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DECISION SUPPORT SYSTEMS FOR FINANCIAL MANAGEMENT CAPITAL OF INDUSTRIAL ENTERPRISES

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The article offers a system of support of decision-making in management of financial capital of production enterprises, which allows to increase efficiency of decision-making in management of financial capital of production enterprises by means of use of specific indicators for calculation of compliance of an enterprise with the strategy of value investment. The system is implemented in the form of a software tool, namely, the code was created using the Vue framework. The interface was created in accordance with the projected design and the needs of the target audience. Testing was carried out according to the most frequent user actions and requests, and in this regard, work was carried out on errors and their correction.

Introduction

Preserving a company's financial capital is a very important part of any business. One of the ways to preserve, and even increase, capital is through investment. Today, there are many investment instruments available: deposits, pension funds, precious metals, real estate, government bonds, cryptocurrencies, etc. But out of all these instruments, shares of large enterprises stand out. Investing in stocks can be very profitable, but this does not mean that buying any company's securities is a safe investment [1–3]. An important part of investing is the fundamental analysis of the securities of companies that can potentially be acquired in an investment portfolio. Automation of this process will improve the quality of analysis, eliminate the human factor from miscalculations, and save a lot of time, which is also useful when analysing hundreds of potential investment portfolio items. Designing systems of this class requires up-to-date and, at the same time, time-tested methods for assessing the financial performance of enterprises. Also, since managers have a great deal of responsibility to the company's employees, it is necessary to be sure that the criteria analysed by the system are reliable. To develop the software tool, the strategy chosen as the basis was the value investing strategy invented by Benjamin Graham, a renowned economist, investor, author and lecturer at Columbia University, whom the most famous investor of all time, Warren Buffett, considers his teacher and whose book The Smart Investor is the best ever written about investments. Since then, the material has been regularly reprinted, and each chapter of the book is accompanied by comments that are relevant to the present day.

The book was translated into Ukrainian and published in 2019 by Nash Format Publishing House [4].

Review and analysis of literature

There are a large number of systems that provide users with up-to-date financial information of enterprises. Such PFMSs offer a large amount of data, charts and historical information not only for companies, but also for government bonds, cryptocurrencies, precious metals, etc. Moreover, the leading giants in this field also offer news related to business, finance and economics. Reference information includes quotes and ratings of securities, press releases and financial reports of companies. Some PFMSs include thematic forums and even offer a range of services for managing personal financial information. One of the largest systems for providing financial information is finance.yahoo.com [5–9], which is a prominent giant in its field. In addition to the browser-based software, the system works on iOS and Android mobile platforms. On the portal (Fig. 1), it is possible to find all the necessary information that may be required not only for fundamental analysis of the enterprise, but also for more complex and narrowly focused calculations.

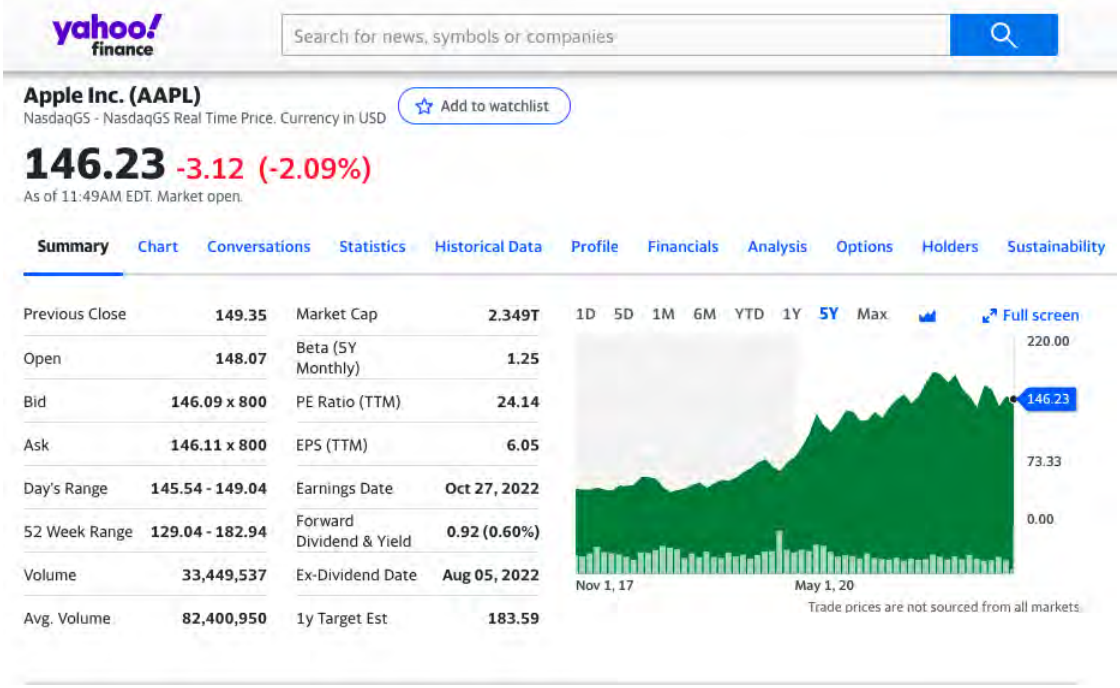

Fig. 1. Primary data of the web resource finance.yahoo.com for the query "Apple Inc"

Also on finance.yahoo.com, users can get information on current economic news, a list of financial instruments that have experienced the biggest rise or fall in the last 24 hours, and some personal finance automation services:

create a personal portfolio that can track up-to-date data on portfolio positions, and get information on taxes and retirement.

