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# УПРАВЛІННЯ РОЗВИТКОМ

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# Analysis of aircraft enterprise activity in the context of economic development of Ukraine

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**Abstract**. The priority direction of the economy of Ukraine is the development of the aircraft industry. Analysis of the activities of aircraft manufacturing enterprises will improve the efficiency of their management, which will contribute to the modernization of the Ukrainian economy in general. The purpose of the study was to analyse the financial condition of aircraft manufacturing enterprises and determine the prospects for expanding their export activities. The research uses the methods of system analysis, induction and deduction, analysis and synthesis, index method. An analysis of the capital of main aircraft-building enterprises of Ukraine was carried out, and distinctive characteristics of the structure, movement and efficiency of its use were established. An analysis of solvency and financial stability was performed. It was established that the financial condition of enterprises is unsatisfactory, which leads to deterioration of the efficiency of the industry as a whole. Studying the activities of enterprises in modern conditions led to the need to conduct a study of the influence of structural factors on the volume of product exports. The presence of dynamic fluctuations in demand requires companies to have the knowledge and skills to use scientific methods of seasonality analysis. The need to use the index method, in particular seasonal indices, to measure the impact of seasonal fluctuations on the volume of product exports has been proved. The amount of aircraft exports during 2018-2020 and the seasonality index are presented graphically. Seasonal fluctuations in the export of aircraft according to monthly data of 2018-2020 by aircraft manufacturing enterprises are estimated. Effective methods of improving the analysis of enterprise activity are proposed. It was estimated that the established trends should be taken into account when forecasting the production indicators of the enterprise. The results of the study can be useful for specialists whose activities are related to ensuring the financial stability and development of the aircraft construction complex of Ukraine

**Keywords:** liquidity, financial condition, solvency, export of aircraft, seasonality index

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## INTRODUCTION

The result of the economic development of Ukraine, the directions of which are developed taking into account global trends and the country's internal capabilities in the National Strategy of Economic Development for the period until 2030, is expected to create a competitive economy on the international market. Financial difficulties are one of the most important threats faced by businesses, regardless of their size and activity. Bankruptcy or collapse of a business can have a negative impact on both the company itself and the global economy. During 1980-2020, financial distress research has been a hot topic for academics and practitioners as it serves as an effective early warning signal for creditors, investors, corporate regulators and other stakeholders.

In the context of forecasting financial problems, researchers are motivated to identify early warning signs of financial problems. In particular, E.I. Altman [1] analysed the effectiveness of the Z-Score model for firms from 31 European and 3 non-European countries using various modifications of the original model. This is the first study to offer such a comprehensive international analysis. His results show that the Z-Score model works well for most countries (prediction accuracy is around 0.75) and the classification accuracy can be improved (above 0.90) with a country-by-country score that includes additional variables. N. Mselmi [2] investigated the ability of financial ratios to signal financial difficulties one or two years before their occurrence. The authors compared the accuracy of five forecasting models. Scientists have established that the PLS-SVM (Partial Least Squares Support Vector Machines) hybrid model overcomes the shortcomings of using

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each method separately and has a high level of prediction. A number of scientists are focused on improving existing bankruptcy forecasting models. J. Almamy [3] tested individual ratios of Altman's original Z-score model and found that cash flow combined with the output variable of the Z-score is very important in predicting the health of British companies. The J-UK model was developed to check the health of UK companies. Compared with the Z-score model, the predictive power of the J-UK model was 82.9%, which is consistent with the British Taffler model.

The problems considered by Ukrainian scientists relate to the generalization of theoretical approaches to determining the essence of the financial state of the enterprise. In particular, V. Chepka [4] provided an interpretation of the concept of "financial condition of the enterprise" as a system of financial relations, which, in addition to indicators of the enterprise's financial resources, includes its competitiveness and ability to finance its activities. In the work of O. Levkovich [5], the methods for studying the financial stability of the enterprise are worthy of attention, as well as the main aspects of its influence on the enterprise's activities are formed, namely: the prerequisites for strengthening competitive positions and the development of investment activities are formed. It should be noted the position of the authors regarding the interpretation and analysis of the categorical apparatus in the study. N. Volkova [6] paid attention to the improvement of the methodology of financial analysis and proposed indicators whose dynamics can satisfy the expectations of stakeholders and owners of the enterprise in the context of sustainable development of the business entity. These indicators characterize the performance of the enterprise, the level of risks in the market, the effectiveness of the use of production potential, the level of financial stability and financial stability. The use of the proposed methodology will ensure timely management decisions to establish the economic and financial balance of the enterprise's activities. Individual authors pay special attention to the issues of registration, storage, transmission, recovery and use of information used for economic analysis. V. Nitsenko [7] proved that the quality of information provided by accounting has a significant impact on increasing the competitiveness of the enterprise, proved the need to separate information and information resources for management needs.

Despite significant scientific progress, a number of important problems in the organization and methodology of financial analysis of enterprises require further research, in-depth study and development of new improvement approaches in modern conditions. Accordingly, the goal was to study the financial condition of enterprises on the example of enterprises of the aircraft industry and determine the prospects for expanding their export activities.

## MATERIALS AND METHODS

To achieve the goal of the research, a combination of general and specific methods of scientific knowledge was used. To establish the main changes that occurred in the financial condition of the enterprises, the method of systematic analysis was used, thanks to which distinctive characteristics of the capital structure of the mentioned enterprises were revealed. The work analyses the activities of such major aircraft manufacturing enterprises of Ukraine as: ANTONOV Company, State Enterprise PLANT 410 CIVIL AVIATION (hereinafter SE "PLANT 410 CA"), Kharkiv State Aircraft Manufacturing Company (hereinafter KSAMC). The sources of information for the analysis of capital and the calculation of indicators of financial stability were the data of annual financial statements of these enterprises, located on the official websites of ANTONOV Company and KSAMC [8-9] and the open data portal "Clarity Project" [10].

The use of inductive and deductive methods in the work made it possible to carry out an analysis of the enterprises of this industry and draw conclusions regarding the determination of prospects for the expansion of export activities. Identification of general and special characteristics of aircraft manufacturing enterprises of Ukraine was carried out using the comparison method. This made it possible to establish that most of these enterprises have unsatisfactory financial stability. Inductive generalization makes it possible to determine the level of potential risk of adverse events. Analysis and synthesis were used to build an algorithm for conducting a financial analysis of the company's activity, which made it possible to identify promising directions for increasing the export component at the companies. The use of the abstract-logical method made it possible to identify the essential elements of the system of indicators of the financial state of the enterprise, as well as to form the conclusions of the study. The assessment of the financial condition is carried out using the analysis of indicators of the property condition, financial stability and liquidity. The procedure for calculating indicators is carried out according to the methodology proposed in the work of O. Yatsukh and N. Zakharova [11]

Visual summarization of the results of the analytical study was carried out using a graphic method. Its use made it possible to reveal the unevenness of the export of aircraft of Ukraine in 2018-2020; demonstrate typical relationships between aircraft exports under different HS (Harmonized System) codes; to clearly present the peak periods of exports during the year. The index method was used to determine the seasonality of the export of aircraft products. The seasonality index is determined by the formula:

$$I_s = \frac{\bar{y}_i}{\bar{y}_0} \times 100, \qquad 1)$$

where $\bar{y}_i$ is the average level of the dynamics series for the time interval i; $\overline{y_0}$ is the average level of the dynamics series for the year. The source of data on the export of aircraft of Ukraine is the UN database on statistics of international trade in goods UN comtrade database [12]. The set of methods used made it possible to conduct a thorough financial analysis of enterprises, emphasizing the uniqueness of the aircraft industry and form development prospects.

## RESULTS AND DISCUSSION

The basis of the successful implementation of reforms in the economic sphere of Ukraine is its structural modernization, improvement of the business climate, creation of conditions for the development of industry. Among the key tasks of modernization of the economy of Ukraine, special attention is paid to ensuring effective management of state-owned enterprises, especially those that are strategically important. Ukraine is one of the nine aircraft-building countries in the world [13]. This branch of mechanical

engineering is strategically important for Ukraine and one of the priority directions for the development of the national economy. The industry includes more than 60 enterprises, which account for about 25% of the people employed in mechanical engineering in Ukraine [14]. As a result of the Russian armed aggression against Ukraine, which began in 2014, cooperation with the Russian Federation was terminated and the industry experienced a crisis.

Financial stability is vital in a market economy because it provides an advantage over other companies in times of economic crisis. Businesses seek to maximize profits, increase capitalization and achieve sustainability. The financial stability of company is the most complete and important analytical characteristic of its financial condition. It determines not only the ability to achieve strategically important goals, but also to ensure their continuous development. As a result, the majority of Ukrainian aircraft construction enterprises are in an unsatisfactory financial condition, which negatively affects the economic efficiency of the industry and the economy of Ukraine as a whole and requires development of measures to improve the current situation. In accordance with the identified opportunities, prerequisites are created, certain changes in processes, technologies and products take place.

