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ALGORITHMIC FINANCIAL ANALYSIS STUDY OF PREDICTIVE ACCURACY

Introduction

Chaotic and complex nature is a distinctive element of trading in the stock exchange market. As a result, investors have tried to use various tools, including Artificial Intelligence and algorithms to predict future market moves[1]. Algorithmic trading became an integrated part of the financial market in the early 1990s when computers and complex algorithms started monitoring markets and determining trading decisions[2]. In scientific literature, it is possible to find numerous methods for predicting future market behavior, such as machine learning and deep learning. Nevertheless, the accuracy of algorithms designed to conduct financial analysis and forecast the market remains unknown. The focal point of this paper is to determine whether algorithmic financial analysis, based on the selected indicators, can be insightful for investors and forecast future stock prices. The paper has been divided into two separate parts. The first one is dedicated to explaining how an original algorithm operates. A financial analysis of chosen companies from different industries has been conducted in further parts. The analysis results can provide helpful insight into the accuracy of the studied method.

1. Methodology

An original algorithm designed using the Python programming language conducts a comprehensive financial analysis of a publicly traded company. It calculates selected indicators and converts the results to a scale with 200 scoreable points. After computing the score, it provides the user with recommendations ranging from ‚strong sell' to ‚strong buy.' To this end, the calculations have been focused on the eight most important indicators and the percentage

1 G. Cohen, *Algorithmic Trading and Financial Forecasting Using Advanced Artificial Intelligence Methodologies*, "Mathematics", Vol. 10(18), 2022, p. 2.

2 A. Chaboud, B. Chiquoine, E. Hjalmarsson, C. Vega, *Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market*, "The Journal of Finance", Vol. 69(5), 2014, p. 2046.

change over time of the chosen indicators. The indicators used in the algorithm are as follows:

- Return on Equity
- Return on Assets
- Return on Sales
- Ebit Margin
- Working Capital Ratio
- Quick Ratio
- Earnings per Share
- Price-to-Earnings

In the next part of this paper, a financial analysis of chosen companies from different industries is conducted after clarifying how the algorithm operates. The analysis results can provide helpful insight into the accuracy of the studied method.

2. Key indicators

Fundamental analysis theory is a commonly used approach for evaluating the price of financial instruments, including stocks. It states that it is possible to determine the future price of the instrument by relying on a comprehensive analysis of available data. This approach includes two main steps. These are macroeconomic analysis and financial indicator analysis[3]. Macroeconomic analysis examines numerous economic variables such as GDP, inflation, and interest rates. On the contrary, financial indicator analysis focuses on the company's internal factors. The company's management board can use financial analysis as a fundamental approach to adjust its strategy. Still, investors can also benefit from it by estimating the financial situation and credibility of the company. The selected indicators in the presented algorithm belong to the primary indicators used in fundamental theory – liquidity, profitability, and shareholders' ratios[4]. The algorithm's output can substitute for the financial analysis used in this approach. However, it should be complemented with macroeconomic analysis to deliver more accurate predictions.

To calculate all of the necessary parameters, publicly available financial data of the studied company are needed. These data can be obtained by analyzing financial statements, including balance sheets and income statements. Since all publicly traded companies must provide the public with their financials,

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3 K. Jajuga, *Osiemdziesiąt lat analizy fundamentalnej,* Zeszyty Naukowe Uniwersytetu Szczecińskiego, nr 75, 2015, p.185-186.

4 Ł. Siemniuk, *Sprawność funkcjonowania przedsiębiorstwa w aspekcie analizy fundamentalnej spółek akcyjnych,* Wydawnictwo Uniwersytetu w Białymstoku, Białystok 2010, p.178-179.

they can be found on the company's official website or various agents such as *Yahoofinance.com*, *WSJ.com*, or *GPW.pl*. Data from at least the past three years must be available for the most accurate recommendations. Notably, since different agencies use different methods of calculating and presenting data, the value of specific metrics can vary. Therefore, it is highly recommended that data obtained from one source be compared with data from two companies.

