and practice. The tax rate is also determined by regulatory requirements. Likewise, assumptions based on internally available company information or contractual arrangements are not included in the sensitivity analysis, as they are considered to have a higher degree of certainty. Variables that are directly dependent on other assumptions are also excluded.

For the purposes of sensitivity analysis, the Microsoft Excel "Data Table" functionality is used, enabling the systematic modelling of variations in two key parameters simultaneously. Alternative scenarios are generated across the horizontal and vertical axes of the tables, allowing

the impact of changes in input variables on company value to be observed. The ranges of variation for each parameter are aligned with the underlying assumption analysis. Based on this approach, three key assumptions are identified for each company as having the greatest impact on valuation. For Rivian Automotive, these are revenue growth, net margin at the end of the transition period, and the beta coefficient in the terminal period. For Vera Therapeutics, they are the market share of one of the company's products, operating margin, and the beta coefficient in the terminal period.

The next stage involves determining the appropriate probability distributions and their parameters. For revenue-related variables, specifically revenue growth at the end of the transition period for Rivian Automotive and product market share for Vera Therapeutics, triangular distributions are applied based on previously defined pessimistic, base-case, and optimistic scenarios, in line with the methodology developed in Chapter Two.

For net and operating margins, a lognormal distribution is applied, as it prevents negative values and allows parameters to be defined using the mean and standard deviation derived from industry and comparable company analysis. Alternative distributions, such as triangular and normal, are also considered. The triangular distribution is not suitable due to the absence of clearly defined scenario bounds, while the normal distribution assigns equal probability to extreme negative and positive values. Given that the DCF method assumes a going concern, negative values for operating margins in the terminal period are not economically meaningful. Therefore, the lognormal distribution is considered the most appropriate. Minimum values of 5% for operating margin and 0% for net margin are imposed, reflecting both definitional relationships and the typically higher profitability observed in the pharmaceutical industry. It should be noted that the lognormal distribution produces long right tails and potentially extreme positive values; therefore, values in the upper percentiles should be interpreted with caution.

In determining the probability distribution for the beta coefficient, a differentiated approach is applied based on industry characteristics. For the automotive company, which exhibits higher sensitivity to economic cycles, a lognormal distribution with a lower bound of zero is used, preventing unrealistic negative values and allowing for higher beta values under adverse market conditions. For the pharmaceutical company, a normal distribution centred around the industry mean is adopted, as risk is less strongly linked to macroeconomic cycles and deviations tend to be more symmetric. In both cases, the mean and standard deviation are derived from samples of

comparable publicly traded companies, with procedures applied to mitigate the influence of extreme observations.

The next stage involves analysing correlation relationships. Correlation matrices are constructed using industry-level data, as company-specific historical data are insufficient due to the early stage of development. Weak correlations are observed among the variables. For Rivian Automotive, economic reasoning does not support the inclusion of even minimal correlations, as these could introduce unrealistic distortions in valuation. For Vera Therapeutics, a conservative assumption of a weak positive correlation between product market share and operating margin is adopted, reflecting the notion that higher market share is typically associated with efficiency rather than price competition, thereby enabling higher margins

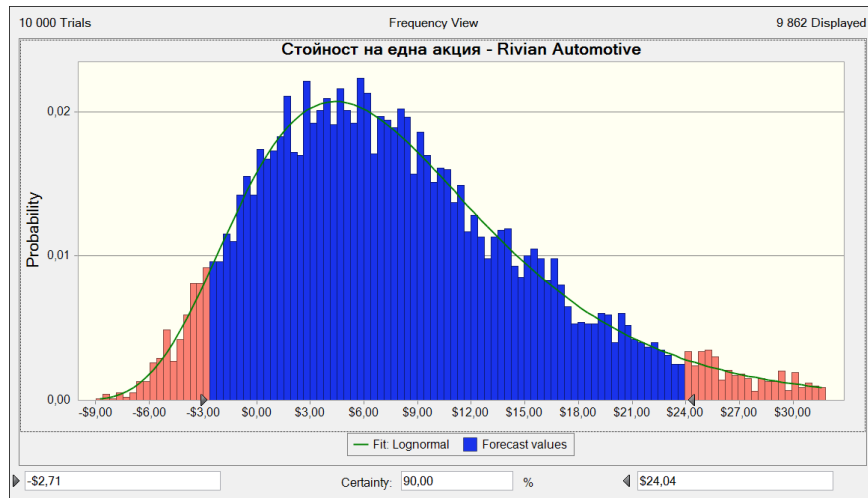
The subsequent stage for both companies involves configuring the Monte Carlo simulation parameters using Oracle Crystal Ball. Each input variable is defined as an assumption cell with the corresponding probability distribution and parameters. Using the “Define Forecast” function, the output cell in Microsoft Excel is specified as the variable to be tracked across simulations, representing the value per share. Correlation relationships between variables are implemented using the “Define Correlations” function.