In the modern business environment, capital plays an important role in the growth of enterprises, protects the interests of its owners and is an important factor in managing the financial situation. Capital and its structural model have a direct impact on the solvency, liquidity and profitability of the enterprise. Capital analysis allows you to get reasonable information about the financial condition of the enterprise and take measures to improve it. The comparative characteristics of the capital of aircraft manufacturing enterprises of Ukraine in 2020 are provided in Table 1.

**Table 1.** Composition and capital structure of aircraft manufacturing enterprises of Ukraine in 2020

| Indicators | ANTONOV Company | SE "PLANT 410 CA" | KSAMC |
|---|---|---|---|
| Capital – total, thousand UAH | 11 905 963 | 465 585 | 2 246 259 |
| Capital structure by source of formation, % of the total: | | | |
| • equity | 69.9 | 39.1 | -73.6 |
| • loan capital | 29.1 | 60.9 | 173.6 |
| Capital structure by nature of circulation, % of the total: | | | |
| • fixed capital | 49.8 | 24.7 | 40.4 |
| • working capital | 50.2 | 75.3 | 59.6 |

**Source:** calculated by the authors based on data [8-10]

From the data in Table 1, it can be seen that the size of the capital of the analysed enterprises is different in terms of scale: SE "PLANT 410 CA" has the smallest capital – 465.6 million UAH, the capital of ANTONOV Company exceeds it 24 times and amounts to UAH 11.9 billion, and the capital of KSAMC is 4.8 times larger than the previous one and amounts to UAH 2.2 billion. The structure of the capital also has significant differences: if at the ANTONOV Company enterprise, the largest share is equity capital – 70%, then the other two are dominated by loan capital. It should be emphasized separately that at the KSAMC enterprise there is a depreciation in equity capital, as a result of which its share is negative and amounts to minus 74%. The obtained results testify to the excellent characteristics of the capital structure of these enterprises. At ANTONOV Company and KSAMC, the structure is more balanced and is characterized by a slight excess of the share of working capital – 50% and 60%, respectively. At SE "PLANT 410 CA" the share of fixed capital is even smaller and is about 25%. This is explained by the specificity of its activity – repair, maintenance and modernization of airplanes and helicopters. Given the fact that the main role in the enterprise's production base is the fixed capital, its structure should be considered in more detail (Table 2).

**Table 2.** Composition and structure of fixed capital of aircraft manufacturing enterprises of Ukraine in 2020

| Indicators | ANTONOV Company | SE "PLANT 410 CA" | KSAMC |
|---|---|---|---|
| Total capital, thousand UAH | 5 934 797 | 115 216 | 907 183 |
| including % of the total: | | | |
| • fixed assets | 83.4 | 42.3 | 11.6 |
| • intangible assets | 0.7 | 57.1 | 85.1 |
| • financial investments | 15.9 | 0.6 | 3.3 |

**Source:** calculated by the authors based on data [8-10]

There are significant differences in the structure of the fixed capital of these enterprises. At ANTONOV Company, the majority of capital is concentrated in fixed assets – 83%. The second important component is financial investments, the share of which is 16%. On the contrary, at the SE "PLANT 410 CA" enterprise, intangible assets account for 60%, and fixed assets account for 42%. At the KSAMC enterprise, intangible assets are the most important and make up 85% of the total fixed capital, while fixed assets are only 12%. The obtained results indicate that KSAMC has a lot of intellectual capital, but does not use it to its full potential. Since the structure of the fixed capital of most enterprises is dominated by intangible assets, their structure needs to be considered in more detail (Table 3).

**Table 3.** Composition and structure of intangible assets of aircraft manufacturing enterprises of Ukraine in 2020

| Indicators | ANTONOV Company | SE "PLANT 410 CA" | KSAMC |
|---|---|---|---|
| Total intangible assets, thousand UAH | 212 757 | 66 888 | 776 470 |
| including % of the total: | | | |
| • property use rights | – | 76.38 | 99.45 |
| • rights to commercial designations | 0.33 | - | - |
| • rights to industrial property objects | 0.68 | - | - |
| • copyright and related rights | 1.35 | - | 0.54 |
| • other intangible assets | 97.64 | 23.62 | 0.01 |

**Note:** "-" – no data

**Source:** calculated by the authors based on data [8-10]

Among the intangible assets of aircraft construction enterprises, the largest share is the rights to use property – 75% for SE "PLANT 410 CA" and 99% for KSAMC. Copyright and related rights, as well as rights to objects of industrial property and commercial designations are presented in a small amount. Other intangible assets are 98% in ANTONOV Company and 23% in SE "PLANT 410 CA". These specific features must be taken into account when working out directions for the development of aircraft industry. Since more than half of the fixed capital consists of fixed assets, the analysis of this element of enterprise assets is carried out in the work. The composition and structure of fixed assets of enterprises in 2020 is presented in Table 4.

**Table 4.** Composition and structure of fixed assets of aircraft manufacturing enterprises of Ukraine in 2020

| Indicators | ANTONOVCompany | SE "PLANT 410 CA" | KSAMC |
|---|---|---|---|
| The initial cost of all fixed assets, thousand UAH | 6 292 835 | 123 171 | 565 594 |
| including % of the total: | | | |
| • buildings, structures and transmission devices | 39,09 | 41,78 | 39,44 |
| • machinery and equipment | 8,90 | 34,16 | 19,76 |
| • vehicles | 38,26 | 4,15 | 2,18 |
| • tools, devices and inventory | 0,91 | 11,63 | 12,90 |
| • other fixed assets | 12,84 | 8,28 | 25,72 |

**Source:** calculated by the authors based on data [8-10]

According to the data of Table 4, it can be seen that the value of fixed assets of the enterprises is very different in size: at KSAMC, the value exceeds the similar indicator of SE "PLANT 410 CA" by 6 times, at ANTONOV Company – by 11 times and amounts to UAH 6.3 billion. The structure of fixed assets is dominated by buildings, structures and transmission devices, the share of which in all enterprises is about 40%. The second place in each enterprise is dominated by a separate group – at ANTONOV Company it is "Vehicles" – 38%, at SE "PLANT 410 CA" it is "Machines and equipment" – 34%, at KSAMC it is other fixed assets – 25%. Accordingly, such structural differences also affected the ratio of other groups of fixed assets. Table 5 presents indicators of the technical condition, movement and efficiency of the use of fixed assets.

**Table 5.** Indicators of fixed assets of aircraft manufacturing enterprises of Ukraine in 2020

| Indicators | ANTONOV Company | SE "PLANT 410 CA" | KSAMC |
|---|---|---|---|
| 1. Indicators of the technical condition of fixed assets | | | |
| Depreciation rate | 0.196 | 0.604 | 0.814 |
| Suitability factor | 0.804 | 0.396 | 0.186 |
| 2. Indicators of movement of fixed assets | | | |
| Receipt ratio | 0.005 | 0.069 | 0.005 |
| Dropout rate | - | 0.001 | 0.001 |
| Growth factor | 0.005 | 0.069 | 0.004 |
| 3. Indicators of the efficiency of the use of fixed assets | | | |
| Fund return | 1.221 | 4.259 | 0.114 |
| Fund capacity | 0.819 | 0.235 | 8.737 |
| Profitability ratio | 0.174 | -0.263 | -0.297 |

**Note:** "-" – no data

**Source:** calculated by the authors based on data [8-10]

The technical condition of fixed assets is good at ANTONOV Company, as the depreciation rate is 20%. On SE "PLANT 410 CA" the technical condition of the fixed assets is satisfactory, as the wear rate is 60%, on KSAMC the technical condition is unsatisfactory, as the wear rate is 81%. A low level of movement of fixed assets is observed

at all aircraft construction enterprises. It is the highest on SE "PLANT 410 CA", but even there the value of indicators does not exceed 10%. Considering the rather high level of wear and tear of this enterprise, this level is not enough for a qualitative renewal of fixed assets. Traffic at the KSAMC enterprise is also unsatisfactory. Here, the coefficients of entry, exit and growth do not even reach 1%. This indicates a threatening situation at the enterprise regarding the renewal and technical condition of fixed assets. At ANTONOV Company, although there is a small amount of income, given the excellent technical condition of fixed assets, this is enough. In most cases, the indicators of the efficiency of using fixed assets indicate the effective use of SE "PLANT 410 CA" except its profitability. The worst indicators are observed at the KSAMC enterprise. Taking into account all the above, it should be noted that the company ANTONOV Company has the most efficient use of fixed assets. Solvency of enterprises significantly affects their financial condition. Determination of the level of solvency is carried out using liquidity ratios (Table 6).

