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COMPANY'S VALUE EVALUATION THROUGH MODIFYING ITS CAPITAL STRUCTURE WITH BONDS AND STOCKS ISSUANCE SIMULATION USING MACHINE LEARNING AND STATISTICAL ANALYSIS APPROACHES

Abstract*: the present financial landscape is complexly woven with the interplay of financial instruments and technologies, reshaping the way companies manage their value. Financial instruments act as the cornerstone of capital structure, influencing cash flows and overall valuation. Meanwhile, financial technologies introduce innovation and efficiency via presenting unprecedented capabilities in assessing and forecasting the impact of these instruments on a company's worth. The ability to make timely decisions on resource allocation and capital raising is a key determinant of success in a rapidly evolving business landscape. Thus, the financial sector undergoes transformative changes, reshaping how companies navigate complexities and make informed decisions in an increasingly dynamic environment. The symbiosis of these elements is reshaping the future of finance, offering new avenues for creating and managing value in an interconnected world.*

Keywords: *company value, capital structure, securities, simulation modeling, machine learning, statistical analysis.*

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ОЦЕНКА СТОИМОСТИ КОМПАНИИ С УЧЕТОМ ИЗМЕНЕНИЙ СТРУКТУРЫ ЕЕ КАПИТАЛА ПРИ МОДЕЛИРОВАНИИ ВЫПУСКА ОБЛИГАЦИЙ И АКЦИЙ С ИСПОЛЬЗОВАНИЕМ ПОДХОДОВ СТАТИСТИЧЕСКОГО АНАЛИЗА И МАШИННОГО ОБУЧЕНИЯ

Аннотация: *нынешний финансовый ландшафт представляет из себя сложное переплетение взаимодействий финансовых инструментов и технологий, меняющего способы управления компаниями своей стоимостью. Финансовые инструменты выступают в качестве краеугольного камня структуры капитала, влияя на денежные потоки и общую оценку. Между тем, финансовые технологии привносят в инновации и эффективность, предоставляя беспрецедентные возможности в оценке и прогнозировании влияния этих инструментов на стоимость компании. Способность принимать своевременные решения о распределении ресурсов и привлечении капитала является ключевым фактором успеха в быстро развивающейся бизнес-среде. Таким образом, финансовый*

сектор претерпевает трансформационные изменения, изменяющие то, как компании справляются со сложностями и принимают обоснованные решения во все более динамичной среде. Симбиоз этих элементов меняет будущее финансов, предлагая новые возможности для создания и управления стоимостью во взаимосвязанном мире.

***Ключевые слова**: стоимость компании, структура капитала, ценные бумаги, имитационное моделирование, машинное обучение, статистический анализ.*

1. General assumptions, data, and methodology.

Financial data of Berkshire Hathaway was selected for this investigation due to its robust track record of successfully issuing substantial bonds, reflecting the company's financial strength, thus possibility to handle huge issuances. With over 2 billion stocks outstanding, Berkshire Hathaway presents a unique opportunity for in-depth analysis of stock dynamics. Additionally, the company's commitment to transparency provides easy access to coherent financial data, a crucial factor in accurate forecasting. This is why the company is an ideal subject for comprehensive financial modeling, offering valuable insights into the intricate interplay of capital structure, stock dynamics, and overall financial performance.

Forecasting time series data involves predicting future values based on historical observations. For this purpose, the often choice is ARIMA [4], exponential smoothing [5], gradient boosting (in our case, XGBoost [11]), linear regression [9], trivial forecast (in our case, mean of three previous observations for prediction), and an annual growth model. Thus, Berkshire Hathaway's financials from 2007 to 2022 are used as an initial data set [1–2]. To assess model accuracy, each financial indicator undergoes rigorous backtesting, evaluating performance over the last five periods of known data using MAPE metric. Such an approach with accuracy evaluation with MAPE on basis of known data ensures robustness in model selection [6, p. 121] and sets the stage for forecasting the company's financial trajectory from 2023 to 2027.