In line with the methodology outlined in Chapter Two and the software guidelines, 10,000 simulation trials are conducted to ensure statistical robustness. A 90% confidence interval is selected in order to minimise the impact of extreme values and improve precision. This choice is justified by the use of lognormal distributions for margins, which generate long tails, and normal distributions for beta. The selected confidence level provides a more realistic range of outcomes, which is more informative for valuation analysis.

The final stage of the valuation involves analysing the empirical results of the simulation for both companies, including descriptive statistical analysis, graphical representation of results, and their interpretation. The Monte Carlo simulation results for both companies exhibit high standard deviation and variance, as well as pronounced skewness, reflecting the significant uncertainty embedded in the input assumptions. In both cases, the standard error of the mean is low, confirming the statistical stability of the results despite the wide range between minimum and maximum values.

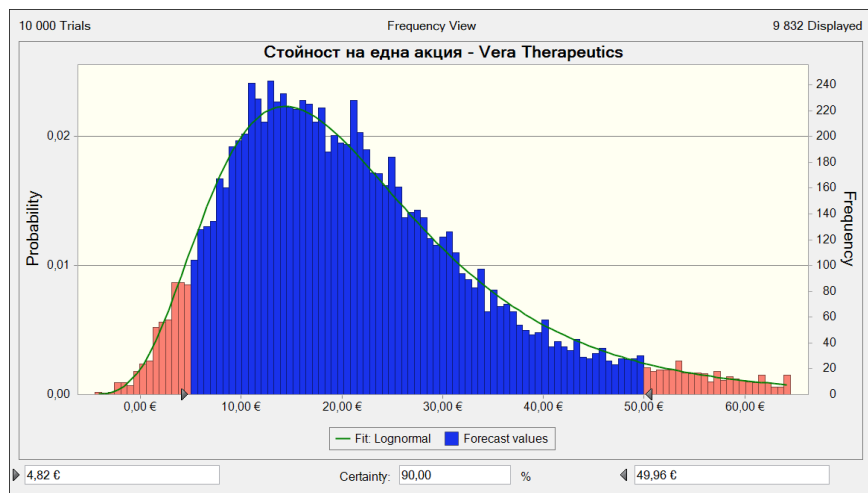
The resulting distributions of the outcomes are presented in the histograms below:

Histogram of the Distribution of Valuation Results for Rivian Automotive (Figure 10 of the Dissertation)



Source: Calculations performed using Oracle Crystal Ball software

Histogram of the Distribution of Valuation Results for Vera Therapeutics (Figure 19 of the Dissertation)



Source: Calculations performed using Oracle Crystal Ball software

The distributions are right-skewed, exhibiting long tails towards higher values, primarily due to the use of lognormal distributions for key parameters. This implies the existence of low-probability but significantly more favourable scenarios, while the lower tail of the distribution includes outcomes with very low or even zero value for shareholders.

The percentile analysis shows that, for the majority of the probability distribution, valuation outcomes are concentrated within relatively narrow intervals around the median, which is close to the base-case estimate. At the same time, market prices for both companies at certain points fall within higher percentiles, suggesting the presence of more optimistic expectations embedded by investors.

