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Stock Valuation Analysis Based on Fuzzy Logic for Investment Selection (Case Study: PT. XL Axiata Tbk. and PT. Telkom Indonesia Tbk.)

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Abstract

The stock value of a company fluctuates with capital market conditions, requiring investors to consider various factors for precise investment decisions. Stock valuation determines the fair price of a company's stock, guiding buying and selling transactions. This research uses Discounted Cash Flow (DCF), Price to Earnings (P/E), and Enterprise Value to EBITDA (EV/EBITDA) to ascertain fair stock prices, integrating results with Mamdani fuzzy logic to determine investment weights. The result of this research is that both EXCL and TLKM hold significant weight in the investment portfolio with TLKM has slightly higher stock weight than EXCL. This suggests TLKM offers more potential for profitable future investments. Investors can use these results in portfolio management for investment selection.

Keywords: Investment; Stock Valuation; Fuzzy Logic

1. Introduction

Stock investment has become a popular trend among the public, driven by increased interest from general society, technological advancements, and the popularity of stock trading applications. Investors often choose sectors for investment based on growth potential, government policies, and economic development. The National Medium-Term Development Plan also known as Rencana Pembangunan Jangka Menengah Nasional (RPJMN) 2020-2024 emphasizes the importance of infrastructure development for sustainable economic growth, making it an attractive choice for investors. Furthermore, within the infrastructure sector, telecommunication companies such as EXCL and TLKM stand out due to their robust income generation and cash flow. Additionally, their established market presence, technological innovation, and strategic positioning within the telecommunications industry make them appealing investment options. (Kementerian PPN/Bappenas, 2020).

Forming a stock portfolio is a common way to participate in the stock market. However, the stock market is complex and high-risk, making it crucial to determine the fair price of stocks to align with the true value of companies. Understanding fair price helps investors manage investment risks (Noveriyanto and Yorinda, 2021). Fair price can also identify overvalued or undervalued stocks, guiding investors on whether to sell or avoid such stocks (Dukalang et al., 2021). A wisely built portfolio helps investors achieve their goals and manage risks effectively in a dynamic market.

Fair price determination uses intrinsic value and relative value approaches. Intrinsic value focuses on future cash flow projections and company fundamentals, with the Discounted Cash Flow (DCF) method being a common tool (Noveriyanto and Yorinda, 2021). In contrast, relative value compares stock valuations with similar market stocks using multiples such as Price to Earnings (P/E) and Enterprise Value to EBITDA (EV/EBITDA) (Alfadilla and Dalam, 2023). Multiples are practical for conveying information and validating investment valuations, avoiding subjective projections required by DCF (Noveriyanto and Yorinda, 2021).

In addition to fundamental analysis, various studies have applied technical analysis to stock valuation. Witayakiattilerd (2019) combined fundamental and technical analysis using financial ratios and the fuzzy Mamdani system to recommend industrial sector stock allocations. Ikhsan et al. (2020) used performance ratios and the fuzzy Mamdani system to achieve a Mean Absolute Percentage Error (MAPE) of 0.2455, demonstrating the system's

effectiveness in assessing company performance. Alamsyah et al. (2022) used the CAPM model to identify efficient and inefficient stocks in a portfolio.

This study differs from previous research by integrating DCF, P/E, and EV/EBITDA methods with fuzzy logic to calculate investment weights. The results indicate stock quality for portfolio formation. This research provides valuable information for investors in managing portfolios and developing investment strategies.

2. Literature Review

2.1. Stock Investment

A stock represents proof of capital ownership in a company, with each stock having a market price known as the stock price. The stock price is used to calculate stock returns, reflecting the profit or loss an investor earns from their investment. Equation (1) determine continuous stock returns over a period of time.

$$R_{it} = \ln\left(\frac{P_{it}}{P_{it-1}}\right) \tag{1}$$

where R_{it} is stock return *i* in period *t*, P_{it} is stock price *i* in period *t*, and P_{it-1} is stock price *i* in period *t*-1 (Sukono et al., 2018). Based on equation (1), equation (2) is used to determine the average stock return.

$$\bar{R}_i = \frac{\sum_{t=1}^{n} R_{it}}{n} \tag{2}$$

where $\bar{R}_i$ is the average stock return *i* and n is number of periods observed.