Although this service provides the necessary variables for calculating all the indicators of a value investing strategy, it does not have specifically identified strategy indicators that are the basis for finding undervalued stocks.

Another resource that occupies a large part of the financial resources niche is Investing.com, which is a financial platform that provides information on corporate stocks, futures, options, analytics, and economic news. In addition to the website, the system is available on iOS and Android mobile platforms. The product does not currently have a Ukrainian localisation.

Similarly to the previously described Yahoo! Finance resource, the first page of the service has a search box that allows you to find information about the desired company. After the necessary query, we see the screen displaying the data found on the company "Apple Inc.", as well as indicators of the largest stock indices, information on similar tickers, as well as a navigation area, which allows us to display information about the company found (Fig. 2).

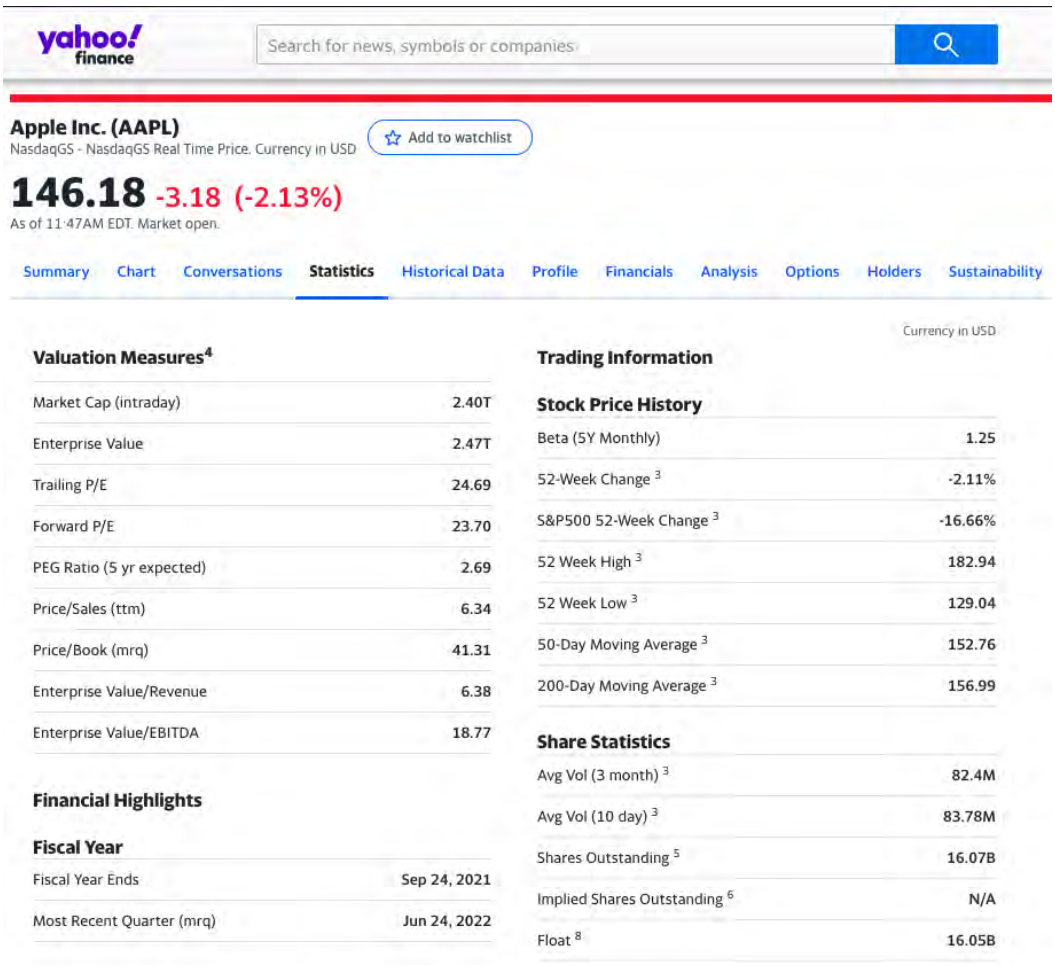

Fig. 2. Fundamental characteristics
and indicators of Apple Inc. provided by finance.yahoo.com

On the investing.com platform, in addition to the company's financial information, the user can find information on publicly traded investment funds and bonds, cryptocurrencies, articles on general market analysis or analysis of a specific investment instrument from invited experts, charts, information on brokers, information on investment conferences and webinars, as well as additional paid content with advanced features for managing a personal investment portfolio, which includes advice on potential investments.

It should be noted that this extended tool allows to calculate all the indicators calculated in the developed software tool. However, there are a number of shortcomings that are essential for the development of a unique decision support system adapted to the realities of modern Ukrainian entrepreneurs and investors:

Calculating the status of each indicator. Since the main area of activity of potential users is not investment and the economic sector in general, statuses for each indicator (recommended, satisfactory, unsatisfactory) were developed to help the user make a decision based on a table of correspondences, in which the recommended values were taken from Benjamin Graham's own standards, and satisfactory values are the minimum allowed in miscalculations.

Displaying the necessary information. The investing.com service provides a large amount of complex information, including charts and calculations of complex financial indicators that are not considered in fundamental analysis. The developed software tool allows us to analyse the company fundamentally, thereby filtering out a large share of financially unhealthy companies.

Intuitive interface. Unlike the reviewed investing.com, the developed system has a user-friendly and minimalised interface exclusively for analysing an enterprise from the point of view of a value investment strategy. Each function of the system is understandable for a user of any website or application.