**Table 6.** Dynamics of liquidity indicators of aircraft manufacturing enterprises of Ukraine in 2020

| Indicators | ANTONOV Company | SE "PLANT 410 CA" | KSAMC |
|---|---|---|---|
| Absolute liquidity ratio | 0.623 | 0.102 | 0.001 |
| Quick liquidity ratio | 1.072 | 0.444 | 0.029 |
| Total liquidity ratio (coverage) | 1.997 | 1.076 | 0.393 |

**Source:** calculated by the authors based on data [8-10]

The calculation of liquidity indicators showed that only at ANTONOV Company the values of indicators are close to the normative ones. At other enterprises, the level of solvency is unsatisfactory. Therefore, it is advisable to analyse the system of indicators of financial stability (Table 7).

**Table 7.** Dynamics of indicators of financial stability of aircraft manufacturing enterprises of Ukraine in 2020

| Indicators | ANTONOV Company | SE "PLANT 410 CA" | KSAMC |
|---|---|---|---|
| Coefficient of autonomy (independence) | 0.664 | 0.251 | -0.652 |
| Coefficient of financial stability | 2.335 | 0.341 | -0.428 |
| Coefficient of financial dependence | 1.505 | 3.977 | -1.534 |
| The coefficient of the ratio of borrowed and equity capital | 0.494 | 2.977 | 0.917 |
| Current liabilities ratio | 0.866 | 0.985 | 0.001 |

**Source:** calculated by the authors based on data [8-10]

ANTONOV Company is distinguished by a sufficient level of financial stability, predominantly financed by own funds and a low level of financial risks. At other enterprises, the level of financial stability is unsatisfactory. Thus, most of the aircraft manufacturing enterprises of Ukraine have an unsatisfactory financial condition, which affects the economic efficiency of the industry and the economy of Ukraine as a whole, and requires the development of measures to improve the existing condition. One of such promising directions is a reorientation to the European and Asian markets and an increase in the export of aircraft devices. Authors of the study agree with the opinion of the authors I.A. Kravchenko and V.Y. Golyuk [13] that the positions of countries in the global market for the production of aircraft equipment for military and special purposes are stable. In particular, Ukraine has a full cycle of aircraft construction, where all types of aviation equipment are produced: airplanes, helicopters, small aircraft, and unmanned aerial vehicles are being developed. In the field of civil aviation, there is a high interest in Antonov aircraft from the countries of Central and South America, Egypt, etc. Ukraine has aerospace developments, takes part in the production of satellites, ballistic missiles, rocket-space complexes. The largest trading partners in this direction are the countries of South America, Asia, the Middle East, and the USA. Realization of the export potential of military aviation of Ukraine, in addition to the production of airplanes and rotorcraft, is also promising for the production of unmanned aircraft complexes. Figure 1 presents data on the export of aircraft from January 2018 to December 2020.

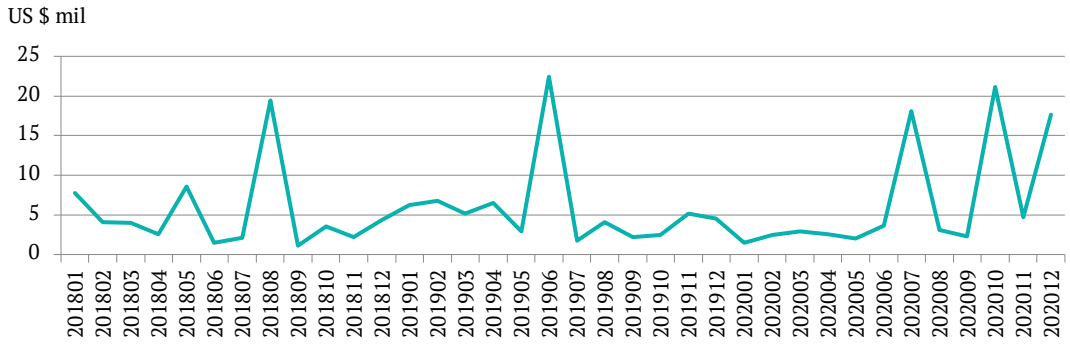


**Figure 1.** Export of aircraft of Ukraine in 2018-2020 per month, million US dollars

**Source:** developed by the authors based on data [12]

From the data presented in Figure 1, it can be seen that the volume of aircraft exports is uneven with a significant increase at the end of the year. The largest amount of exports was in June 2019 and amounted to US $22 million. On the other hand, in 2020, there were more peak values – in July and October, about US $20 million. The total amount of exports increased from US $60.1 million in 2018 to US $81.9 million in 2020, which is 136%. The characteristics of the export of aircraft are carried out according to HS codes and include the following types of export products: code 8801 – balloons and dirigibles, gliders, hang gliders and other non-powered aircraft; code 8802 – other aircraft (for example, helicopters, airplanes); spacecraft (including satellites) and suborbital and spacecraft launch vehicles; code8803 – parts of goods of heading 8801 or 8802; code8804 – parachutes (including dirigible parachutes and paragliders) and rotochutes; parts thereof and accessories thereto; code 8805 – aircraft launching gear; deck-arrestor or similar gear; ground flying trainers; parts of the foregoing articles (Fig. 2).

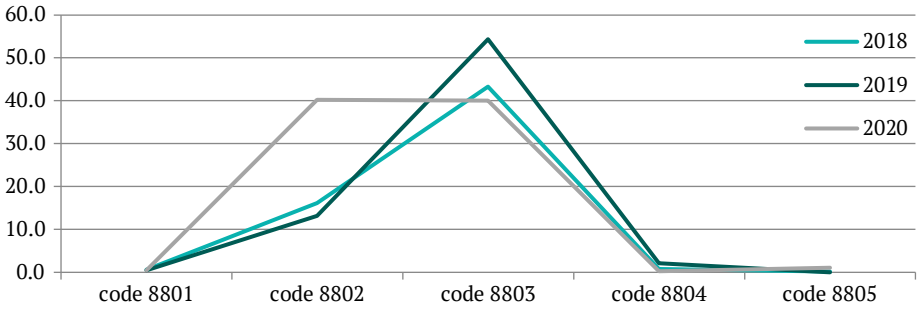


**Figure 2.** Export turnover of aircraft of Ukraine in 2018-2019 (according to HS codes), million US dollars
**Source:** developed by the authors based on data [12]

According to the data presented in Figure 2, it can be seen that the largest share of exports falls on aircraft parts in the amount of US $40-50 million annually. In 2020, the export of airplanes and helicopters increased significantly.

According to the data presented in Figure 1, it can be seen that the export of aircraft is carried out unevenly with moderate growth in the second half of each year. In addition, there are noticeable fluctuations between the volume of exports in different months of the year. This makes it possible to analyse the seasonality of the presented dynamic series, which will increase the effectiveness of forecasting and planning of seasonal indicators of the enterprise's export activity. The graphic representation of the seasonality index is shown in Figure 3. The results of the seasonality index calculations are presented in Table 8.

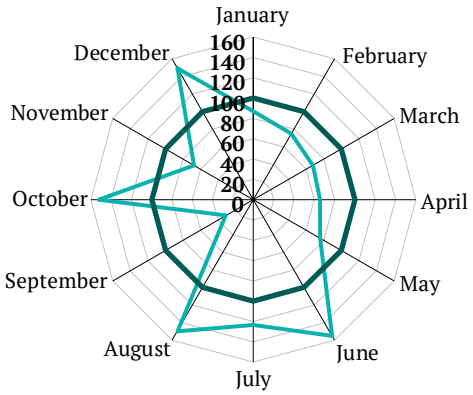


**Figure 3.** Indicator of seasonality of the export of aircraft of Ukraine, %
**Source:** developed by the authors based on their own calculations

**Table 8.** Calculation of seasonal indicators of the export of aircraft of Ukraine in 2018-2020, thousand US dollars

| Months of the year | 2018 | 2019 | 2020 | Average value | Absolute deviation | Relative deviation, % | Seasonality index, % |
|---|---|---|---|---|---|---|---|
| January | 7 739 | 6 259 | 1 477 | 5 158 | -763 | -12.89 | 87.11 |
| February | 4 076 | 6 786 | 2 459 | 4 440 | -1 481 | -25.01 | 74.99 |
| March | 3 996 | 5 142 | 2 873 | 4 004 | -1 918 | -32.39 | 67.61 |
| April | 2 560 | 6 528 | 2 592 | 3 893 | -2 028 | -34.25 | 65.75 |
| May | 8 603 | 2 892 | 1 985 | 4 493 | -1 428 | -24.12 | 75.88 |
| June | 1 466 | 22 427 | 3 650 | 9 181 | 3 259 | 55.04 | 155.04 |
| July | 2 096 | 1 764 | 18 102 | 7 321 | 1 399 | 23.63 | 123.63 |
| August | 19 385 | 4 099 | 3 118 | 8 867 | 2 946 | 49.75 | 149.75 |
| September | 1 118 | 2 156 | 2 305 | 1 860 | -4 062 | -68.60 | 31.40 |
| October | 3 501 | 2 443 | 21 107 | 9 017 | 3 095 | 52.27 | 152.27 |
| November | 2 167 | 5 127 | 4 683 | 3 992 | -1 929 | -32.58 | 67.42 |
| December | 4 343 | 4 540 | 17 614 | 8 832 | 2 911 | 49.15 | 149.15 |

**Source:** developed by the authors based on data [12]

As can be seen from the obtained results, Ukraine's export of aircraft is characterized by significant fluctuations both in one direction and in the other direction in relation to the average annual level. A deviation at the level of 70% in a smaller direction is observed in September; to a greater extent – in June, August, October and December. In the first half of the year, the export level is usually lower than the annual average. Information on the largest export deliveries in 2018-2020 is presented in Table 9.