2.2. Discounted Cash Flow (DCF)

Discounted Cash Flow (DCF) method values stocks by adjusting cash flows over time based on the time value of money. The cash flow calculated is Free Cash Flow to the Firm (FCFF) which is obtained by subtracting operating cash flow from capital expenditures (Alfadilla and Dalam, 2023). The cash flows are projected for 5 years based on FCFF calculated by equation (3).

$$FCFF_t = FCFF_{t-1}(1+g) \tag{3}$$

where $FCFF_t$ is FCFF in period *t*, $FCFF_{t-1}$ is FCFF in period *t*-1, and g is growth rate. Meanwhile, the terminal value calculated by equation (4) is used for the following years.

$$TV_n = \frac{FCFF_n \cdot (1+g)}{r-g} \tag{4}$$

where TV_n is last period terminal value, $FCFF_n$ is last period FCFF, and r is discount rate. The discount rate or the Weighted Average Cost of Capital (WACC), is calculated using equation (5).

$$r = \frac{D}{D+E} \cdot r_d \cdot (1-T) + \frac{E}{D+E} \cdot r_e \tag{5}$$

where D is debt, E is equity, and T is tax rate (Sasongko and Tanujaya, 2020). The discount rate consists of the cost of equity (r_e), determined by the Capital Asset Pricing Model (CAPM), and the cost of debt (r_d), determined by comparing the interest expense to debt. The expected return by CAPM is calculated using equation (6).

$$E(R_i) = R_f + \beta_i[E(R_m) - R_f] \tag{6}$$

where $E(R_i)$ is expected stock return *i*, R_f is risk-free rate, β_i is systematic risk of stock *i*, $E(R_m)$ is market expected return (Sukono et al., 2018). Based on the equation above, the present value of future cash flows is stated by equation (7) (Sasongko and Tanujaya, 2020).

$$PV = \sum_{t=1}^{n} \frac{FCFF_t}{(1+r)^t} + \frac{TV_n}{(1+r)^n} \tag{7}$$

Therefore, the fair price of stocks using DCF is obtained by the equation (8)

$$Fair\ price = \frac{Present\ value - Debt}{Shares\ outstanding} \tag{8}$$

2.3. Price to Earnings (P/E)

P/E is a market valuation ratio that compares the market price per share to earnings per share and is stated by equation (9) (Pradnyaningsih and Suarjaya, 2022)

$$P/E = \frac{Market\ price}{Earnings\ per\ share} \tag{9}$$

The P/E ratio indicates how much investors are willing to pay for each unit of earnings the company generates (Lestari dan Suryantini, 2019). Therefore, the fair price of stocks using P/E is obtained by the equation (10).

$$Fair\ price = Earnings\ per\ share \cdot Average\ P/E \tag{10}$$

2.4. Enterprise Value to EBITDA

EV/EBITDA focuses on the overall value of the company and reflects core operational performance unaffected by non-cash factors such as depreciation and tax expenses. This ratio is stated by equation (11) (Koller et al., 2005).

$$EV/EBITDA = \frac{Enterprise\ value}{EBITDA} \tag{11}$$

The EV/EBITDA ratio indicates how much investors are willing to pay for each unit of operational income the company generates. Therefore, the fair price of stocks using EV/EBITDA is obtained by the equation (12).

$$Fair\ price = \frac{(EBITDA \cdot Average\ EV/EBITDA) - Debt}{Shares\ outstanding} \tag{12}$$

2.5. Fuzzy Mamdani

In fuzzy Mamdani, fuzzification divides variables into fuzzy sets and determines membership functions. It calculates the output membership degree (μ) by taking the minimum value of associated input memberships. The fuzzy set solution is obtained by selecting the maximum value from each associated fuzzy rule. The crisp set solution is obtained using the centroid method stated by equation (13).

$$w_i = \frac{\int_x x\mu(x)dz}{\int_x \mu(x)dz} \tag{13}$$

where w_i is the center point of fuzzy region. Based on equation (13), the fuzzy weights are normalized by equation (14).