One of the most crucial profitability ratios is Return on Equity (ROE). It gives insight into how efficiently a corporation generates its profit based on total shareholder equity. The higher the ROE, the more attractive the company is for investors. For instance, ROE valued at 0.15 indicates that per 1 monetary unit of total equity, 0.15 monetary units of profit are generated.

$$ROE = \frac{Net\ Profit}{Total\ Equity}$$

Equation 1. ROE

$$\Delta ROE_t = \frac{ROE_t - ROE_{t-1}}{|ROE_t|}$$

Equation 2. ROE percentage change over time

Return on equity equal between 0,15 and 0,20 is considered a desired level. However, this indicator can be easily manipulated by the company. This can be achieved by executing a buyback. In this case, the company repurchases its shares from its shareholders, thus decreasing the value of a denominator and increasing the value of the indicator itself. This scenario can create a false impression of the improved efficiency of the management and attract new potential investors[5]. To avoid such misinterpretation, ROE should be studied over time. For that reason, the algorithm calculates the value of ROE itself and its percentage change over the preceding two years.

The next indicator from the group of profitability ratios is the Return on Assets. In this case, the metric shows how efficiently management uses the company's assets to generate profit—in other words, it allows analysts to determine the company's operational efficiency[6].

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5 M. Bhaumik, *What is Return on Equity?*, Value Research, https://www.valueresearchonline.com/stories/51995/what-is-return-on-equity/?__cf_chl_tk=ymoCZRK4AwuxkMuGsXI4vEdOiSq5TsQ6zEZ1lRwGDac-1708806659-0.0-3773# (access: 25.02.2024).

6 M. Heikal, M. Khaddafi, A. Ummah, *Influence Analysis of Return on Assets, Return on Equity, Net Profit Margin, Debt to Equity Ratio, and Current Ratio, Against corporate Profit*

$$ROA = \frac{Net\ Profit}{Total\ Assets}$$

Equation 3. Return on Assets

$$\Delta ROA_t = \frac{ROA_t - ROA_{t-1}}{|ROA_t|}$$

Equation 4. ROA percentage change over time

Operational efficiency may vary among companies in different sectors. Some firms might require substantial asset holdings to support their operational activities, which leads to lower ROA, whereas others may operate with minimal asset requirements. I do not believe comparing ROA to other firms in the same industry is insightful. Nowadays, many companies are based on the idea of a sharing economy, where underutilized assets are shared with others without a transfer of ownership[7]. Airbnb Inc., which operates on this principle, will have fewer assets than most hotel chains in the same industry. Hotels of moderate quality might compete with Airbnb, but they will require significantly more assets in the form of buildings, food, furniture, etc. Thus, the main idea behind using ROA in this algorithm is to study the improvement of operational efficiency by calculating the yearly increase of ROA rather than the operational efficiency itself.

Return on Sales is another indicator used to calculate a company's operational efficiency. This time, it shows how efficient the company is in turning sales into profits; in other words, ROS provides insight into how much profit is derived from 1 monetary unit of sales. Investors seeking valuable information regarding the company's financial stability rely highly on ROS. It accurately communicates the percentage of operating cash a company makes on its revenue and provides insight into potential dividends, reinvestment potential, and the company's ability to repay debt[8].

Growth in Automotive In Indonesia Stock Exchange, "International Journal of Academic Research in Business and Social Sciences", Vol. 4(12), 2013, p. 104.

7 D. Schlagwein, D. Schoder, K. Spindeldreher, *Consolidated, Systemic Conceptualization and Definition of the "Sharing Exonomy"*, "Journal of the Association for Information Science and Technology", Vol. 71:817–838, 2019, p. 818.