**Table 9.** Countries with the largest volume of aircraft imports from Ukraine

| Country | 2018 | Country | 2019 | Country | 2020 |
|---|---|---|---|---|---|
| Exports of Ukraine for the year, million US dollars | 61.0 | Exports of Ukraine for the year, million US dollars | 70.2 | Exports of Ukraine for the year, million US dollars | 81.9 |
| including % of the total | | | | | |
| • USA | 32.6 | • India | 28.9 | • USA | 24.9 |
| • India | 21.8 | • USA | 28.2 | • Turkey | 21.5 |
| • Sudan | 10.0 | • UAE | 4.7 | • Kazakhstan | 12.2 |

**Source:** developed by the authors based on data [12]

Therefore, the analysis of the calculations regarding the characteristics of seasonality confirms the presence of seasonal fluctuations in the export of aircraft of Ukraine. This process is characterized by a significant amplitude of oscillations – more than 50%. Uneven loading of enterprises during the year, idle labour force and equipment during a drop in demand negatively affect not only the volume of production, but also its quality, labour productivity, the level of use of fixed capital, etc. Adjusting production volumes for seasonal indices will make it possible to forecast fluctuations in sales volumes, which will ensure the sustainable development of manufacturing enterprises in the aviation industry of Ukraine. The need to reduce seasonal fluctuations in demand will encourage the expansion of export activities at the expense of non-seasonal areas, such as the provision of maintenance services for aircraft engines, current and major repairs of aircraft. According to experts, the market share of such services in the total costs of the global aviation industry in 2017 was 11.3% [15].

Expanding the export activity of aircraft manufacturing enterprises will allow the realization of the National Strategy of Economic Development for the period until 2030 in terms of creating a competitive economy on the international market, achieving the export value of at least $150 billion and increasing the efficiency of the functioning of state-owned enterprises [16]. On the basis of the conducted analysis, it can be stated that the results of all types of activities of the enterprise are interdependent and affect its financial condition. Economic instability, which has intensified in Ukraine since 2014, forces enterprises to regularly use financial analysis tools to achieve harmony in crisis conditions between the economic development of the enterprise and its sustainability. The financial analysis methodology used in this work can be expanded in accordance with the conditions of the aircraft industry and the needs of state property management. Worthy of attention is the work of M.V. Pataridze-Vyshinska [17], in which, based on the analysis of the methods of various Ukrainian scientists, an own approach is proposed. It provides, in addition to performing an express analysis, performing an in-depth analysis of the financial state of the enterprise by carrying out an assessment of property potential; liquidity, solvency; financial stability; business activity; cash flows; financial results; efficiency of activity; probability of insolvency and bankruptcy.

Y. Kovtunenko and A. Oleksiichuk [18] payed attention to the specifics of financial analysis in conditions of economic instability. This is a really relevant problem, but it is not disclosed by the authors quite fully. Their recommendations on this issue come down to the need for constant analysis of the company's activity without providing periodicity parameters or introducing additional indicators. In practice, acute financial difficulties do not always lead to bankruptcy. Compulsory revisions are possible, or a company can strategically go bankrupt early to break unprofitable contracts and protect itself from lawsuits; or a firm can avoid bankruptcy by meeting its current obligations even though it is technically insolvent in the long run. Authors of the article agree with the opinion of R. Jayasekera [19], whose research includes an overview of known bankruptcy forecasting models, a critical discussion of these models, and the proposal of the "Value Erosion Model" concept. According to this concept, "value" is interpreted as the future potential of the firm.

The work of N. Koussis [20] deserves the respect. In it, in order to change the upcoming external financing and the risk of losses, a model is propagated, in which non-distribution of profits is saved in the form of liquid assets, which bear a certain interest per period. In the opinion of the authors, this serves as a substitute for changing the upcoming foreign financing and the risk of bankruptcy. The authors emphasize negative impact of accumulated money savings on the cost of own capital through the likelihood of spending in case of default, which is not compensated by the high costs of external financing. A U-like connection from the company's equity is also creating a new return on capital and investment. understanding the specifics of the activities of enterprises in a particular area. E. Akyildirim [21] traced the impact of airline accidents on the profitability and financing structure of the engine manufacturer. The investigators brought the dramatic impact of the plane crash on the net income and financial leverage of the generator regardless of whether the generator was found guilty of such an incident. This work reinforces the importance of the findings made by L. Khoja [22], due to the need to look into the analysis of financial problems not only from accounting data, but also from macroeconomic and industrial indicators. The results showed that the financial status of companies can be researched on the place within the local microenvironment. This is also important for effective management of the company, as paying more

attention only to the aspect of financial activity increases the risk of insolvency. In the face of political and economic instability, it is necessary to find new approaches to help businesses overcome the crisis and protect their financial and economic situation.

Research and application of new methods of analysis and ways of improving the financial condition of the enterprise will allow to increase its property potential, restore solvency and profitability. Providing management personnel with up-to-date information on financial sustainability on a regular basis contributes to strengthening the enterprise's ability to further develop and overcome existing crisis phenomena at state-owned enterprises in the aircraft industry of Ukraine. In this work, the seasonality of the export of products of aircraft manufacturing enterprises was investigated, the amplitude of monthly fluctuations of which is more than 50%. The results of the calculations provide an opportunity to improve the production activity of enterprises in the aviation industry of Ukraine and ensure their sustainable development.

## CONCLUSIONS

It is important for the state to determine priority and strategic industries for its development, among which is the aviation industry of Ukraine. A rational and balanced approach to the analysis of enterprises in this industry, namely financial analysis, becomes the basis and enables enterprises to determine sustainable directions of development: determining the prospects for expanding export activities. According to the results of the financial analysis, excellent characteristics of capital structure of the analysed enterprises were established, which is explained by the specificity of their activities – repair, maintenance and modernization of airplanes and helicopters. There are significant differences in the structure of fixed capital of the mentioned enterprises, which are manifested due to concentrating of the share of capital in fixed assets. Among the intangible assets of aircraft construction enterprises, the largest share is the rights to use property, which must be taken into account when developing directions for the development of this industry. It is established that only one of the analysed enterprises has financial stability, namely ANTONOV Company.

According to the results of the analysis of the export of aircrafts of Ukraine, the main share of which falls on structural elements of airplanes and helicopters, its significant unevenness during the year was established. A promising way to prevent the negative impact of seasonal fluctuations in demand is the provision of aircraft maintenance and repair services. Based on the above, the urgent need for financial analysis in conditions of relative scarcity of key resources and unstable demand becomes a reality for most companies. Based on the results obtained in the study, the direction of further research may be in finding ways to improve the financial condition of other Ukrainian machine-building enterprises.