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \tag{14}$$

where w_i is stock i investment weight and W_i is stock i normalized investment weight (Kusumadewi and Purnomo, 2013).

3. Materials and Methods

3.1. Materials

The object includes analyzing monthly stock closing prices and financial reports from PT. XL Axiata Tbk. (EXCL) and PT. Telkom Indonesia (TLKM) companies listed on the Indonesia Stock Exchange (IDX) during 2020-2022. Data were obtained directly from the official websites of Yahoo Finance (https://finance.yahoo.com) and IDX (www.idx.co.id). Analysis and data processing were conducted using Microsoft Excel and Matlab R2021a.

3.2. Methods

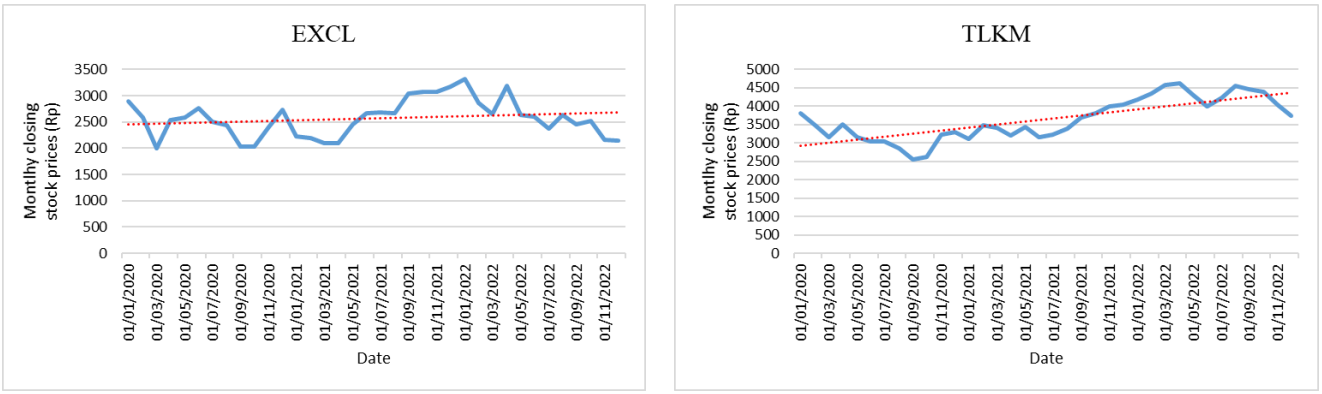
Methods include: the stages and formulas that are used in data analysis, arranged sequentially step by step.

1) Collect monthly closing prices and financial reports of the company period 2020-2022.
2) Calculate stock returns and average returns using equations (1) and (2), then determine expected returns using equation (6).
3) Calculate the discount rate using equation (5), project cash flows with equations (3) and (4), and determine the present value with equation (7). Use DCF to find the fair stock price with equation (8).

4) Calculate the P/E ratio with equation (9) and determine the fair stock price using equation (10).
5) Calculate the EV/EBITDA ratio with equation (11) and determine the fair stock price using equation (12).
6) Perform fuzzification and fuzzy inference to obtain stock weights using equation (13) and normalize weights with equation (14).

4. Results

This research uses EXCL, TLKM, and the Jakarta Stock Exchange (JKSE) monthly closing stock prices. Based on closing stock price data, a graph showing the fluctuations of EXCL and TLKM stock prices, created with Microsoft Excel, is presented in Figure 1.