8 W. Wierzbicka, *Return On Sales For Companies In Eastern Poland*, "Olsztyn Economic Journal", Vol. 10(4), 2015, p. 375-376.

$$ROS = \frac{Net\ Profit}{Sales}$$

Equation 5. Return on Sales

$$\Delta ROS_t = \frac{ROS_t - ROS_{t-1}}{|ROS_t|}$$

Equation 6. ROS percentage changes over time

It is highly recommended to compare the company's ROS to other companies in the industry, ideally to a similar size. Moreover, the percentage change in ROS over time is even more critical and insightful. Let us assume that company "A" has ROS 5% greater than their sector competitors. At first glance, this might be attractive for potential investors looking to acquire new stocks. However, further research shows that the ROS decreased by 3% from the previous year and 7% during the two preceding years. In this case, we can assume the company has run into financial troubles. Despite yearly ROS being higher than its competitors, the trend analysis shows that there is a high probability that the company will become even less efficient in the next few years and deliver worse financial results. Such cases emphasize the importance of studying the trend of this indicator.

Ebit Margin provides insight into how much operating earnings are derived from one unit of sales. Ebit represents Earnings Before Interest and Taxes and depicts profits from the company's primary operations. When combined with all the indicators above, EBIT margin can provide an accurate perception of the efficiency and health of the analyzed company.

$$Ebit\ Margin = \frac{Ebit}{Sales}$$

Equation 7. EBIT Margin

Indicators from the group of liquidity ratios study the financial structure of the company and its most liquid assets, including cash, cash equivalents, and short-term investment (i.e., all the assets that can be liquified within one year)[9]. The Working Capital Ratio helps determine whether the company can cover its short-term liabilities using its assets used for day-to-day operations.

9 S. Qadir Dar, A. Ahmad Dar, *The Working Capital and Its Ratios: A Qualitative Study*, "International Journal of Statistics and Actuarial Science", Vol. 1(1), 2017, p. 24.

$$WCR = \frac{Current\ Assets}{Current\ Liabilities}$$

Equation 8. Working Capital Ratio

The principle known as the Golden Financing Rule says that the value of current liabilities ought not to exceed the total value of current assets. Therefore, the Working Capital Ratio (WCR) should not depreciate below the threshold of 1.0. This indicator also depicts the structure of the net working capital – the portion of assets used for day-to-day operations with long-term financing. For instance, if the WCR equals 1.67, net working capital equals 67% of the company's current liabilities. Since current assets contain only the most liquid assets, including cash and its equivalents, the value of this indicator should not be too great. WCR over 2.0 might indicate ineffective cash allocation, which could have been used for potential investments. However, specific industries might require substantial current assets holdings to sustain their operations. To solve the issue of interpreting the liquidity ratios, further analysis is needed, using more "conservative" indicators.

$$Quick\ Ratio = \frac{Cash + Cash\ Equivalents + Short\ Term\ Investments}{Current\ Liabilities}$$

Equation 9. Quick Ratio

Quick ratio considers only cash, its equivalents, and short-term investments. It eliminates short-term inventories and, therefore, gives more detailed insight into the company's financial structure and ability to pay short-term obligations. Since these assets are usually easier to liquefy, it also depicts the company's ability to make new and unexpected investments.

The algorithm relies on earnings per share and price-to-earnings ratios from the group of shareholders' ratios. Earnings per share can help determine how much net profit, after subtracting preferred dividends, is being generated per one unit of ordinary shares. Although this metric is not as insightful into the company's profitability as ROS, ROA, and ROE, it is crucial for calculating the P/E ratio.

$$Earnings\ per\ Share = \frac{Net\ Profit - Preferred\ Dividends}{Number\ of\ Ordinary\ Shares}$$

Equation 10. Earnings per Share

$$Price\ to\ Earnings = \frac{Market\ Price\ per\ Share}{Earnings\ per\ Share}$$

Equation 11. Price-to-Earnings

Since the Price-to-Earnings ratio considers market price per share and earnings per share, it provides information on whether the company is over or underpriced compared to its efficiency. The desired level of P/E ratio may vary among different sectors. Safe, well-established companies will have an excellent P/E ratio compared to smaller and more risky companies from the same industry. In this case, investors are willing to pay more for the security; however, they must sacrifice possible greater returns from the investment.