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## Аналіз діяльності авіабудівних підприємств в контексті економічного розвитку України

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**Анотація.** Пріоритетним напрямком економіки України є розвиток авіабудівної галузі. Аналіз діяльності авіабудівних підприємств дозволить покращити ефективність управління ними, що сприятиме модернізації української економіки загалом. Метою дослідження був аналіз фінансового стану авіабудівних підприємств та визначення перспектив розширення їх експортної діяльності. В дослідженні застосовано методи системного аналізу, індукції і дедукції, аналізу і синтезу, індексний метод. Здійснено аналіз капіталу основних авіабудівних підприємств України, встановлено відмінні характеристики структури, руху та ефективності його використання. Виконано аналіз платоспроможності та фінансової стійкості. Встановлено, що фінансовий стан підприємств є незадовільним, що призводить до погіршення ефективності функціонування галузі в цілому. Вивчення діяльності підприємств у сучасних умовах призвело до необхідності проведення дослідження впливу структурних факторів на обсяги експорту продукції. Наявність динамічних коливань попиту вимагають від підприємств знань та умінь використовувати наукові методи аналізу сезонності. Доведено необхідність застосування індексного методу, зокрема індексів сезонності з метою виміру впливу сезонних коливань на обсяг експорту продукції. Представлено графічно розмір експорту літальних апаратів протягом 2018-2020 рр. та індекс сезонності. Оцінено сезонні коливання експорту літальних апаратів за щомісячними даними 2018-2020 рр. виробничими підприємствами авіабудівництва. Запропоновано ефективні методи удосконалення аналізу діяльності підприємства. Встановлено, що слід брати до уваги встановлені тенденції при прогнозуванні виробничих показників підприємства. Результати дослідження можуть бути корисними для фахівців, діяльність яких пов'язана із забезпеченням фінансової стійкості та розвитку авіабудівного комплексу України

**Ключові слова:** ліквідність, фінансовий стан, платоспроможність, експорт літальних апаратів, індекс сезонності

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# Adaptive approach to engineering infrastructure reconstruction program and project management

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**Abstract**. Standard approaches to managing projects and programs for the reconstruction of engineering infrastructure in a turbulent environment are ineffective due to the lack of possibilities to adapt to external and internal influences. Therefore, the purpose of the article was to characterize the application of the conception of adaptivity in managing such projects and programs and to analyse the means for its application in management processes. The research presented in this article was conducted using scientific methods of critical analysis, systems analysis, mathematical modelling, formalization, analysis, synthesis, graphical and abstract-logical methods. The main constraints in the development of the program architecture were identified. The influence of the application of the standard approach to planning and managing programs and projects for the reconstruction of engineering infrastructure on the increase of the probability of risk emergence was investigated. The tasks of managing programs and projects in the implementation of management as the manifestation of control action were formulated. The concepts of active and passive methods of adaptive program management were considered, a combined method that involves preliminary modelling of managerial influences and learning from the experience of exerting such control actions was developed. The means of adaptive program management were analysed, the expediency of their use in the management of programs for the reconstruction of engineering infrastructure at different stages of their implementation was determined. The results of the study can be used by managers of programs and projects for the reconstruction or modernization of engineering infrastructure to determine approaches to management and selection of adaptive management tools for different phases of implementation, and also provide a methodological basis for further research

**Keywords:** organizational and technical systems, control action, risks, architecture planning, forecasting

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## INTRODUCTION

The issue of reconstruction of the engineering infrastructure of cities is relevant both for Ukraine and for other countries of the world. Reconstruction measures can be implemented both at the micro level (modernization or repair of individual system facilities – boiler houses, substations, central heating plants, etc.) and at the macro level (reconstruction of large parts of systems or systems as a whole). Reasons for reconstruction may include physical or moral obsolescence of equipment, replacement of damaged equipment, adaptation of systems to current consumption conditions, optimization of resource consumption in energy production, etc.

The modernization and reconstruction of engineering infrastructures and their management are widely represented in the works of many scholars. For example, N. Yushchenko [1] offers methods for planning the reconstruction, modernization and replacement of technological equipment of heat substations, heat networks of thermal energy enterprises, developed on the basis of network planning methods. Adapted methods of graph theory, deterministic and probabilistic mesh models taking into account time, cost and resources are proposed. The author notes the possibility of using network methods for network planning and management systems (NPMSs), including the use of automated NPMSs. Although the proposed methods can be successfully applied in the implementation of programs and projects for the reconstruction and modernization of engineering infrastructure, they do not provide an integrated approach to the management of such programs.

The study by E. Ciapessoni [2] proposed a quantitative probabilistic methodology for modelling the process

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of restoring the infrastructure of power supply systems. This method enables the modelling of individual steps of restoring infrastructures and their dependencies on human and environmental factors. It allows to identify the most influential factors using an analytical model through what-if analysis, which avoids the use of the black box method in modelling when applying statistical data. This methodology allows for the consideration of external and internal factors that influence the processes of infrastructure restoration in their modelling, which enables better adaptation of reconstruction program management processes, which is also influenced by the use of statistical data on the processes under study. However, it involves only probabilistic process modelling and can be used as a tool for managing programs and projects, without implementing an integrated management approach.

The thesis of D. Nieviedrov [3] developed an integrated approach to managing the level of environmental and social safety of construction and reconstruction projects of critical infrastructure through the development and implementation of models and methods for assessing the impact of certain impacts in conditions of turbulent changes. Although the work considers the adaptation of certain processes to the impact of external factors, the presented results relate to managing individual processes of infrastructure reconstruction project management, not taking into consideration an integrated approach to their implementation. The article by N. Bespala [4] analyses the main directions of the strategic development of regional energy systems, gives a comparative description of some regional programs, and determines the steps for the implementation of Smart Grid in regional energy systems. The results of the study directly relate to the implementation of engineering systems development programs, but focus on the conceptual level of development of such programs and do not provide a specific methodology for their management.

The article by M. Çelik [5] provides an overview of the literature regarding the implementation of actions for the reconstruction of critical infrastructure in the implementation of humanitarian operations, the classification of research by the main problems that they address, models, problem-solving methods employed as well as the goals and main solutions formulated throughout the research process, the future directions of research in this field are identified. The work presents information on existing research regarding the reconstruction of critical infrastructure but does not provide a comprehensive methodology for managing relevant processes. In the context of adaptive management, there is a lot of attention paid to the management of natural resources [6], environmental protection [7], etc. Researchers K.E. Papke-Shields and K.M. Boyer-Wright [8] proposed a "rational adaptive" approach to project management, developed on the basis of strategic planning methods. According to the results of the empirical evaluation, this approach has a positive impact on the success of project implementation but only addresses project management planning and does not consider the specifics of projects and programs for the reconstruction of engineering infrastructure.

The existing studies relate mainly to the management of individual processes within the overall project management structure, whereas they do not provide at all or provide a limited application of adaptation mechanisms to external and internal influences. The issue of adaptivity in project and program management is poorly addressed. Therefore, this article aimed to analyse the structure of programs for the reconstruction of engineering infrastructure, identify the existing specifics of such programs, and describe the methodology for managing such programs using an adaptive approach.

## MATERIALS AND METHODS

The research presented in this article is based on theoretical foundations regarding the adaptation of systems, concepts, and means of adaptive program management. In particular, a methodology regarding the separation of management types as the implementation of control action, depending on the application of the principles of adaptivity (the use of feedback, changes in the law of management, etc.) was applied [9-10]. To analyse the concept of adaptation, adaptivity, and adaptive management, the materials of thorough research in this field were used [11-13]. Consideration of the concept of adaptivity from the point of view of cybernetics is appropriate for analysing the possibilities of its implementation in the processes of managing complex organizational and technical systems and developing appropriate models. The study also used the definition of active and passive adaptive program management by K. Tervo-Kankare [14]. It enabled to synthesize a combined approach that considered elements of both studied approaches and is more effective for the implementation of program management processes. The methodology of adaptive program management is considered on the basis of the existing standard for program management by developed by the PMI (Project Management Institute) [15].

Methods of analysis and synthesis were used to study the process structure of program management and adaptive program management tools. The critical analysis method is used to evaluate existing research materials on adaptive program and project management. Methods of system analysis were employed to examine the program structure as well as the program management system. The method of mathematical modelling was used to develop program models and program management systems. The formalization method was used to describe the above systems, formulate restrictions for the program structure and tasks for managing programs for the reconstruction of engineering infrastructure. The graphical method was applied to illustrate the process structure of program management and processes of adaptive program management. The abstract-logical method was used to identify the specific features of managing programs for the reconstruction of engineering infrastructure as well as the typical risks associated with such programs.