The ultimate objective of forecasting Berkshire Hathaway's financials lies in simulating the potential impact of issuing bonds and stocks on its financial results. By utilizing these forecasts, various scenarios may be simulated, exploring how different levels of bond and stock issuances might influence the company's overall financial health. This simulation approach allows for strategic planning and risk management, aiding in decision-making related to capital structure, financing options, and potential implications for shareholders.

The investigation introduces simulations of bond and stock issuances at varying levels, conducted separately to analyze their distinct impacts. Stock issuance levels are set at 0.05%, 0.1%, 0.3%, and 0.5% of existing shares, equivalent to 1.1kk, 2.2kk, 6.6kk, and 11kk shares, respectively. Similarly, bond issuances are simulated at levels of 300k, 700k, 2000k, and 3500k pieces. To maintain comparability, all bonds have a 5-year maturity, a face value of 1000, and a coupon rate of 2%. The chosen numbers facilitate a comprehensive analysis, allowing for a straightforward comparison between stock and bond issuances. Stocks and bonds are issued once, in the year 2023.

These specific quantities were selected to ensure that issuing 300k bonds results in a comparable increment in total assets to issuing 1.1kk stocks. This equality is maintained across various levels, providing a consistent basis for evaluation. Coupon payments associated with bond issuances are considered liabilities and influence total assets. However, dividend payments are not factored into the analysis, aligning with Berkshire Hathaway's policy of not paying dividends.

The simulation incorporates the nuanced impact of issuing bonds and stocks on the company's financials. Since issuing bonds introduces additional debt, it affects both Liabilities and Total Assets. Concurrently, issuing stocks adds to equity, influencing Total Assets [8]. These dynamics are seamlessly integrated into the forecasted financials, ensuring a comprehensive representation of the company's evolving capital structure. To derive Revenue, a sophisticated approach is employed, utilizing weighted rates of Revenue to Assets, Revenue to Debt, and Revenue to Equity which show how dependent one variable is on another and are calculated as dividing the first specified variable by the second. Further those are also used to calculate Free Cash Flow and Net

income that occur when bond and stock issuing scenarios are deployed. Both while issuing bonds and stocks, forecasted rates associated with dependence on debt were used to make results comparable. This approach is used because pure forecasting of Net Income is only applicable for estimating algorithms accuracy, while running scenarios is a more complicated task. Thus, this method considers the diverse effects of financial instruments on the various components of the company's structure.

2. Models evaluation and financials forecasting.

Backtesting process is shown on example of Revenue forecasting in Figure 1. As it can be seen, gradient boosting encounters challenges in predicting this specific financial metric, primarily due to limited training dataset. Expanding the dataset by incorporating quarterly financials may be a potential solution, providing machine learning algorithms with a richer context. This allows the algorithms to identify subtler patterns, leading to more accurate predictions. Extending to big data opens opportunities of using neural networks which unlocks additional opportunities in enhancing prediction capabilities.

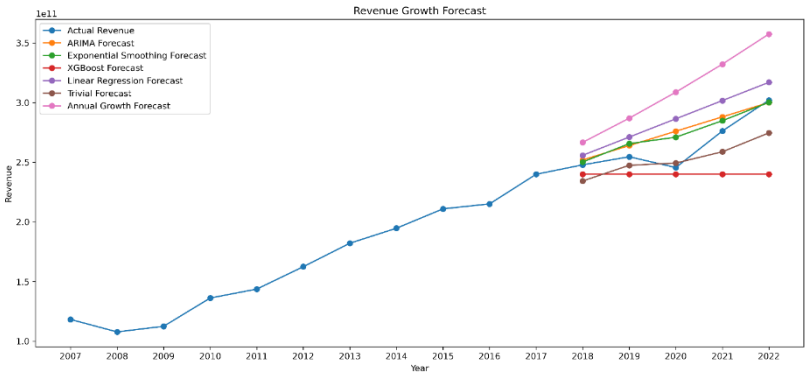


Fig. 1. Backtesting algorithms on Revenue, 2018–2022 (compiled by the author based on data from [1–2])

In Table 1, the results of backtesting are provided. Notably, dependencies of one variable on another were more challenging for prediction than pure financials, which highlight either vulnerability of such dependencies or lack of data available [7]. All in all, these results underscore the importance of choosing models tailored to specific financial indicators, as each of them has own characteristics in patterns.