3. Grading System and Interpretation

To begin the analysis, the algorithm needs to be provided with the following data (table 1). In addition, the average values of ROS, EBIT margin, EPS, and P/E of other companies operating in the same sector are needed. These values can be obtained from various internet sources. Still, for the further part of this paper, it has been decided to calculate them using the most prominent companies from the analyzed sector, with data provided by Yahoo Finance.

Table 1. Necessary Financial Data of The Analyzed Company

T	T-1	T-2
Net Profit	Net Profit	Net Profit
Total Sales	Total Sales	Total Sales
Total Assets	Total Assets	Total Assets
Current Assets	-	-
Current Liabilities	-	-
Total Equity	Total Equity	Total Equity
EBIT	-	-
Cash, Cash Equivalents, Short-Term Investments	-	-
Receivables	-	-
Earnings per Share	-	-
Market Price per Share	-	-

Source: Own elaboration.

The values of indicators are calculated and then compared to the benchmark values (table 3). The grading system is based on 200 scoreable points. For each indicator, the analyzed company can receive up to 2 points, which are later multiplied by the rating of the indicator. If the indicator's value is unsatisfactory, the company might receive 0 points. Further recommendation is based on the sum of all the points and is as follows:

Table 2. Recommendation Criteria

Sum of points	Recommendation
161 – 200	Strong Buy
121 – 160	Buy
81 – 120	Hold
41 – 80	Sell
0 – 40	Strong Sell

Source: Own elaboration.

Table 3. Grading System[10]

Indicator	Benchmark Value	Rating	0 points	1 point	2 points
ROE	<0.15 ; 0.20>	10	(-∞ ; 0.135) ∨ (0.220 ; ∞)	(0.135 ; 0.150) ∨ (0.200 ; 0.220)	(0.150: 0.200)
ΔROE t-1	0<	5	(-∞ ; 0)	-	(0 ; ∞)
ΔROE t	0<	5	(-∞ ; 0)	(0 ; 1.05•ΔROE t-1)	(1.05•ΔROE t-1 ; ∞)
ROA	0.05<	10	(-∞ ; 0.045)	(0.045 ; 0.055)	(0.055 ; ∞)
ΔROA t-1	0<	5	(-∞ ; 0)	-	(0 ; ∞)
ΔROA t	0<	5	(-∞ ; 0)	(0 ; 1.05•ΔROA t-1)	(1.05•ΔROA t-1 ; ∞)
ROS	X<	10	(-∞ ; 0.95•X)	(0.95•X ; 1.05•X)	(1.05•X ; ∞)
ΔROS t-1	0<	5	(-∞ ; 0)	-	(0 ; ∞)
ΔROS t	0<	5	(-∞ ; 0)	(0 ; 1.05•ΔROS t-1)	(1.05•ΔROS t-1 ; ∞)
EBIT Margin	X<	10	(-∞ ; 0.95•X)	(0.95•X ; 1.05•X)	(1.05•X ; ∞)
WCR	<1.50 ; 2.30>	10	(-∞ ; 1) ∨ (2.3 ; ∞)	(1 ; 1.5)	(1.5 ; 2.3)

10 X = industry average of the indicator.

Quick Ratio	<0.50 ; 1.00>	10	(-∞ ; 0.4) ∨ (1.1 ; ∞)	(0.4 ; 0.5) ∨ (1 ; 1.1)	(0.5 ; 1)
P/E	>X	10	(1.05•X ; ∞)	(0.95•X ; 1.05•X)	(-∞ ; 0.95•X)

Source: Own elaboration.