## RESULTS AND DISCUSSION

At the macro level, the reconstruction and modernization of engineering infrastructure are carried out through projects that are interconnected both in terms of resources and in their logic of technical interaction to achieve a global strategic goal. This allows to talk about an aggregate of such projects in the terminology of program management. The PMI Program Management Standard defines a program as a set of related projects, ancillary programs,

and program activities managed in a coordinated manner to produce benefits not available under individual management [15]. Accordingly, the program model can be presented as follows:

$$P = \{Pr_1, Pr_2, \ldots, Pr_n\}), \quad (1)$$

with $P$ being a program; $Pr_n$ being a project. Constraints to the model are the availability of financial resources and the technical feasibility of implementing projects. The latter is related to the possibility of including in the program projects that perform the same functions in the process of achieving the strategic objectives of the program or do not contribute to the achievement of such objectives given the current environmental conditions. Constraints on finances and technical feasibility are reflected in the formulas (2; 4), respectively.

$$\sum_{i=1}^{n} Cf_i \leqslant Inv_p, \quad (2)$$

where $Cf_n$ is the sum of the cash flows for the project $i$, which is part of the program architecture; $Inv_p$ is the total investment in the program implementation; $n$ is the total number of projects in the program architecture.

$$Ef_{P_{ri}} \neq Ef_{P_{ri+1}}; \quad (3)$$

$$\sum_{i=1}^{n} I^s_{P_{ri}} = 1, I^s_{P_{ri}} \geqslant 0, \quad (4)$$

where $Ef_{P_{ri}}$ is the effect of implementing the project $i$; $I^s_{P_{ri}}$ is the index of achieving the strategic objectives of the program for the project $i$. In this case, $Ef_{P_{ri}}$ can be displayed as a set (5).

$$Ef_{P_{ri}} = \{PA_1, PA_2, \ldots, PA_n\}, \quad (5)$$

where $PA_n$ is the change in the parameter $n$ of the object of management. The model of the program management system can be presented in the form of a formula (6).

$$PM = \{MD, MP, ID, K\}, \quad (6)$$

where $PM$ is the program management system; $MD$ is a set of managerial decisions; $MP$ is a set of program management processes; $ID$ is a set of program output data; $K$ is a set of knowledge. The input set can be defined as:

$$ID = ID_{leg} \cup ID_{par} \cup ID_{\text{req}} \cup ID_{ei}, \quad (7)$$

where $ID_{leg}$ is the regulatory framework in the field of program implementation; $ID_{par}$ is the parameters of the system-object of management; $ID_{req}$ is the requirements for the final product of the program; $ID_{ei}$ is the data on the disturbances of the external environment of the program. The set of program management processes is shown in Figure 1.


**Figure 1.** Set of program management processes

**Source:** developed by the authors based on [16]

Sets of knowledge and solutions are responsible for the decomposition of program management processes. Sets of knowledge and managerial decisions include knowledge and managerial decisions on the management of program integration, program communication, etc. The application of a rigid standard approach to program management, which does not provide for adaptivity, is widespread in various types of programs. However, programs for the reconstruction of engineering infrastructure as programs, whose objects are complex organizational and technical systems, are characterized by a high degree of structural and dynamic complexity, which in the synthesis of the adaptation system leads to the following problems:

- the problem of lack of a priori information when the invariant model of the program for the reconstruction of engineering infrastructure and an adequate model of the management system cannot be built on the basis of available information;
- the problem of the impossibility of constructing an analytical mathematical model by traditional means (functions, differential equations).

In correlation with the constraints indicated by formulas (1; 2), these issues directly affect the content management processes in the context of the development of the application architecture. The architecture, in turn, affects the hierarchical structure of works, program scheduling, cost estimation, supply planning. Applying a standard approach to the planning and managing of programs for the reconstruction of engineering infrastructure increases the probability of risks, including cost risks: errors in

the development of the program architecture and lack of adaptation to environmental disturbances can lead to exceeding the program budget and/or failure to achieve its strategic objectives. Schedule risks make it impossible to adapt to environmental disturbances when managing the program architecture, which can lead to overdue program implementation and increases the probability of cost risks. Operational risks may arise during the program implementation and are associated with the impact of external disturbances; the lack of a mechanism for adapting to such disturbances may adversely affect the effectiveness of the program implementation. Technological risks – the inability to adapt to changes in the implemented technologies, and the emergence of more effective technological means can lead to incomplete achievement of the strategic objectives of programs for the reconstruction of engineering infrastructure. Thus, for the effective development and management of the program architecture, it is advisable to use an adaptive approach to the management of programs for the reconstruction of engineering infrastructure.

F. Heylighen [11], considering the issue of self-organization of systems, defines adaptation as the achievement of a state of compliance between the system and the external environment. Simultaneously, the term "compliance" reflects the configuration of the system, in which the latter can maintain its state or grow under specific environmental conditions. The discrepancy, in turn, leads to an increase in entropy in the system and its destruction under current boundary conditions. For complex systems, adaptation is determined by the ability of the system to adapt to new boundary conditions, maintaining the highest possible level of stability of their organization. In cybernetics, adaptation is defined as the task of control, which consists in minimizing deviations from the target system configuration by responding to perturbations from the external environment before such perturbations jeopardize the basic organization of the system. Thus, adaptivity is a characteristic of the system that determines its ability to adapt.

Accordingly, an adaptive system can be understood as a system that adjusts to environmental changes to control the level of entropy. In the case of artificial systems, among the tasks of adaptivity can be distinguished: support for the ability of the system to perform its functions under the influence of external disturbances; the ability of the system to maintain the initial level of efficiency of its functioning in accordance with the conditions of the external environment. However, adaptivity could not be considered as a characteristic inherent in artificial systems that are not guided by humans or do not utilize artificial intelligence technology. Organizational and technical systems can adapt to disturbances of the external environment through the exercise of control action, such action can also be exercised by means of artificial intelligence.

Researchers distinguish the concepts of "adaptivity" and "adaptability" for intelligent information systems [12]. Adaptability differs from adaptivity by the need for the system parameters to be changed by the user, according to which the system is adjusted to the necessary conditions. An example of adaptability could be a user changing the interface of a software product. The system can be adaptive and adaptable, to a certain extent, depending on the degree of user participation in the initiation of changes. Full adaptivity implies the absence of human control over the initiation process, full adaptability, in turn, is its direct presence. Partial adaptivity, meanwhile, may involve both informing the user in advance about the initiation of changes and choosing the nature of the adaptation by the user.

Taking into account the above, a preliminary conclusion about the possibility of applying the concept of adaptability to technical systems as a whole can be made. The stable functioning of such systems provides for the regular exercise of control action over their elements. Independent initiation of changes is impossible in most cases. Organizational and technical systems, in turn, can be characterized as generally adaptive due to the exercise of control action, depending on the available information about the state of the system and the existing influence of the external environment on it. However, it should be noted that the adaptivity of the system directly depends on the presence of feedback between its elements. Program management systems belong to complex organizational and technical systems. Such a system can be considered potentially adaptive, provided that the principles of adaptive management are applied. The study by R.M. Argent [13] identifies four components of adaptive ecosystem management, as shown in Figure 2.

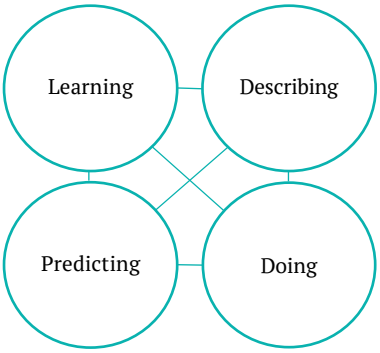


**Figure 2.** Set of program management processes
**Source:** developed by the authors based on [13]

In the context of systems management, O. Feldbaum [9] defines adaptation as the third hierarchy. The first hierarchy is management as the implementation of control action, the second is regulation as the implementation of control action using feedback. In the case of the first hierarchy, the management task can be formally expressed by formula (8) [17].

$$Q(x,\omega) \underset{x \in X}{\longrightarrow} \max(x), \quad (8)$$

where $Q$ is the quality function of the system; $x$ is the control influence; $\omega$ is the disturbance of the external environment. The main task of the management system is to find control actions that maximize the quality function of the $Q$ system under the influence of external disturbances. The quality parameter of the system includes the suitability of programs for the reconstruction of engineering infrastructure for implementation and its value, that is, bringing the value of the index of implementation of strategic objectives to one $I_s = 1$; maximization of financial, technological and aggregated values of the program. In the case of

an open system, the model should account for the impact on the object of the entire complex of environmental influences. This constraint leads to an excessive increase in the complexity of the management system. Reducing the requirements for the management system is possible with the introduction of feedback. Its application provides the management system with the information about a gap between the actual output of the system and the output required by the management task. The formal statement of the management task for the case of feedback application is as follows [17]:

$$Q(S, x, y, \omega) \xrightarrow[x \in X, y \in Y]{} \max(x), \quad (9)$$

where $S$ is the task, a management plan; $y$ is the state of the object of management. In non-stationary conditions, when the program is exposed to various external factors, the issue of management quality becomes significant. According to the method of modification variability, both a decrease in entropy and an expansion of the methodological base that forms the management algorithm lead to an improvement in the quality of management. Formally, the management task is converted into the following form:

$$Q(S, x, y, m, \omega) \xrightarrow[x \in X, y \in Y, m \in M]{} \max(x), \quad (10)$$

where $m$ is the law or management algorithm. It is necessary to find a law or management algorithm that ensures the maximum value of the index of strategic goals in a given range of control actions. Simultaneously, external disturbances cause a violation of the optimum and a drop in the quality of management. A further decrease in the quality of management, due to the widening gap between the new optimal management law (the law that ensures the extreme value of $Q$) and the existing law, can lead to instability and uncontrollability of the system.