Table 1

Backtesting results for each financial

Indicator	Best Model	MAPE
Revenue	Exponential Smoothing	3.88%
Total Liabilities	Linear Regression	2.10%
Total Equity	ARIMA	7.44%
Free Cash Flow-Revenue Rate	Trivial	16.06%
Net Income-to-Revenue Rate	Trivial	48.99%
Share Price	Linear Regression	9.19%
Revenue-from-Assets Rate	Exponential Smoothing	5.87%
Revenue-from-Debt Rate	Linear Regression	7.71%
Cost-of-Debt Rate	ARIMA	27.22%
Net Income-from-Assets Rate	Trivial	46.12%
Net Income-from-Debt Rate	Exponential Smoothing	48.35%
Free Cash Flow-from-Assets Rate	Trivial	13.95%
Free Cash Flow-from-Debt Rate	Trivial	13.01%

(compiled by the author based on data from [1–2]).

It is noteworthy that the simple trivial model often outperforms complex models in forecasting time series data, making it a tough competitor to beat. Despite its simplicity, it is really effective when there is no access to large datasets that ML algorithms thrive on. Forecast example is depicted in Figure 2 and shows the prediction of Revenue for 5 years.

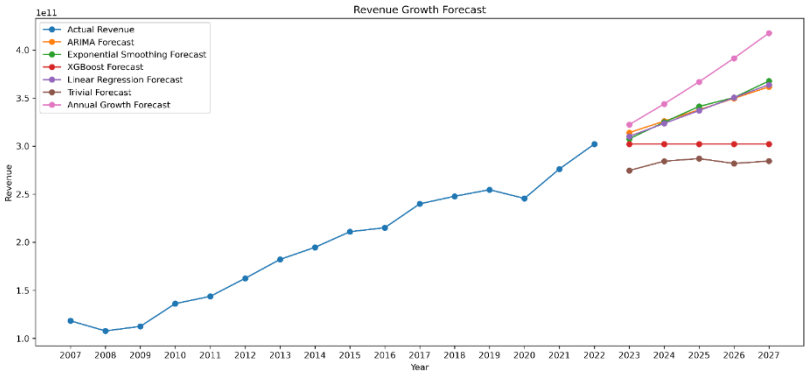


Fig. 2. Forecasting Revenue, 2023–2027 (compiled by the author based on data from [1–2])

All forecasted values are shown in Table 2. According to the forecast, Revenue is expected to grow, as well as Total Liabilities. Total Equity is about to increase with

lower paces, while predicted Share Price is quite vulnerable. As for dependencies, those are expected to stay almost unchanged.

Table 2

Forecasting results for each financial, 2023–2027

Indicator	2023	2024	2025	2026	2027
Revenue, mln. USD	307587.54	324846.27	341237.32	350460.28	367719.01
Total Liabilities, mln. USD	486216.12	495883.14	531534.3	549857.36	559524.37
Total Equity, mln. USD	482294.33	492613.78	485175.04	486694.38	488161.07
Share Price	306.51	315.60	318.89	313.67	316.05
Free Cash Flow-Revenue Rate	9.19%	8.62%	8.34%	8.72%	8.56%
Net Income-to-Revenue Rate	19.26%	19.81%	15.46%	18.18%	17.82%
Revenue-from-Assets Rate	29.59%	30.08%	30.51%	30.06%	30.22%
Revenue-from-Debt Rate	61.65%	62.82%	63.01%	62.49%	62.77%
Cost-of-Debt Rate	4.63%	5.11%	4.93%	5.00%	4.97%
Net Income-from-Assets Rate	5.58%	5.79%	4.57%	5.31%	5.22%
Net Income-from-Debt Rate	13.26%	16.05%	15.75%	15.10%	17.89%
Free Cash Flow-from-Assets Rate	2.69%	2.57%	2.52%	2.60%	2.56%
Free Cash Flow-from-Debt Rate	5.63%	5.39%	5.22%	5.41%	5.34%