The sensitivity analysis for both companies reveals similar dependencies on input variables, despite the use of different valuation models. For Rivian Automotive, the highest sensitivity is observed with respect to the beta coefficient in the terminal period, revenue growth, and net margin at the end of the transition period. For Vera Therapeutics, the key variables identified are the beta coefficient, operating margin, and the expected market share of one of the company's products during the high-growth phase. The simulation results indicate that, for Rivian Automotive, sensitivity to the beta coefficient and net margin is relatively balanced. In contrast, for Vera Therapeutics there is a pronounced dominance of sensitivity to the beta coefficient, with approximately 20–25% of the variance explained by operating margin and product market share. This suggests that both market risk and operational performance have a roughly equal impact on the value of Rivian Automotive. Investors should therefore consider both the company's market sensitivity and its ability to manage costs and achieve sustainable margins. For Vera Therapeutics, market risk remains the primary driver of valuation, although the company's ability to achieve significant market share and maintain adequate margins also plays an important role. While Rivian Automotive's valuation depends on a balance between market conditions and internal efficiency, Vera Therapeutics' valuation is more heavily concentrated in market risk and key product-related variables. This indicates that Vera Therapeutics represents a higher-risk investment, whereas Rivian Automotive is more dependent on long-term positioning and margin management.

This risk profile is also reflected in the greater asymmetry observed in the simulation results for Vera Therapeutics. The right-skewness is more pronounced, indicating the presence of potentially highly favourable outcomes. For investors, this suggests that a substantial portion of the company's value is contingent upon the successful development and commercialisation of its key product. Rivian Automotive exhibits a more balanced sensitivity to key variables and a more symmetrical distribution of outcomes. This is largely due to the assumption of a lognormal distribution for the beta coefficient, which offsets the lognormal distribution applied to net

margins. From an interpretative perspective, in the presence of skewed distributions, the median represents a more appropriate estimate of fair value, as it reflects the most likely outcome, whereas the mean is influenced by rare extreme scenarios. Nevertheless, the mean remains relevant in the context of diversified portfolios, where such extreme outcomes tend to offset one another.

The comparison with market prices as at 31 December 2024 and those observed in August indicates similar patterns for both companies. For Vera Therapeutics, the market price as at 31 December 2024 lies above the 90th percentile of the distribution, while for Rivian Automotive it is around the 80th percentile. This suggests potential overvaluation or strong expectations of optimistic scenarios. By August 2025, the price of Vera Therapeutics converges significantly towards the estimated value, reaching approximately the 60th percentile, while Rivian Automotive falls between the 60th and 70th percentiles. Initial overvaluation is a common feature of early-stage companies and is often driven by high investor expectations, reinforced by optimistic management projections. In this context, the application of Monte Carlo simulations enhances the reasonableness of the valuation by moving beyond a single-point estimate and capturing the full range of possible scenarios and their associated probabilities. This enables a more accurate assessment of both risk and potential, as well as a more objective comparison with current market prices.

The results confirm that integrating Monte Carlo simulations into the DCF framework allows for a more comprehensive representation of uncertainty and asymmetry in potential outcomes compared to traditional deterministic approaches. The methodology is particularly applicable to companies characterised by high risk and limited historical data, such as early-stage technology and biotechnology firms.

A key advantage of the applied methodology is that valuation is not expressed as a single point estimate but as a range of possible outcomes. This is especially important in conditions of high uncertainty, where individual input assumptions may vary significantly and lead to substantial deviations in valuation results. Presenting results through percentile intervals allows for the identification of both the most likely scenarios and the risks associated with extreme outcomes, making the analysis more realistic and practically relevant. By incorporating probability distributions and quantitative risk measures, the methodology provides a more reliable basis for investment decision-making, taking into account not only expected value but also downside risk

and the deviation of market prices from fundamentally justified values. Furthermore, it enables the positioning of current market prices within the distribution of outcomes, making it a highly practical tool for valuation and risk management under conditions of significant uncertainty.