4. Case Study of Occidental Petroleum Corporation

Occidental Petroleum Corporation operates in the energy industry. Its operations focus on the exploration and production of oil and gas. Moreover, it processes, transports, and stores oil, natural gas liquids, carbon dioxide, and power. As of March 2024, the company's market cap exceeded USD 54 billion[11]. Financial statements as of 2022, 2021, and 2020 will be considered to study the algorithm's accuracy, and the recommendation will be compared with the outcome observed in 2023.

Table 4. Occidental Petroleum Corporation – Financial Data

Metrics	31/12/2022	31/12/2021	31/12/2020
Net Profit (USD)	13,304,000,000	2,790,000,000	(13,533,000,000)
Total Sales (USD)	36,634,000,000	25,956,000,000	17,809,000,000
Total Assets (USD)	72,609,000,000	75,036,000,000	80,064,000,000
Current Assets (USD)	8,886,000,000	-	-
Current Liabilities (USD)	7,757,000,000	-	-
Total Equity (USD)	30,085,000,000	20,327,000,000	18,573,000,000
EBIT (USD)	15,147,000,000	-	-
Cash, Cash Equivalents, Short-Term Investments (USD)	984,000,000	-	-
Receivables (USD)	4,281,000,000	-	-
Earnings per Share (USD)	12.40	-	-
Market Price per Share (USD)	59.15	-	-

Source: Yahoo Finance, https://finance.yahoo.com/quote/OXY/financials/ (access: 13.03.2024).

11 Global Data, https://www.globaldata.com/company-profile/occidental-petroleum-corp/ (access: 13.03.2024).

Table 5. Energy Industry Average Indicators (as of December 31, 2022)

Return on Sales	EBIT margin	Price-to-Earnings
0.18	0.25	8.78

Source: Own elaboration based on data provided by Yahoo Finance, https://finance.yahoo.com/sectors/energy/ (access: 13.03.2024).

Once the algorithm is provided with the data from Tables 3 and 4, all the necessary indicators are computed, and a recommendation based on the criteria from Table 2 is given. The algorithm's output is as follows.

Picture 1. Algorithm's Output

Source: Own elaboration.

Occidental Petroleum Corporation concluded 2022 with a market price per share of USD 59.15. As of March 2024, the company trades at USD 62.06 per share. Should the investor follow the algorithm's recommendation, the potential return on the investment, including dividends, could be 6.5%.

5. Case Study of Newmont Corporation

Newmont Corporation is the world's leading gold company and silver, copper, zinc, and lead producer. The company operates on multiple continents, including Africa, Australia, and the Americas. The executives talk about Newmont as an industry leader in value creation, supported by robust safety standards, superior execution, and technical expertise[12]. Despite being the only gold producer listed in the S&P 500 Index and having received multiple awards, including being named the top mining company on FORTUNE's 2020 list, it has struggled to generate positive financial outcomes from its operations.

12 Newmont, https://www.newmont.com/about-us/default.aspx (access: 17.03.2024).

Table 6. Gold & Silver Ore Mining Industry – Average Indicators (as of December 31, 2022)

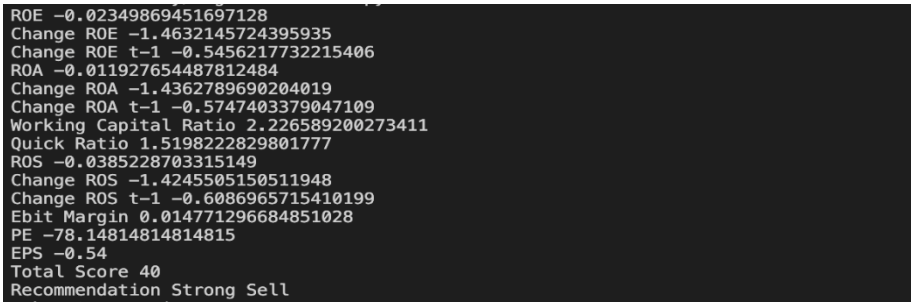
Return on Sales	EBIT margin	Price-to-Earnings
0.12	0.19	20.02

Source: Own elaboration based on data provided by Yahoo Finance, https://finance.yahoo.com/sectors/basic-materials/ (access: 13.03.2024).