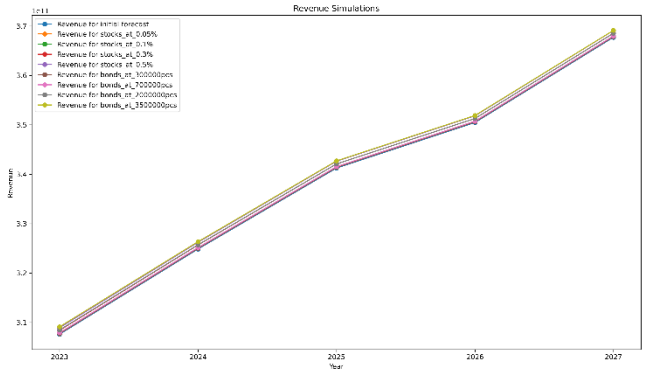
(compiled by the author based on data from [1–2]).

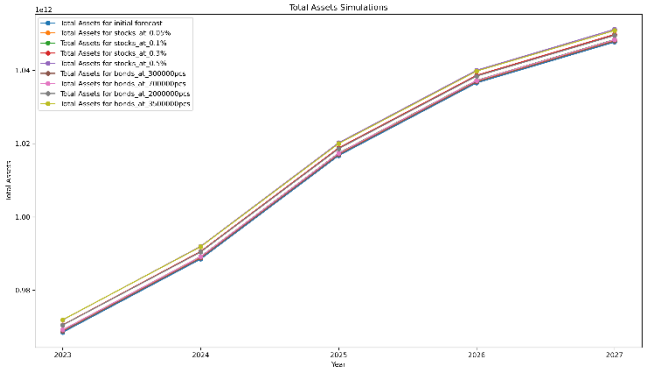
Thus, for getting accurate predictions diverse models were employed and rigorously backtested, so that the chosen models serve as a robust foundation for forecasting the company's trajectory for future periods. It is important to mention that an ultimate forecasting model does not exist, thus testing and evaluating the most suitable one for specific characteristics of dataset is crucial. This forward-looking exercise provides a strategic outlook for simulating the impact of issuing financial instruments.

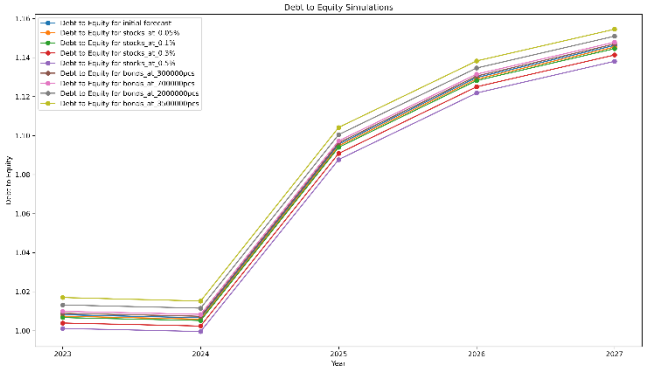
3. Simulation modeling.

Dynamics of the most important results of all simulations is shown in Figure 3. Those include changes in Revenue, Total Assets, Debt-to-Equity ratio, and WACC. It can be noted that both issuing stocks and bonds led to growth of Revenue, Total Assets, and Net Income. Simulations with stock issuance decreased D/E ratio, opposite to bonds issuance. Insignificant WACC growth was typical to stocks issuance, contrasting

with bonds issuance, primarily because of differences in forecasted COD and COE. At this point it seems that the results are linear or, in case of capital structure ratios, symmetrical referring to corresponding levels of bonds and stocks issuances.