Ukrainian localisation. Since the software application was developed for use by Ukrainian entrepreneurs and investors, it is important that the system provided services in the state language, which is understandable to everyone regardless of their knowledge of a foreign language.

Another resource that is popular among analysts is finviz.com. This service provides information on financial analytics of companies, futures, cryptocurrencies, and news that may affect financial markets. It has become most popular for displaying the state of the stock market through an interactive map (Figure 3), which adapts the size of each company depending on its sector and market capitalisation.

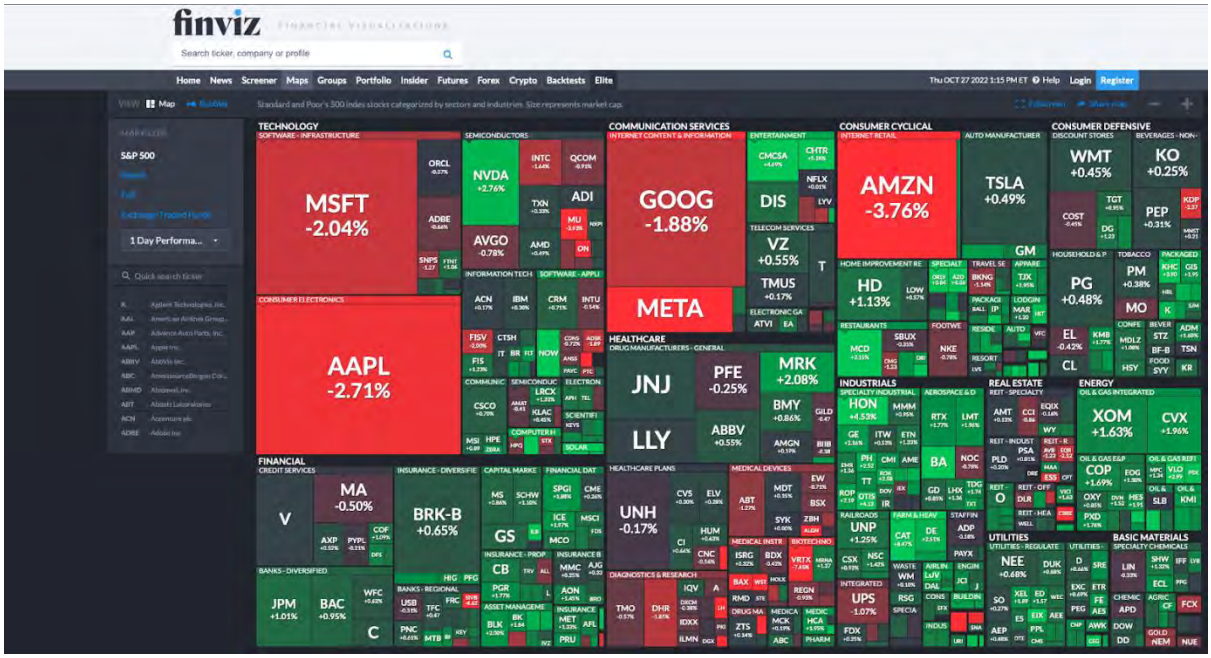

Fig. 3. Stock market map provided by finviz.com

To date, there are no widely available systems that would analyse an enterprise comprehensively and exclusively by the value investment strategy. At this stage, we have considered systems that partially or indirectly calculate one or another strategy indicator separately. This is the main disadvantage of the systems described below, since each indicator does not indicate the reliability of investing in an enterprise, but the comprehensiveness and recommendation of all indicators is the reliability of an enterprise for long-term investment in it.

There are many decision support systems, including economic ones [10–12]. Such systems are implemented in the form of software tools (most often web applications or desktop programs), for example, such as yahoo.finance or finviz. Using these systems, you can find a large amount of historical information, charts, news, expert articles and analytics. However, they do not offer the user any strategy for how to use this information. Therefore, we propose a decision support system that allows the user to analyse the securities of companies using a search field and check whether the company is suitable for a value investment strategy.

Value investing is an investment strategy based on the identification of undervalued securities using fundamental analysis, proposed by Benjamin Graham and David Dodd. Securities eligible for the strategy should have a number of criteria that an investor can use to assess the strategy's suitability: the security should be trading below book value, have a good dividend history, and have low price/earnings and price/book values. Specific recommendation values are listed in the table of correspondence between indicator values and statuses.

Block diagram and algorithm of the decision support system for managing financial capital of manufacturing enterprises

The figure (Fig. 4) shows a block diagram of the decision support system. The input data must be received from the user, most often through the form elements – a search field for entering keywords to find an enterprise for analysis. After the user has entered the data, a list of found enterprises is generated, in which the user can select the desired enterprise. The algorithm of the decision support system for managing the financial capital of manufacturing enterprises is shown in Fig. 5.

The software starts by receiving data from the user using the search field. Upon receiving the data, the client (frontend) of the software tool processes it into a format that the server understands and sends the appropriate requests. The server, in its turn, makes appropriate queries to the database in order to process them and send the client the required response. After the client receives a response from the server, the data goes through two levels of processing – through the indicator service and the status service, where the business logic of the software tool is already running – calculating indicators and comparing each indicator with the correspondence table in order to form the status of the indicator and send the already generated data for rendering in HTML.