For programs for the reconstruction of engineering infrastructure, an adequate solution to this problem is the synthesis of an adaptive management system that restructures the management law (algorithm) depending on the disturbances [10]. Requirements for the quality of regulation of programs for the reconstruction of engineering infrastructure as organizational and technical systems necessitate optimization of the parameters of the management system, which is possible only if there is a well-formalized model of the object of management. The introduction of the adaptation loop (third hierarchy or quality feedback) enables modelling a management system that implements optimal management in the dynamics. The need for adaptation arises in conditions of incompleteness of information [18]. In the process of adaptation, knowledge is accumulated and the system is improved. In system management, adaptation consists in making changes to the parameters of the system, its structural elements, and relationships as well as management algorithms to ensure the required values of the quality criteria.

The above outlined problems related to the high structural and dynamic complexity of the programs for the reconstruction of engineering infrastructure can be solved by modelling the system, which is the object of management, using the "black box" modelling method. The dependencies (11) (statistical model), (12) (dynamic model) will be relevant for the inputs of the $N$ system and the outputs of the $Y$ system.

$$y_i = f_i(n_1, n_2, \ldots, n_i), n \in N, \quad (11)$$

where $y_i$ is the I-th output of the object of management; $n_i$ is the I-th input of the object of management.

$$y_i(T) = F(n_1(T), n_2(T), \ldots, n_n(T)); \quad \forall T \in T^{max} = \{T^{St}, T^{Fin}\}, n \in N, \quad (12)$$

where $T$ is the time of operation of the object of management; $T^{max}$ is the maximum value of the time of operation of the object of management; $T^{St}$ is the initial moment of operation of the object of management; $T^{Fin}$ is the final moment of operation of the object of management. During the implementation of programs for the reconstruction of engineering infrastructure, the information on the inputs of the object of management is gathered and also information on its outputs is clarified. This information is accumulated in the knowledge base and transmitted both in the management system and in the adaptation system. Scholars distinguish active and passive adaptive management [14]. The essence of passive adaptive management consists in introducing the process of learning from the experience of program management into the existing approach, that of active management consists in the preliminary search and analysis of information to determine the best approach to management. A simplified diagram of the process of passive adaptive management of programs for the reconstruction of engineering infrastructure can be presented graphically (Fig. 3).

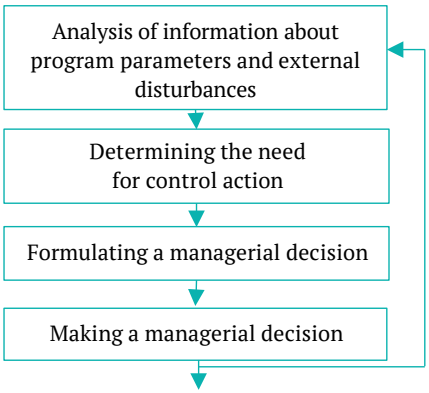


**Figure 3.** The process of passive adaptive management of programs for the reconstruction of engineering infrastructure

**Source:** developed by the authors based on [14]

A similar approach to managing programs for the reconstruction of engineering infrastructure involves the use of feedback to maximize the effectiveness of the control actions performed and the implementation of the program objectives. The data obtained are used to forecast the outcomes of future control actions, adjust the interim objectives of the program, etc. Thanks to the accumulated experience in managing an open dynamic system, which a program for the reconstruction of engineering infrastructure is, the passive adaptive approach provides for a better

adaption to external disturbances and minimization of the negative impact of the external environment on the program implementation process. The scheme of the process of active adaptive management of programs for the reconstruction of engineering infrastructure is shown in Figure 4.

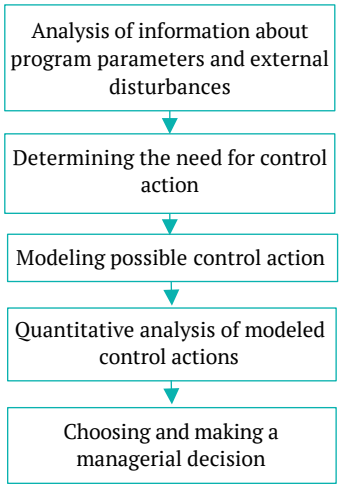


**Figure 4.** The process of active adaptive management of programs for the reconstruction of engineering infrastructure

**Source:** developed by the authors based on [14]

The main difference from the passive approach is the preliminary forecast of the outcomes of the exercise of control action and the choice of the best possible option. To maximize the effectiveness of the implementation of programs for the reconstruction of engineering infrastructure, it is advisable to use elements of both approaches: the application of both forecast and learning processes by the program management system. The scheme of this approach is shown in Figure 5.

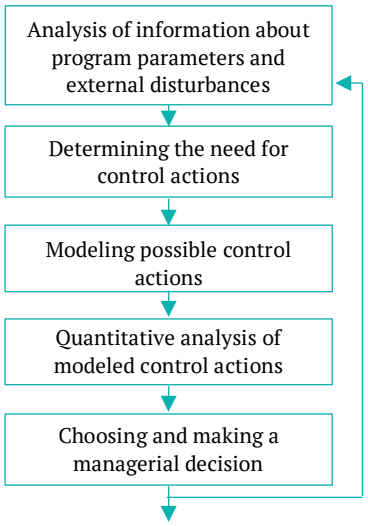


**Figure 5.** The process of combined adaptive management of programs for the reconstruction of engineering infrastructure

**Source:** developed by the authors on the basis of the data [14]

Thus, there is both the use of feedback and the accumulation of experience in the implementation of control actions during the implementation of programs for the reconstruction of engineering infrastructure and the application of this experience in their modelling and analysis. Thanks to the application of a combined approach to adaptive management, it is possible to achieve maximum efficiency of program management. Accordingly, the model of the program management system when applying the adaptive approach will have the following form:

$$PM = \{MD, MP, ID, K, AM\}, \quad (13)$$

where $AM$ is a set of adaptive program management tools. The set of adaptive management tools is illustrated by the formula (14).

$$AM = AM_{learn} \cup AM_{omod} \cup AM_{for} \cup AM_{exp} \cup AM_{ADSS}, \quad (14)$$

with $AM_{learn}$ being learning methods; $AM_{omod}$ being models and tools for modelling the object of management; $AM_{for}$ being methods and tools for forecasting; $AM_{exp}$ being management experiments; $AM_{ADSS}$ being adaptive means of supporting managerial decision-making.

Among the existing adaptive program management tools proposed by R. Bolling [19], it is advisable to apply adaptive logical-structural matrices, the use of real-time data, flexible program financial framework, structured learning cycles, action research for engineering infrastructure reconstruction programs. Adaptive logical-structural matrices differ from the usual matrices in that they allow the target indicators and the structure of the program to be adapted given the conditions of the external environment. The use of real-time data involves the continuous collection of information on the progress of the program. Flexible financial frameworks represent a variable cost structure and built-in opportunities to reallocate the budget during the implementation of the program. Structured learning cycles correspond to the concept of passive adaptive program management and include the introduction of a cyclical learning process based on feedback data. The essence of action research is the constant collection and analysis of data on the results of the control actions carried out to further optimize the management process.

Although other of the proposed tools can be used in the management of programs, but their application is inexpedient in the implementation of the programs considered in this study. An example of these tools is the evolutionary approach which is close to the concept of active adaptive program management and consists in testing control actions, scaling more effective and rejecting less effective ones. It provides for an analysis of already implemented actions, which is inappropriate in programs for the reconstruction of engineering infrastructure due to the high level of technical and financial risks. Inappropriate in the implementation of programs for the reconstruction of engineering infrastructure is also the inclusion of "bottom-up" – the involvement of beneficiaries and the program management team to obtain information on the implementation of the program and the formation of managerial decisions; this approach is important, but in the context of the management of programs for the reconstruction of engineering

infrastructure cannot be fully applied due to the high level of technical and financial risks.