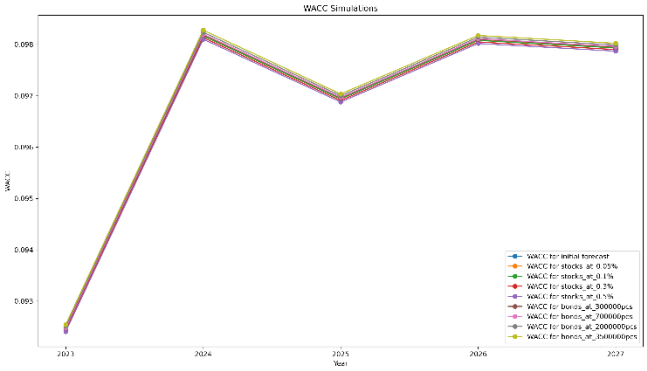


Fig. 3. Results of simulations. Dynamics of Revenue, Total Assets, Debt-to-Equity, and WACC correspondingly for 2023–2027 (compiled by the author based on data from [1–2])

Dynamics of Business Value and Market Capitalization are depicted in Figure 4. Thus, stocks issuance contribute more both Business Value and Market Capitalization in comparison to bonds.

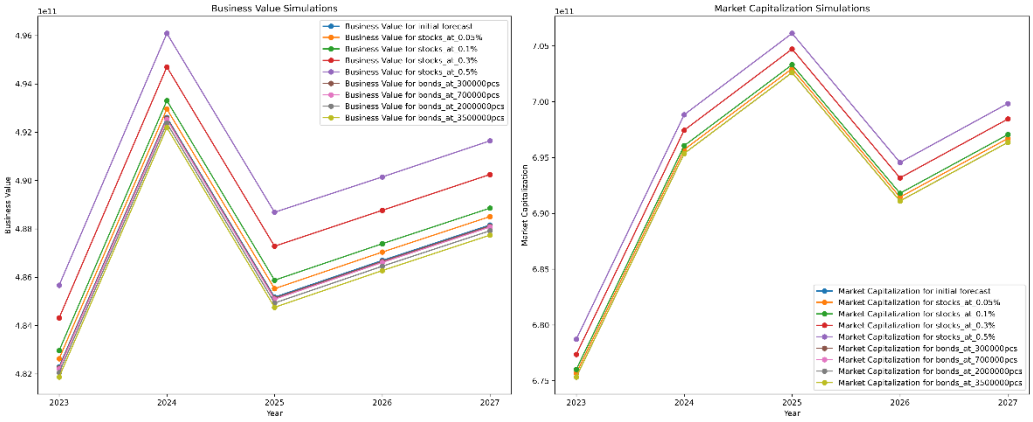


Fig. 4. Dynamics of Business Value and Market Capitalization of Berkshire Hathaway associated with issuing bonds or stocks, 2023–2027 (compiled by the author based on data from [1–2])

Analyzing absolute total figures presents challenges, emphasizing the importance of examining relative dynamics, as depicted in Figure 5. The data is normalized to the initial forecast, revealing non-linear impacts of stocks and bonds, contrary to initial perceptions of previous figures. Distinct patterns emerge; early Revenue growth is predominantly influenced by bonds issuance, with equity financing proving more profitable in the long run. In contrast, debt borrowing yields a more substantial initial jump in profitability. Net Income is more significantly impacted by bonds issuance than stocks, while Total Assets experience a greater increase with stocks issuance due to its non-obligatory nature [10]. WACC follows the trend discussed earlier, rising with larger stock issuance, and dropping with increased bond issuance. This nuanced perspective provides a more comprehensive understanding of the complex dynamics between stock and bond issuance, profitability, and the overall financial structure of Berkshire Hathaway.