(a) (b)

Figure 1: Plot monthly stock closing prices; (a) EXCL, (b) TLKM

Based on Figure 1, EXCL and TLKM stock prices have increased, indicating that investors expect these prices to continue rising. To form a stock portfolio, the initial step is to determine stock and market index returns based on monthly closing prices. Returns and average returns are calculated using equation (1) and equation (2). The expected return with CAPM is calculated using equation (6) and the results are displayed in Table 1.

Table 1: Expected return of stock

Stock	$E(R_i)$
EXCL	0.05431
TLKM	0.04984

Table 1 indicates that investors anticipate a higher return from EXCL compared to TLKM, suggesting that EXCL is perceived to have slightly better growth prospects. Using equation (5), the discount rates for EXCL and TLKM are 9.56% and 5.51%, respectively. These rates were then applied to financial report data to project cash flows for 5 years using equation (3) and equation (4) for subsequent years. The present value of these cash flows was determined using equation (7). Based on these, the fair stock prices were calculated using equation (8). The results in billions of IDR unless stated otherwise are shown in Table 2.

Table 2: DCF valuation method

Stock	$FCFF_1$	$FCFF_2$	$FCFF_3$	$FCFF_4$	$FCFF_5$	TV_5	Fair price (IDR)
EXCL	5,644.57	5,926.80	6,223.14	6,534.30	6,861.01	99,607.35	7,447.93
TLKM	36,390.20	38,209.71	40,120.20	42,126.21	44,232.52	1,507,173.16	13,235.21

Based on Table 2, the results indicate that, according to the DCF valuation method, TLKM has a higher intrinsic value than EXCL. Investors might interpret TLKM as having stronger fundamentals and a better growth outlook, making it potentially a more attractive investment compared to EXCL.

The next step is to determine the fair stock price relatively using P/E. Based on the data from the financial report, the P/E ratios for the years 2020-2022 were calculated using equation (9). The average ratio obtained for both stocks is 29.15. Based on this ratio, the fair stock prices were calculated using equation (10). The results are shown in Table 3.

Table 3: P/E valuation method

Stock	P/E_{2020}	P/E_{2021}	P/E_{2022}	Fair price (IDR)
EXCL	78.35	26.25	20.47	3,047.45
TLKM	15.76	16.16	17.90	6,106.83

Based on Table 3, according to the P/E valuation method, it indicates that TLKM stock is relatively more highly valued compared to EXCL. This results imply that investors may perceive TLKM to have stronger earnings potential or lower risk, thus justifying the higher price per share.

The subsequent step involves determining the fair stock price relatively using the EV/EBITDA. Based on financial report data, the EV/EBITDA ratios for 2020-2022 were determined through equation (11). The average ratio for both stocks was computed to be 3.8. This ratio was then utilized to compute the fair stock prices through equation (12), with the results presented in Table 4.

Table 4: EV/EBITDA valuation method

Stock	$EV/EBITDA_{2020}$	$EV/EBITDA_{2021}$	$EV/EBITDA_{2022}$	Fair price (IDR)
EXCL	2.35	2.97	2.05	4,040.53
TLKM	4.93	5.22	5.27	2,261.75

Based on Table 4, despite TLKM having a lower fair price compared to EXCL with the EV/EBITDA ratio, it could indicate that TLKM's earnings are relatively more valuable when considering the company's enterprise value. This variation underscores the importance of utilizing multiple valuation metrics to gain a comprehensive understanding of a stock's intrinsic value.

Variables $K_1, K_2,$ and K_3 represent the fair prices obtained using DCF, P/E, and EV/EBITDA, respectively, inputted into the fuzzy inference system using the Mamdani method with Matlab R2021a. The input variables are divided into three fuzzy sets: "overvalued" (O), "fair valued" (F), and "undervalued" (U), while the output variable W is divided into five fuzzy sets: "very low" (VL), "low" (L), "medium" (M), "high" (H), and "very high" (VH).