Based on the conducted research, a set of structured guidelines for the practical application of the proposed methodology has been developed. These guidelines are organised into sequential stages, including: assessment of methodological applicability, analysis of corporate and financial profiles, definition of input assumptions and probability distributions, integration of Monte Carlo simulations into the DCF framework, and analysis and interpretation of results. Key emphasis is placed on ensuring internal consistency between the base DCF model and probabilistic modelling, limiting the simulation model to the most significant and uncertain variables, selecting appropriate probability distributions and parameters, and correctly interpreting the results.

The conducted simulations confirm that the application of Monte Carlo methodology to DCF models significantly enhances the reasonableness of fair value estimation by replacing point estimates with probabilistic ranges that more accurately capture market uncertainty and dynamics. The comparison with actual market prices supports the validity of the selected probability distributions, as the correction of initial overvaluation falls within the projected range. Although Monte Carlo-based fair value estimates may be perceived as conditional, the study demonstrates that this is, in fact, a methodological strength. Through statistical validation and probabilistic modelling, simulations transform fair value from a fixed point into a robust range that incorporates uncertainty and provides a more objective basis for comparison with market valuations. This does not reduce but rather enhances the credibility and reliability of valuation, which is particularly important for early-stage and high-risk companies where limited historical data make point estimates inherently less convincing.

IV. SUMMARY OF CONTRIBUTIONS OF THE DISSERTATION

1. Theoretical Contributions

- The development of the fair value concept in economic and financial theory and its incorporation into accounting and valuation practice has been systematically analysed.
- A comparative analysis between the US and international regulatory frameworks has been conducted, identifying key differences and outlining directions for further harmonisation.

2. Methodological Contributions

- A new methodology is proposed for integrating Monte Carlo simulations into the discounted cash flow (DCF) method, systematising the process of identifying, modelling, and evaluating uncertain assumptions.
- The algorithmic steps of the simulation-based model are defined - from the selection of probability distributions to the interpretation of results, ensuring methodological consistency and reproducibility.

3. Practical Contributions

- The proposed methodology is empirically tested on two publicly traded companies characterised by a high degree of uncertainty and negative cash flows, where traditional DCF models exhibit limited reliability.
- It is demonstrated that simulation-based valuation enables the construction of a confidence interval for fair value and provides a more objective representation of risk in investment decision-making.

V. LIST OF PUBLICATIONS RELATING TO THE DISSERTATION

- 1) Andreeva, S. (2023), “Methodological Aspects of a Simulation-Based Model in Determining the Cost of Capital”, Yearbook “Economics and Business”, Vol. 8, Department of Economics, New Bulgarian University, Sofia, pp. 78–86, ISSN 2534-9651. Available at: [link](#)
- 2) Andreeva, S. (2023), “Risks in the Use of Platforms for Financial Information by Individual Investors”, in Proceedings of the International Conference “The Economy of the 21st – Crises, Transformations, Sustainability”, Department of Economics, New Bulgarian University, pp. 750–764, ISBN 978-619-233-291-4 (print), ISBN 978-619-233-292-1 (electronic). Available at: [link](#)
- 3) Andreeva, S. (2023), “Digital Transformation and Investor Expectations in the Financial Sector – Challenges Facing Individual Investors”, in Proceedings of the 6th International Scientific and Practical Conference “Sociocultural Codes of Contemporary Development”, Askoni-Izdat Publishing House, Sofia, pp. 662–771, ISBN 978-954-383-148-7. Available at: [link](#)
- 4) Andreeva, S. (2023), “The Impact of ESG Factors on the Determining the Fair Value of Companies”, in Proceedings of the International Scientific and Practical Conference

“Bulgaria of the Regions”, Talant Academic Publishing, Plovdiv, pp. 138–147, ISSN 2815-5262 (online). Available at: [link](#)

- 5) Andreeva, S. (2024), “Sustainable Finance and Some Aspects of Company Valuation”, in Proceedings of the 7th International Scientific and Practical Conference “Contemporary Socio-Economic Systems: Management, Prospects and Solutions”, Askoni-Izdat Publishing House, Sofia, pp. 536–546, ISBN 978-954-383-152-4.