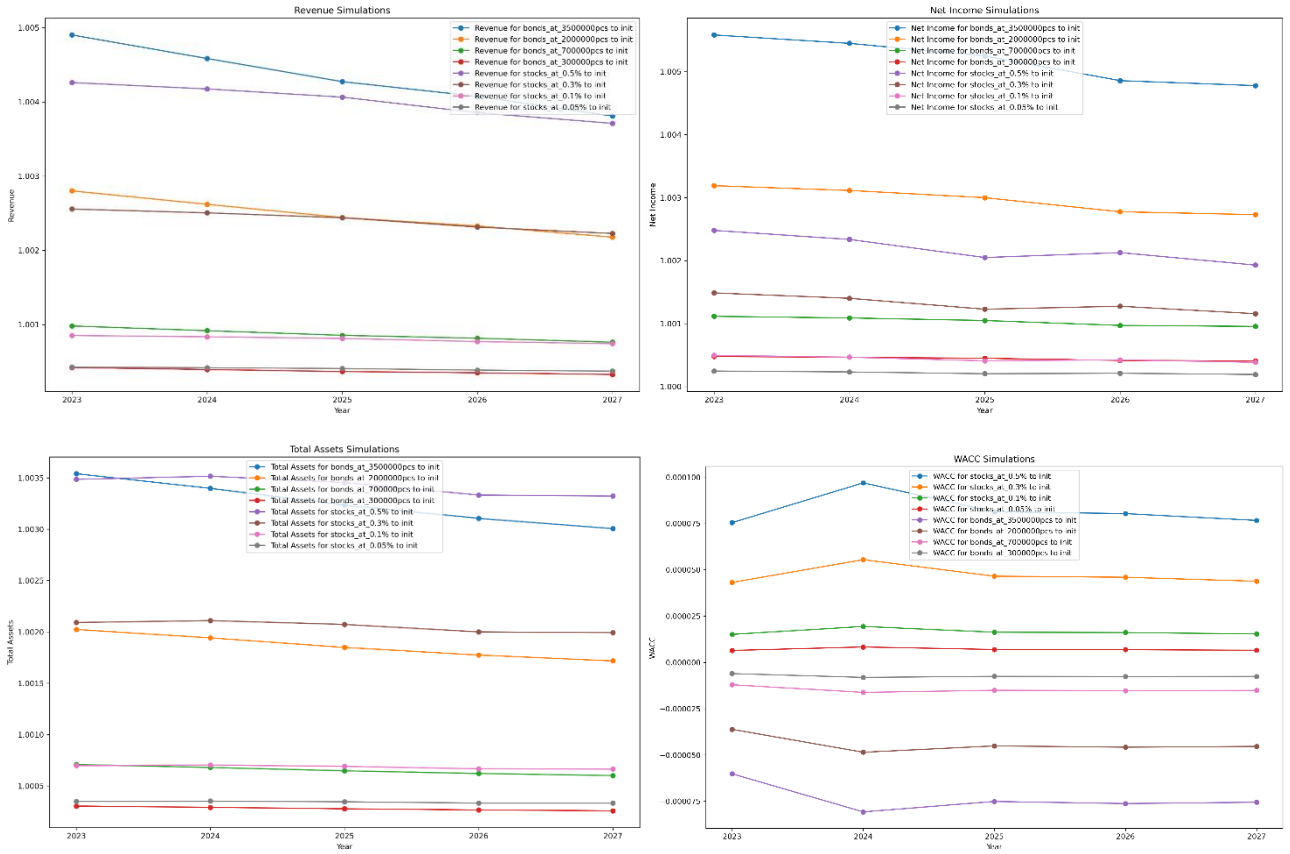


Fig. 5. Relative dynamics of Revenue, Total Assets, Debt-to-Equity, and WACC correspondingly normalized to initial forecasting, 2023–2027 (compiled by the author based on data from [1–2])

Table 3 presents the specific variations in simulation results compared to the initial forecast. It's important to note that each simulation value represents the mean of all forecasted years for the corresponding indicator. All percentage values are additional (or subtractive) percentages relative to the initial forecast. In general, the table reaffirms the empirical observations mentioned earlier. Notably, contrary to stocks, bonds exhibit minimal impact on Market Capitalization. Additionally, bonds tend to have a negative effect on a company's Business Value, decreasing it as more bonds are issued. Moreover, the average growth rates for Revenue and Net Income are higher in scenarios involving bonds issuance, along with an increase in Total Assets. These findings align with the earlier-described patterns.