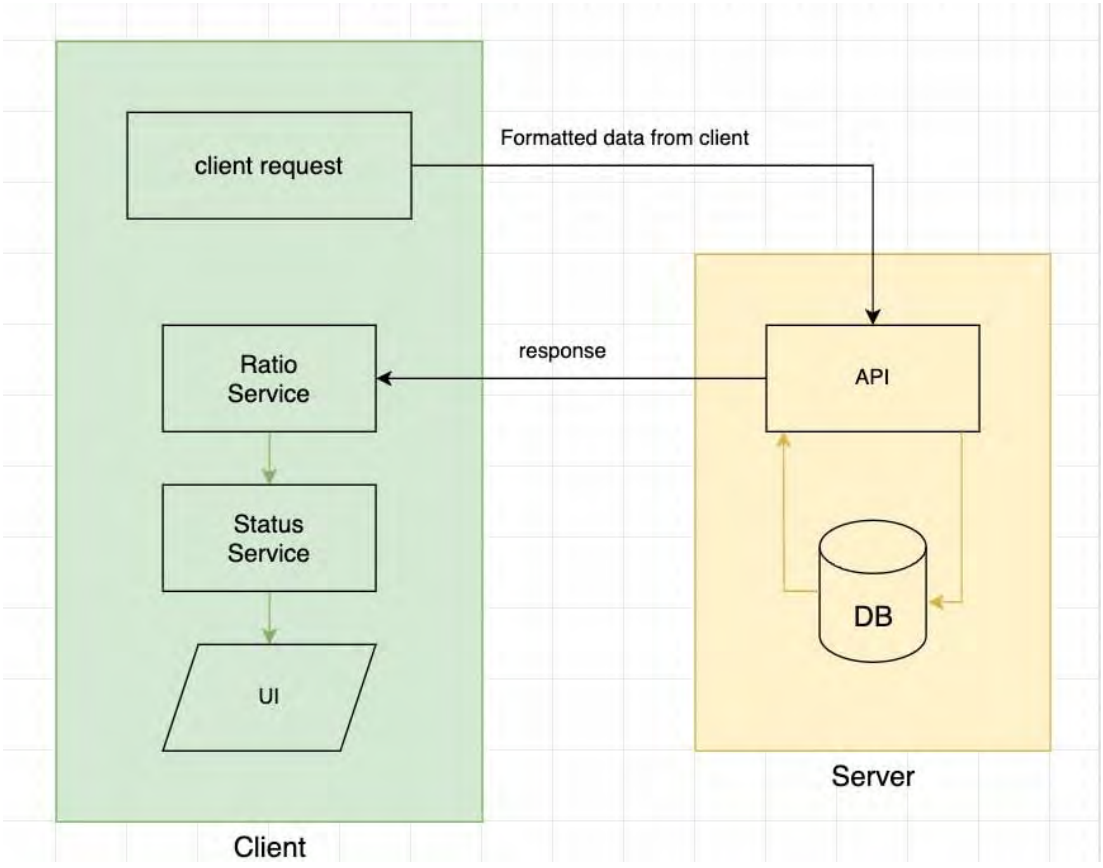

Fig. 4. Technical diagram of the SPRD operation

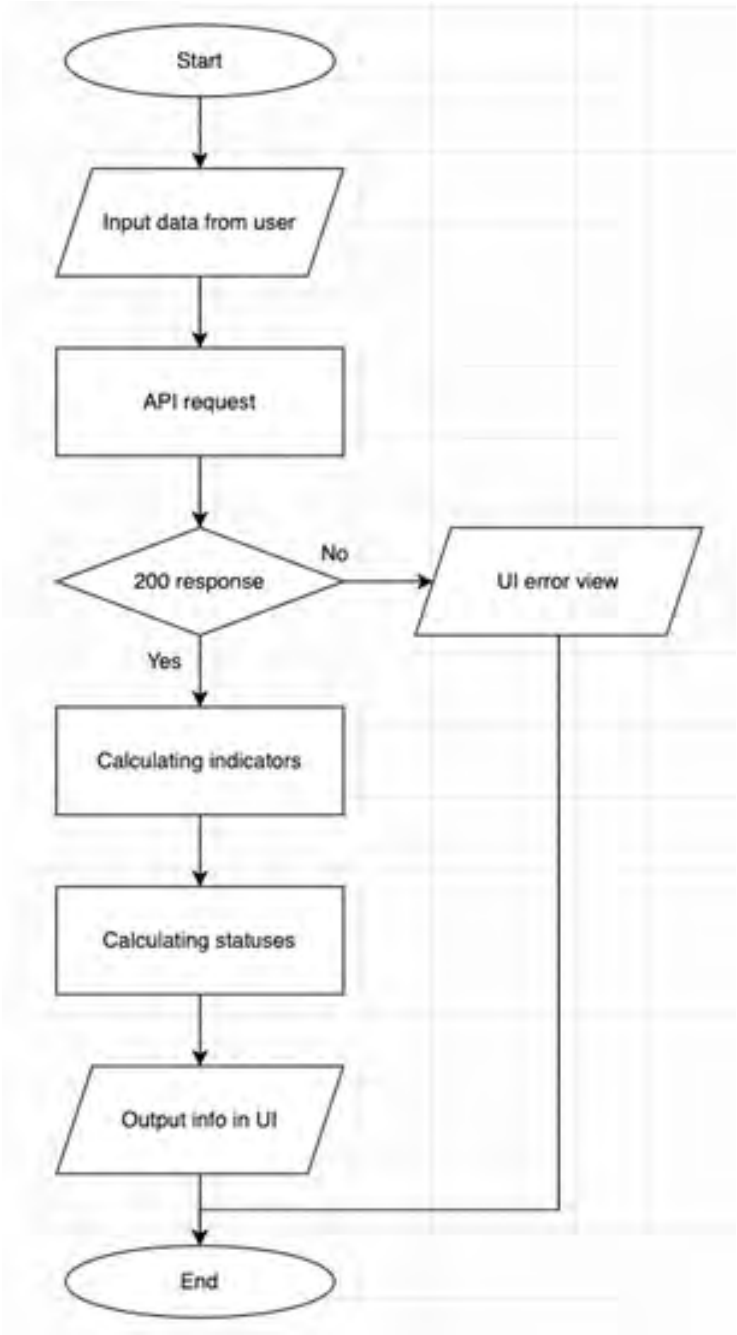

Fig. 5. Algorithm of the decision-making support system
for financial capital management of manufacturing enterprises