Gaussian and S curves are utilized as membership functions for input variables, while trapezoidal and triangular curves are employed for output variables. K_1 is derived based on the fundamental characteristics of each company, whereas K_2 and K_3 are comparative, representing inter-company stock comparisons. Thus, the domain of K_1 varies for each stock, depending on the descriptive statistics of the respective closing stock prices, while the domain of K_2 and K_3 is consistent for all stocks, determined by the descriptive statistics of both stocks. The membership functions for input and output variables are illustrated in Figure 2.

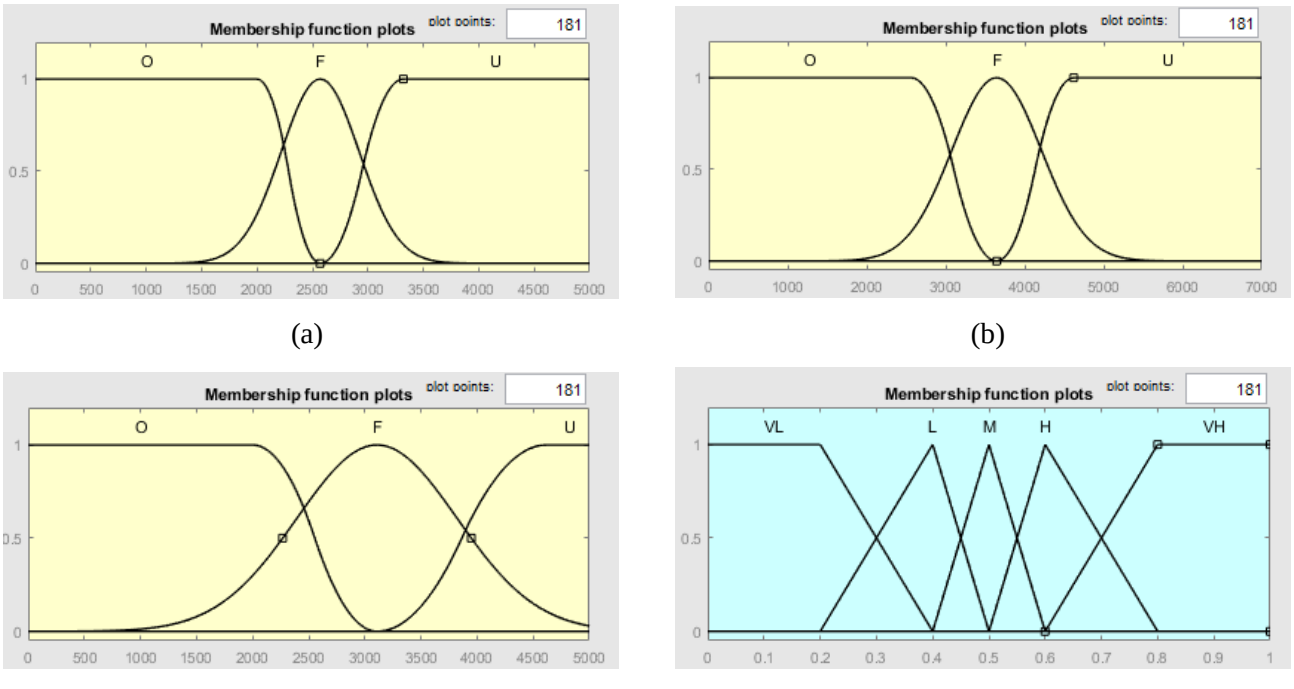


Figure 2: Membership functions plot; (a) Variable K_1 for EXCL, (b) Variable K_1 for TLKM, (c) Variables K_2 and K_3 for both stocks, (d) Variable W

The fuzzy rule base is established assuming that undervalued stocks will yield high weights, and vice versa. Based on this assumption, weights are assigned as follows: 0 for overvalued stocks, 0.5 for fair valued stocks, and 1 for undervalued stocks, resulting in 27 combinations forming the basis of the fuzzy rule.

The Mamdani method's inference process is computed with the assistance of Matlab software, and defuzzification is performed using equation (13). The obtained stock investment weights are normalized using equation (14). The results are presented in Table 5.