Table 3

Relative dynamics of indicators normalized to initial forecasting; all scenarios mean for 2023–2027

Scenario	Revenue, mln. USD	Total Assets, mln. USD	Net Income, mln. USD	Business Value, mln. USD	Market Capitalization, mln. USD
Initial Forecast	338370.08	1011590.78	65604.40	486987.72	692161.09
stocks 0.05% / init	0.04%	0.03%	0.02%	0.07%	0.05%
stocks 0.1% / init	0.08%	0.07%	0.04%	0.14%	0.10%
stocks 0.3% / init	0.24%	0.21%	0.13%	0.43%	0.30%
stocks 0.5% / init	0.40%	0.34%	0.22%	0.71%	0.50%
bonds 300k pcs / init	0.04%	0.03%	0.04%	-0.01%	0.00%
bonds 700k pcs / init	0.09%	0.07%	0.10%	-0.02%	0.00%
bonds 2kk pcs / init	0.25%	0.19%	0.30%	-0.05%	0.00%
bonds 3.5kk pcs / init	0.43%	0.33%	0.52%	-0.09%	0.00%

(compiled by the author based on data from [1–2]).

Table 4 showcases average changes in ROS, D/E, and WACC, which are absolute, and EPS, which is normalized to initial forecasting. D/E logically decreases with stock issuance, in contrast to bonds, with almost identical paces. Although WACC changes are relatively insignificant, the table confirms earlier statements about dependence of WACC and introducing debt or equity. It is important to mention once more that simulating Net Income and Free Cash Flow required weighted calculations, as in the case of Revenue. ROS experiences a more substantial decrease with stock issuance compared to the growth observed in bonds ROS, which is, thus, due to patterns of Net Income simulated. The decrease in EPS for stocks is attributed to the slower pace of revenue growth relative to the rapid increase in stock issuance. It's essential to note the interconnected nature of ROS and EPS with revenue, where bonds issuance exhibited higher revenue growth, influencing these results.

Table 4

Relative dynamics of indicators normalized to initial forecasting; all scenarios mean for 2023–2027

Scenario	ROS	D/E	WACC	EPS
Initial Forecast	19.39%	1.0773	9.67%	29.7753
stocks 0.05% / init	0.00%	-0.0008	0.00%	-0.03%

stocks 0.1% / init	-0.01%	-0.0015	0.00%	-0.06%
stocks 0.3% / init	-0.02%	-0.0046	0.00%	-0.17%
stocks 0.5% / init	-0.04%	-0.0076	0.01%	-0.28%
bonds 300k pcs / init	0.00%	0.0007	0.00%	0.04%
bonds 700k pcs / init	0.00%	0.0017	0.00%	0.10%
bonds 2kk pcs / init	0.01%	0.0049	0.00%	0.30%
bonds 3.5kk pcs / init	0.02%	0.0086	-0.01%	0.52%

(compiled by the author based on data from [1–2]).

For Total Valuation DCF model is used, with Free Cash Flow dynamics depicted in Table 5. The results reflect the impact of various scenarios on FCF, in percentages relative to the initial forecast. This disparity suggests that bond issuances contribute more significantly to the increase in the DCF valuation of Berkshire Hathaway compared to stock issuances. Lower costs of capital through bond issuances lead to a higher valuation in a DCF model because of lower WACC and shifts in capital structure [3, p. 70].