After making the appropriate selection, the client receives information about the selected company in an understandable format, thus being able to send a correct request to the server to obtain all the information about the company. The API, receiving requests from the client, returns the relevant data to the client via the HTTPs protocol, using a unique security key, without which it is technically impossible for the server to return data to the client. If the key is missing, the server returns a 403 Forbidden error to the client, which is usually sent by the server due to internal restrictions. After the data is correctly sent to the client,

it goes through two levels of processing – through the indicator service and the status service – to perform the necessary formatting so that the system can correctly display the formatted data on the user's screen. After successful formatting, the user sees the system interface – the company has been added to the list of analysed companies, and the right side of the screen displays extended information about the company, graphs and calculated coefficients.

Calculation of ratios

The indicators that Benjamin Graham analysed in his research are still relevant today, as they are fundamental for any company and show how stable, growing and exposed to financial global crises the company's business is. The indicators are presented below.

Current ratio

This indicator describes the extent to which the company is solvent. It indicates the ability of the company to repay its current liabilities, in such a way that the company converts its current assets into money, and this money is used to cover its liabilities. The recommended value is greater than 2. If this indicator is calculated below the recommended value, it indicates that the company has solvency problems, as it has insufficient current assets to meet its current liabilities. The current ratio is a ratio:

$$Current\ liquidity\ ratio = \frac{Current\ assets\ of\ the\ enterprise}{Current\ debts\ of\ the\ enterprise}\ .$$

Obviously, for a potential investor, the higher the value of this indicator, the better. But on the other hand, if the indicator is too high, it indicates an inefficient asset structure, i.e. inefficiency of the company's managers and owners. However, it is worth noting that the calculation should analyse the current liquidity of the company with competitors in the industry, as the recommended value of the ratio may differ in many areas. Over time, the current liquidity of large, successful enterprises is declining. This is due to improved budget planning and faster asset turnover.

Stable company profits

In general, this indicator means that the company should not have had any unprofitable quarters or fiscal years in the last ten years. Stable profit is an important component of any business. The company's profit is the main source of funding

for the company's development, ensuring all forms of investment, paying dividends, and improving the material and technical base. All company activities are aimed at stabilising profits at a certain level, or even at ensuring profit growth. Stable profit is an indicator of successful management, the relevance of the products manufactured or services provided by the company.

Dividend history

The company must have been consistently paying dividends to its security holders for the past twenty years. Dividends are a part of net profit distributed among participants (owners) in accordance with their share in the company's charter capital. Dividend history is an important component of a joint-stock company's strategy. This indicator affects the attractiveness of the company for investors, the value of the business, and the company's image. In addition to actual dividend payments, an excellent indicator is the growth of dividend payments per share. This indicates that the company's profit is growing. A stable level of dividend payments signals that the capital invested by investors is working effectively.

Profit growth

The most comprehensive indicator, calculated as the difference between the return on each security in the last and first three years of the decade. Average data for the first and last 3 years of the decade are taken to smooth out frequent market fluctuations caused by the economic cycle. From the point of view of assessing the potential profitability of a company, the average is more reliable and accurate if you compare the indicator only for the last year. Moreover, the advantage of averaging is that it can be used to address the issue of all additional expenses and tax deferrals, which are also part of the company's financial history.

The Graham coefficient is calculated as a ratio:

$$\frac{Company\ assets - company\ debts}{number\ of\ ordinary\ shares}.$$

Benjamin Graham first discussed net present value per share (NCAV) in Security Analysis [4], co-authored with David Dodd. In the book, NCAV is defined as current assets minus all liabilities and claims to be issued. Benjamin Graham was looking for companies whose market value was less than two-thirds of their net working capital. This indicator is one of the key ones for a value investing strategy, because if a company were to cease operations and sell all of its physical assets, the value of these assets would be the liquid value of the company.

The liquid value of an enterprise is the total value of all its physical assets, such as inventory, equipment, and real estate. It excludes intangible assets such as intellectual property and brand awareness.

Thus, a security trading below the Graham ratio allows an investor to buy a stake in a company at a lower price than the value of its current assets. And as long as the company has reasonable prospects, investors are likely to get significantly more than they pay. According to Graham, investors will benefit significantly if they invest in businesses whose share price does not exceed 67% of their Graham's P/E. However, it is important to be clear that not all stocks selected using the NCAVPS formula will have high returns, and that investors should also diversify their assets using this strategy. Graham recommended having 10–30 stocks in a portfolio.