Table 5: Investment weight

Stock	w_i	W_i
EXCL	0.742	0.484
TLKM	0.79	0.516

Based on Table 5, TLKM is considered to have a higher impact on the portfolio's performance compared to EXCL. This evaluation is based on the allocation of a higher investment weight to TLKM, indicating that investors perceive TLKM as having greater potential to contribute to the overall returns of the portfolio. Consequently, investors may be advised to consider allocating a larger portion of their investment funds to TLKM as it is expected to contribute more significantly to the overall portfolio returns.

5. Discussion

In this research of EXCL and TLKM stocks, the fair stock price calculations using three valuation methods, Discounted Cash Flow (DCF), Price to Earnings (P/E), and Enterprise Value to EBITDA (EV/EBITDA), serve as input variables in Mamdani fuzzy logic. This diverse approach from each valuation method enhances the accuracy and precision of the analysis, aiding in investment decision-making by generating investment weights for each stock. These weights reflect how well the stocks perform for investment based on predefined criteria, informing investors of more precise investment priorities.

Traditional stock valuation often leads to buy or sell decisions without offering detailed insights into the strength of such recommendations. However, fuzzy logic allows for more varied investment weights, with values closer to 1 indicating higher certainty levels in recommendations. This approach provides investors with clearer guidance, facilitating more informed and strategic investment decisions.

6. Conclusion

Based on the comprehensive analysis involving various valuation methods and fuzzy logic, it is evident that both EXCL and TLKM hold significant weight in the investment portfolio with EXCL and TLKM weights are 0.742 and 0.79, respectively. These results suggest that investors perceive both companies as valuable assets for portfolio diversification and potential returns. These weights are indicative of the confidence investors have in the performance and prospects of EXCL and TLKM within the telecommunications sectors. The higher weights assigned to TLKM compared to EXCL could imply that TLKM is perceived to have a slightly stronger impact on portfolio performance. However, the relatively high weights for both stocks underscore their importance in the investment strategy, highlighting the strategic significance of telecommunications companies in driving portfolio growth and stability. For future research, additional variables such as the Dividend Discount Model (DDM) can be used to determine the fair stock price. A different approach for determining stock investment weights can also be employed using financial ratios such as liquidity and solvency ratios.

References

Alfadilla, J., & Dalam, W. (2023). Stock Valuation Using Discounted Cash Flow and Relative Valuation Methods. Proceedings of the 4th International Conference on Applied Economics and Social Science. EAI. https://doi.org/10.4108/eai.5-10-2022.2325901

Koller, T., Goedhart, M., & Wessels, D. (2005). Valuation Measuring And Managing The Value Of Companies.

Kusumadewi, S., & Purnomo, H. (2013). Applications of Fuzzy Logic to Decision Support (2 ed.). Yogyakarta: Graha Ilmu.

Lestari, I. S. D., & Suryantini, N. P. S. (2019). The influence of CR, DER, ROA, and PER on share prices in pharmaceutical companies on the IDX. Udayana University Management E-Journal, 8(3), 1844–1871. https://doi.org/10.24843/EJMUNUD.2019.v08.i03.p24

Pradnyaningsih, N. W. A., & Suarjaya, A. A. G. (2022). The Influence of Company Fundamental Factors on Stock Returns. Udayana University Management E-Journal, 11(7), 1377–1396. https://doi.org/10.24843/EJMUNUD.2022.v11.i07.p06

Sasongko, A., & Tanujaya, E. (2020). Valuation Analysis of PT XYZ's Initial Share Value Regarding the 2020 IPO Plan with Discounted Free Cash Flow and Relative Valuation Method. Makalah disajikan dalam Proceedings of the 2nd International Conference of Business, Accounting and Economics. Purwokerto: EAI. https://doi.org/10.4108/eai.5-8-2020.2301192

Sukono, et al. (2018). Analysis of stock investment selection based on CAPM using covariance and genetic algorithm approach. IOP Conference Series: Materials Science and Engineering, 332, 012046. https://doi.org/10.1088/1757-899X/332/1/012046