Table 5

Discounted Cash Flows for stocks and bonds issuance scenarios normalized to initial forecast, 2023–2027

Year	Initial Forecast, mln USD	stocks 0.05% / init	stocks 0.1% / init	stocks 0.3% / init	stocks 0.5% / init
2023	25081.40	0.02%	0.05%	0.15%	0.24%
2024	22652.15	0.02%	0.05%	0.14%	0.23%
2025	21296.54	0.02%	0.04%	0.12%	0.21%
2026	20898.91	0.02%	0.04%	0.11%	0.18%
2027	19462.88	0.02%	0.03%	0.10%	0.16%
Year	Initial Forecast, mln USD	bonds 300k pcs / init	bonds 700k pcs / init	bonds 2kk pcs / init	bonds 3.5kk pcs / init
2023	25081.40	0.05%	0.11%	0.32%	0.56%
2024	22652.15	0.05%	0.11%	0.32%	0.55%
2025	21296.54	0.05%	0.11%	0.30%	0.53%
2026	20898.91	0.04%	0.10%	0.30%	0.52%
2027	19462.88	0.04%	0.10%	0.30%	0.52%

(compiled by the author based on data from [1–2]).

The Total Valuation in the DCF model, considering the Terminal Value (Table 6), illustrates that bonds have a more pronounced impact on total valuation compared to stocks. This is attributed to the fact that bonds generate a more substantial revenue, influencing both the TV and Present Value of TV. The percentage variations in the total valuation for different scenarios of stock and bond issuance, relative to the initial forecast, show that bonds, especially at higher levels, contribute more significantly to the total valuation.

Table 6

Total Valuation using DCF model for each scenario, 2027

Indicator, 2027	Initial Forecast, mln USD	stocks 0.05% / init	stocks 0.1% / init	stocks 0.3% / init	stocks 0.5% / init
TV	1010257.55	0.05%	0.10%	0.29%	0.48%
PV TV	633181.09	0.05%	0.10%	0.31%	0.51%
Total Valuation	739189.84	0.05%	0.10%	0.29%	0.48%
Indicator, 2027	Initial Forecast, mln USD	bonds 300k pcs / init	bonds 700k pcs / init	bonds 2kk pcs / init	bonds 3.5kk pcs / init
TV	1010257.55	0.02%	0.04%	0.11%	0.20%
PV TV	633181.09	0.01%	0.03%	0.09%	0.16%
Total Valuation	739189.84	0.02%	0.04%	0.12%	0.21%

(compiled by the author based on data from [1–2]).

Overall, in the DCF valuation of Berkshire Hathaway, different scenarios show that bonds have a more pronounced impact on Total Valuation than stocks. This analysis, using Free Cash Flow dynamics, indicates that bond issuances, by lowering WACC and altering the capital structure, lead to a higher valuation. This effect is evident when considering both the Terminal Value and its Present Value. The comparison of various stock and bond issuance scenarios reveals that bonds, especially in larger quantities, significantly enhance total valuation relative to the initial forecast.

Conclusion.

The analysis from 2007 to 2022 involves diverse models, backtested with MAPE. Complex models do not always show better accuracy than trivial model. Despite its

simplicity, the trivial model often competes well because of timeseries data specificity of and limitations of dataset. Metrical evaluation ensures robust model selection for forecasting Berkshire Hathaway's trajectory from 2023 to 2027. The forecasted values serve as a foundation for scenarios involving bond and stock issuances.

Separate bond and stock issuances influence the company’s financial landscape differently. Bonds influence early revenue growth, while equity proves more profitable in the long-term. Net Income is more impacted by bonds issuance than stocks, while Total Assets increase more with stocks issuance due to its non-obligatory nature. The relative dynamics reveal non-linear effects, with bonds exerting a more substantial influence on total valuation due to significant revenue generation. Such an approach allows for a detailed understanding of the unique consequences of each financial instrument, providing insights into the interplay between debt and equity financing. Consequently, the simulation contributes to a robust foundation for forecasting and evaluating the potential impact of strategic decisions on Berkshire Hathaway's financial trajectory, emphasizing the pivotal role of revenue generation and dependencies in shaping overall company valuation.

In DCF valuation, bond issuances notably outperform stocks in impacting Total Valuation. This is due to bonds lowering the WACC and altering the capital structure, thereby increasing the valuation. The effect is pronounced in both Terminal Value and its Present Value, with larger bond issuances significantly boosting total valuation.

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