The Graham number is calculated as follows:

$$\sqrt{22.5 \times \frac{market\ capitalization}{annual\ profit\ of\ the\ company} \times \frac{market\ capitalization}{book\ value\ of\ the\ company}}.$$

Graham's number measures the fundamental value of a stock, taking into account the company's earnings per share (EPS) and book value per share (BVPS). The Graham number is the upper limit of the price range that a defensive investor should pay for a stock. According to the theory, any share price below the Graham number is considered undervalued and therefore worth investing in. The ratio is used as a general test when trying to identify stocks that are currently selling at a good price. The value of 22.5 is included in the calculation to reflect Graham's belief that the price-to-earnings (P/E) ratio should not exceed 15x and the BVPS should not exceed 1.5x (hence, $15 \times 1.5 = 22.5$). Graham's number is also a key indicator in calculating whether a security is suitable for a value investing strategy, although it does not take into account many of the fundamental characteristics that are considered reliable for finding a potential investment, such as the quality of management, major shareholders, industry characteristics and the competitive environment.

To develop the business logic of the software application, it was necessary to analyse the shortcomings of existing systems to solve a specific task: analysing the enterprise for compliance with the value investment strategy.

The main disadvantages are:

– insufficient data to calculate the necessary indicators;

– lack of statuses on the calculated indicators;

– an intuitive interface;

– Ukrainian localisation.

After analysing the main competitors in the industry, it was necessary to design a table of correspondences, which would help to calculate the status of each indicator (recommended, satisfactory, unsatisfactory). The values in the table for each indicator were taken from Benjamin Graham's recommendations, which he described in his book The Intelligent Investor, as well as the Graham Ratio and the Graham Number, which are calculated to find undervalued and potentially economically successful companies. Table 1 shows the correspondence between the values of the indicators and the statuses displayed by the developed software tool.

Table 1

Correspondence of indicator values and statuses displayed by the developed software tool

Name of the coefficient	Recommended status	Satisfactory status	Unsatisfactory status
Current liquidity ratio	≥ 2	< 2	< 1
Stable profits	No unprofitable years were identified	A loss-making quarter, but not a year, is identified	A loss-making year is identified
Dividend history	The company has been paying dividends for the last 20 years	The company currently pays dividends	The company does not pay dividends
Height profits	Average earnings per share for the last 3 years are at least 33% higher than the average earnings for the first 3 years of the last decade	The average profit for the last 3 years is higher than the average profit for the first 3 years of the last decade	The average profit for the last 3 years is lower than the average profit for the first 3 years of the last decade
Profit growth			Over the ten-year period, a loss was recorded
Graham's coefficient	Current share price within 50–70% of the ratio	Current share price within 40–80% of the ratio	The current share price is not within 40–80% of the ratio
Graham's coefficient			Negative value of the ratio
Graham's number	The Graham number is greater than the current share price	–	The Graham number is less than the current share price
Graham's number			The set of P/E and P/B ratios is greater than 22.5

Development of a decision support system for managing financial capital of manufacturing enterprises in the form of a software tool

To develop the decision support system, the Visual Studio Code programming environment was used. This is a free tool for creating modern software tools. It is positioned as a lightweight code editor for cross-platform development of software applications.

The development of browser-based software applications is usually divided into front-end (development of the client side of the software tool) and back-end (development of the server side of the software tool), although this division is rather superficial. In fact, the development of a software tool consists of several large stages beyond programming.

A programming language is the most important tool for any developer. It is used as a tool to create programmes that control the behaviour of machines. In fact, a programming language is similar to a foreign language, but it can be used to convey information to a computer rather than a person. Continuing to draw parallels between a foreign language and a programming language, we can say that the goal of a programmer is to use the language so that the computer understands the developer.

The developed software tool was created using the Vue.js frontend framework, which was written in the JavaScript programming language. JavaScript is a dynamic, object-oriented, scripting prototyping programming language. It is most often used on web pages to make the interface dynamic, but it can also be used to develop desktop, backend, and mobile applications.

It should be added that the development of client applications in a browser is impossible without the use of such languages as HTML (HyperText Markup Language) and CSS (Cascading Style Sheets). HTML is a hypertext markup language that absolutely every browser understands and then interprets the code into an interface that is displayed on the monitor screen. CSS, in turn, is a style language used to describe the appearance of HTML documents. These languages cannot be used to express a specific algorithm of actions to be performed by a computer, but they are very important for web development, because it is thanks to them that the user sees a convenient and understandable interface that is already dynamically working with the help of the JavaScript programming language. All these three languages are the main technologies of the World Wide Web.

If we describe only frontend development separately, JavaScript programs are called scripts that are embedded in the HTML code of a page and executed by the browser. Scripts are executed as plain text, so they do not require a compiler or other additional processing. JavaScript does not provide low-level access to

memory or CPU, as it was originally created as a language that could add dynamics to software applications in the browser. Today, JavaScript is the only programming language for client-side applications, as it has two significant advantages: full integration with HTML/CSS and support for all modern browsers.

The design of the software tool (Fig. 6) was based on the assumption that most users will not be experienced in fundamental analysis of the enterprise, and therefore the interface should be as simple and intuitive as possible for any user [13]. Each calculated coefficient is displayed in a geometric shape with a colour corresponding to the status – green, yellow or red. It is known from the school curriculum that red means danger, while green, on the contrary, is perceived calmly and symbolises safety. Yellow, in the context of a software tool, is an intermediate status between recommended and not recommended, not radically perceived by the user as a negative value, but also makes them pay attention and weigh their decision further. The price of one share of the company is shown in a neutral blue figure, because only after analysing the coefficients of the value investment strategy can the user understand whether the price of the security is fair.