Table 7. Newmont Corporation – Financial Data

Metrics	2022	2021	2020
Net Profit (USD)	(459,000,000)	1,109,000,000	2,666,000,000
Total Sales (USD)	11,915,000,000	12,222,000,000	11,497,000,000
Total Assets (USD)	38,482,000,000	40,564,000,000	41,469,000,000
Current Assets (USD)	6,515,000,000	-	-
Current Liabilities (USD)	2,926,000,000	-	-
Total Equity (USD)	19,533,000,000	21,861,000,000	23,879,000,000
EBIT (USD)	176,000,000	-	-
Cash, Cash Equivalents, Short-Term Investments (USD)	3,757,000,000	-	-
Receivables (USD)	690,000,000	-	-
Earnings per Share (USD)	(0.54)	-	-
Market Price per Share (USD)	47.20	-	-

Source: Yahoo Finance, https://finance.yahoo.com/quote/NEM/financials (access: 16.03.2024).



Picture 2. Algorithm's Output

Source: Own elaboration.

In this case, the algorithm turned out to be accurate as well. The Newmont Corporation closed the year 2022 with USD 47.20 per share. As of March 2024, the company's stock is trading at USD 33.88, reflecting a depreciation of USD 13.32. After following the algorithm's recommendation, investors could have avoided 24.3% of loss, including dividends paid during that period.

Conclusion

Based on several financial indicators, the algorithm can give accurate recommendations ranging from ‚strong sell' to ‚strong buy.' The Occidental Petroleum Company case study proved its accuracy by predicting the future growth of the stock value. The algorithm also correctly predicted the depreciation of Newmont Corporation's stock. In both cases, after following the algorithm's feedback, investors could have scored a satisfactory return on the investment or protected themselves from negative returns. Notably, the algorithm studies only eight indicators and their percentage change over time. Therefore, it should not be treated as the primary source of recommendations regarding the analyzed stocks. The accuracy of the presented method of financial analysis proves it can be used in a fundamental theory approach for forecasting the stock exchange market. Nevertheless, it should be complemented with a macroeconomic analysis.

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Abstract

The paper describes the grading system and operation of an algorithm designed using Python programming to conduct a comprehensive financial analysis of a publicly traded company. The algorithm relies on the most important economic indicators: profitability, liquidity, and shareholders' ratios. Financial analyses of two randomly chosen companies were conducted using the financial statements for 2020, 2021, and 2022 to assess the algorithm's accuracy. The results were then compared with the outcomes from 2023 and the first quarter 2024. Case studies of Occidental Petroleum Corporation and Newmont Corporation demonstrate the accuracy of the studied algorithm, which correctly provides the user with accurate recommendations.

Keywords: Financial Analysis, Algorithm, Python

ALGORYTMICZNA ANALIZA FINANSOWA – BADANIE SKUTECZNOŚCI PRZEWIDYWANIA WYNIKÓW

Streszczenie

Artykuł opisuje system oceniania oraz działanie algorytmu zaprojektowanego przy użyciu języku programowania Python w celu przeprowadzanie analizy finansowej spółki akcyjnej. Algorytm opiera się na najważniejszych wskaźnikach finansowych z grup *Liquidity, Profitability, Shareholder's ratios*. W celu oceny skuteczności algorytmu przeprowadzono analizy finansowe dwóch losowo wybranych spółek, wykorzystując sprawozdania finansowe za lata 2020, 2021 i 2022. Następnie wyniki porównano z rzeczywistymi wynikami za lata 2023 i pierwszy kwartał 2024 roku. Studia przypadków Occidental Petroleum Corporation i Newmont Corporation potwierdzają skuteczność badanego algorytmu, który trafnie dostarcza użytkownikowi swoje rekomendacje.

Słowa kluczowe: Analiza Finansowa, Algorytm, Pyhton