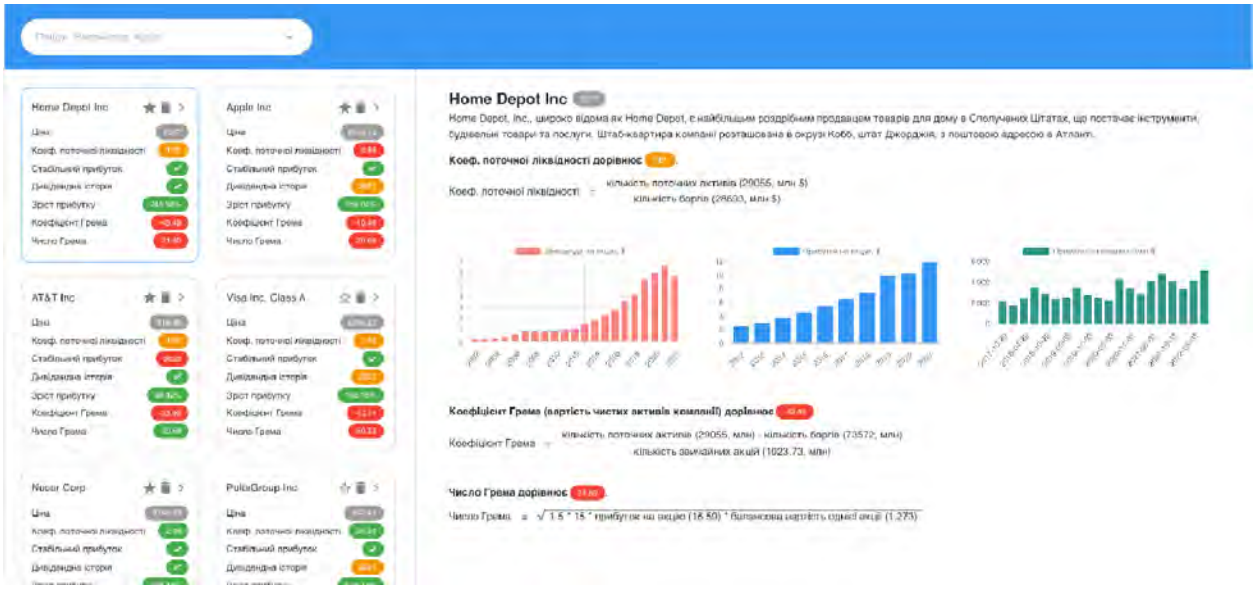

Fig. 6. Interface of the software tool

At the top of the screen, there is a search box that allows users to use keywords to the ability to find the required company for analysis. After entering the keyword, the application sends a request to the server and receives a list of companies that were found for the corresponding query in the Alpha Vantage database (Fig. 7).

The user can select any of them, and after that the company will be added to the list of analysed companies (Fig. 8) Information about each enterprise is displayed in the form of a card (Fig. 9), which contains the name of the enterprise,

icons for quick actions, such as adding to favourites, removing from the list and making it active, as well as the name and value of the coefficient with the corresponding status. The active enterprise is the one that the user added to the list last or selected by clicking on the corresponding icon. On the interface, the active company is highlighted by a blue frame, which is the main colour of the application – it is used for the top part of the application, as well as the colour of the EPS chart. The blue colour is more neutral than the colours used for statuses, so it will not distract the user from the main functionality of the application, but adds a corporate identity and separates the application interface from the top of the browser interface itself.

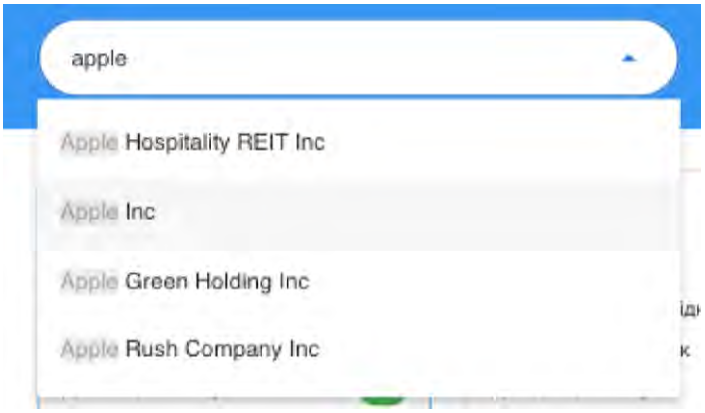

Fig. 7. List of companies found by the query apple

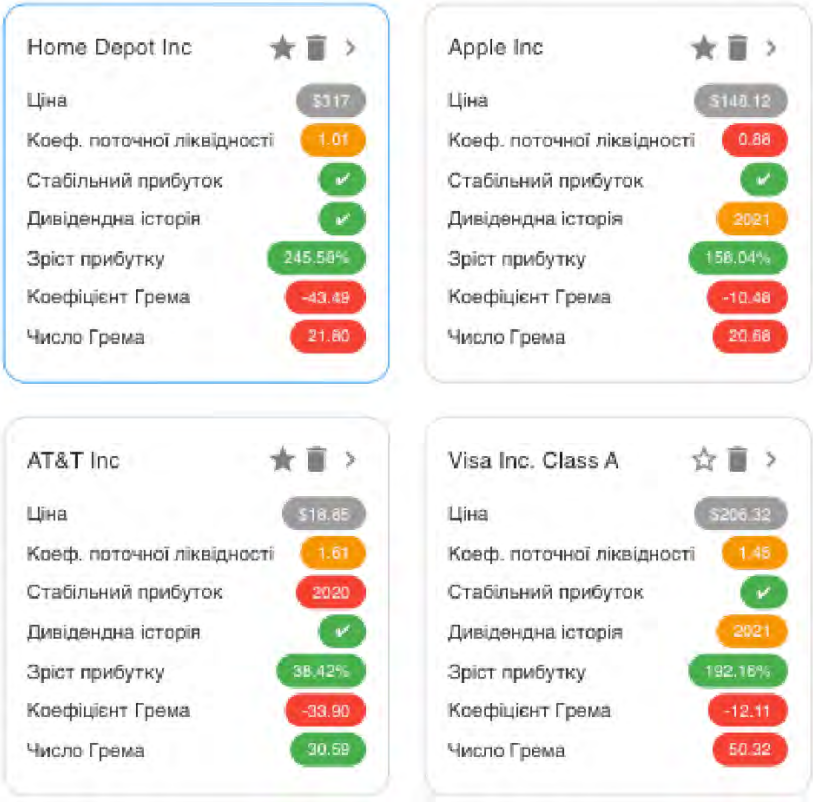

Fig. 8. List of analysed companies in the current user session

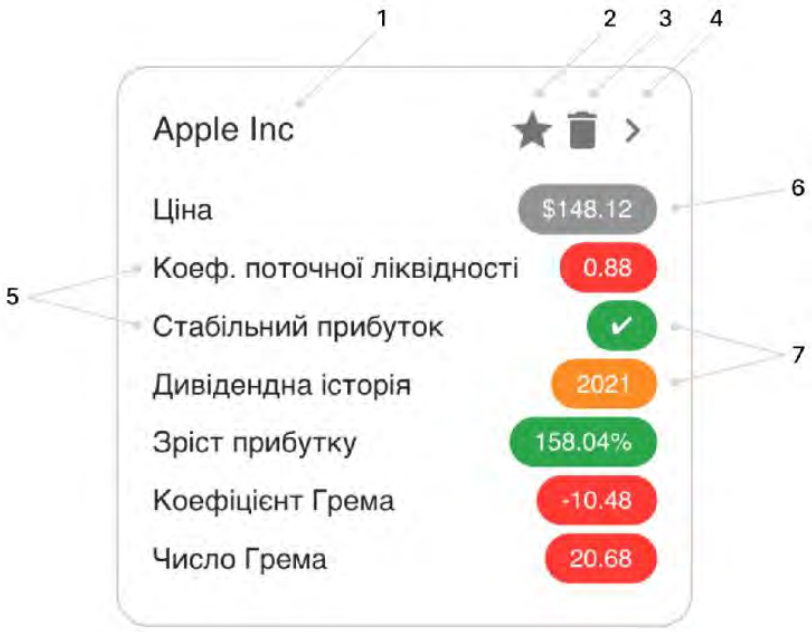

Fig. 9. Card with general information about the company

Card with general information about the company, where:

1 – Full name of the company. The layout is designed in such a way that if the name is too long to fit on the card, the name is cut off and the last characters are replaced with an ellipsis.

2 – Icon for adding a company to the list of favourite companies. If the company is already in the list, the icon is greyed out, otherwise only the silhouette of the icon is displayed, which indicates that the company is not added to the list of favourites. After reloading the page, all information about the enterprises that have been added to the favourites list will be loaded again with the most up-to-date data.

3 – Delete icon. It removes the company not only from the list of analysed cards of the current browser session, but also from the list of selected companies.

4 – Icon for setting the enterprise to the active position. When you click on the icon, a blue frame is added to the card, indicating that the company is in the active position. On the right side of the screen detailed information about the company will be displayed: dividend schedules for per share, earnings per share, profit for the quarter, as well as detailed information on the calculation of the value investing strategy ratios.

5 – Names of coefficients.

6 – Share price. When you hover over the price, a message appears with information about the last update of the price of one share of the company.

7 – Calculated coefficients, according to the names, as well as with automatic calculated statuses, such as recommended, satisfactory and not recommended,

with colours corresponding to the status name. On the right side of the screen, the user can see extended information about the calculated coefficients (Fig. 10), as well as a short description of the analysed company. Each coefficient corresponds to either a formula that was used to calculate the coefficient or a graph showing the data used to form the coefficient value. This data is very important for the user, as it allows him or her to check the correctness of calculations, make sure what data is needed for the fundamental analysis of the company, and see the regularity in the graphs, for example, in which quarter the company receives the largest profit or what is the movement of dividend payments. When analysing several companies with similar ratios, this can play a key role in decision-making.

Fig. 10. Extended information on the company's ratios

After the user has entered a keyword to search for a business and clicked on any business in the provided match list, a request is sent to the API to receive a response from the server with the relevant information. The program code checks whether the response contains a 200 status, and only in this case the application continues to calculate the data from the server. In any other case, the user will see a message on the interface that the server is unable to return the correct data. In this case, the user can try to repeat their actions or try to select another company in the email displayed after entering the search keyword.

Conclusions

Investments are currently one of the most popular and effective ways to preserve and increase financial capital and generate passive income. The first step in analysing a potential investment is a fundamental analysis of the company, which allows you to draw initial conclusions about the company's business, which is the basis for making a decision on investment. Automation of this process is a necessity, as searching for company data for fundamental analysis is a time-consuming process, and the human factor can play a key role in analysing a large amount of data. Thus, the proposed decision support system for managing the financial capital of manufacturing enterprises allows to increase the efficiency of decision-making in the management of financial capital of manufacturing enterprises by using specific indicators to calculate the compliance of the enterprise with the strategy of value-based investment.

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