Such adaptive management tools can be applied throughout the life cycle of the program [15]. For different phases of the life cycle, there are characteristic features for the use of both the above mentioned means and elements of adaptive management in general. In the implementation phase, the principles of adaptive control can be used most comprehensively through learning and forecasting processes. To exert a control action, it is possible to conduct a preliminary analysis of the accumulated experience, information on the state of the object of management and the presence of external disturbances, the use of this data for further forecast of the effect of the action. In the absence of a description of the object of management, it can be created, but this process is more relevant for the program definition phase. For the closure phase, it is more relevant to analyse the accumulated information and formulate best practices, lessons learned, etc. These processes demonstrate the use of learning as an element of adaptive management, but at the level of the organization where the program is implemented. The information obtained can be used to adjust similar program management processes in the future, but for this program at the closure phase, this information will no longer be relevant. The program definition phase involves more likely the use of means that provide opportunities for adaptation in the future: adaptive logical-structural matrices and flexible financial frameworks. Learning can be applied solely on the basis of previous program implementation experience. However, among the elements of adaptive management described in [13], forecasting and description are relevant. A list of supporting activities for the PMI program definition phase is provided in Figure 6.

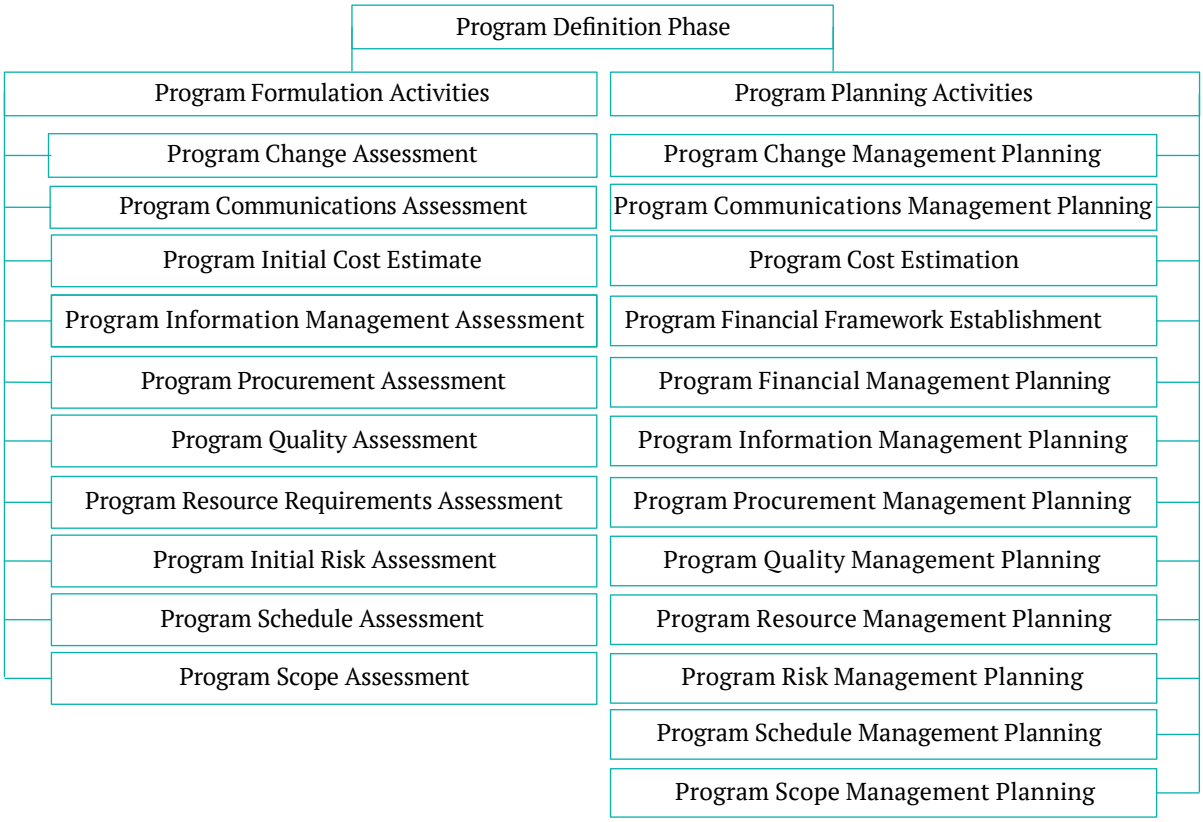


**Figure 6.** Structure of supporting activities of the program definition phase

**Source:** developed by the authors based on [15]

Forecasting methods can be applied to a large number of listed activities, including those related to managing quality, resources, schedule, scope, cost and finance, etc. The description of the object of management is also multifunctional in the context of the listed processes. The phases of program definition and implementation provide for the successful application of an adaptive approach, whereas it is necessary to note the importance of adaptivity for the definition phase. As mentioned earlier, scope assessment and program architecture development are the basis for assessing the program initial cost, changes, resources, risk and schedule. To select the optimal components of programs for the reconstruction of engineering infrastructure and their adaptation to environmental conditions, it is possible to use adaptive tools to support managerial decision-making.

The study by S. Canessa [20] is a good example of the application of an adaptive approach in the implementation of biodiversity protection projects, where the researchers' successful use of modelling and probabilistic analysis methods must also be highlighted. The approach was implemented by constructing a quantitative model of the system, the uncertainty of the model parameters was formulated using probability distributions, and the learning

benefits were evaluated using simulations. The authors note an increase in the effectiveness of monitoring and changing actions within the project, as well as ensuring the possibility of a safer response to negative external influences. However, the findings of the study in the context of programs and projects for the reconstruction of engineering infrastructure can be used only in part due to the lack of consideration of their special features.

The article by L. Gutheil [21] systematically reviews 21 studies on adaptive project management in the field of civil society to systematize ideas about adaptive practices, their perceived effect, obstacles and recommendations for their implementation from the perspective of donors and implementers. The work provides a basis for further research as it contributes to the definition of adaptive practices, the systematization of existing experiences in the implementation of adaptive management of such projects and identifies gaps in the current theoretical framework. However, it does not include more practical means of adaptive project management. G.B. de Azevedo [22] proposed an adaptive project management model to create a professional doctorate in business management. As a result, an adaptive project management model has been developed that includes constant planning of activities in each interaction cycle, an incremental approach to project execution, regular review of interim results, and the ability to adapt to changes in project content during the implementation phase. This work is a good case study of the practical use of adaptive project management tools. However, the findings of the study cannot be fully applied to the management of the program, as the application of an incremental approach to their implementation is inappropriate.

R.A. Samrah [23] analyses internal and external variables in the management of large programs to improve the effectiveness of program risk management. The authors have developed a system dynamic program model that takes into account the above variables and can be used for the management of large programs. The work presents a systematic approach to program management, provides an adaptive management tool that is valuable in terms of the possibility of further use of its findings, but does not take into account the specifics of programs and projects for the reconstruction of engineering infrastructure. The article by M. Wirkus [24] analyses the adaptive approach to project management and demonstrates the possibility of applying this approach to the implementation of a project for the reconstruction of a railway line. They discuss the issue of introducing adaptivity in infrastructure project management, but their main focus is placed on the development of project documentation within this approach. The findings of the study are useful given the general lack of disclosure of the processes of project documentation development in other sources.

The study by J.A. Thomann [25] is devoted to a critical assessment of strategies for adaptive groundwater management in urban water supply, agriculture and mining. The authors identified a number of problems with the application of adaptive management principles in the cases reviewed, including the lack of significant mitigation action and/or assessment of recovery potential. The need to develop clear definitions and guidelines for adaptive management is emphasized in order to ensure more transparent planning and efficiency in achieving objectives. The case analysis enabled the authors to identify the main problems in adaptive groundwater management and to develop appropriate recommendations that form the basis for the further development of management tools. In this paper, however, adaptive management is considered in a more general context, without a clear link to programs and projects.

The use of methods and tools for the adaptive management of programs and projects for the reconstruction of engineering infrastructure can therefore have a significant impact on the effectiveness of their implementation in turbulent conditions. By using learning methods, modelling of managerial influences, forecasting their results, etc. in different phases of the life cycle, it is possible to better adapt the management system to internal and external influences as well as a higher level of achievement of the program or project objectives.

## CONCLUSIONS

Program and project management as a whole occurs under conditions of uncertainty in the external and internal environment, where uncertainty stems not only from social, political conditions in the country of the project or program implementation but also from technical, human, and other factors of the management system and beneficiary organizations. This particularly applies to programs and projects for the reconstruction of engineering infrastructure as complex organizational and technical systems. They are also characterized by problems such as: it is impossible to build an invariant model of the program for the reconstruction of engineering infrastructure and an adequate model of the management system due to the lack of a priori information; an analytical mathematical model cannot be built using traditional methods. Uncertainties in the environment are sources of operational, technical, cost and schedule risks. The occurrence of any risks directly affects the possibility of achieving the objectives of programs and projects and complying with the set constraints.

To reduce the probability of these risks, it is recommended to employ an adaptive approach to program and project management. Adaptivity in program and project management involves the introduction into the management processes of learning from the results of control actions, modelling of managerial influences and assessing the effectiveness of their implementation, describing the control systems-objects and conducting managerial experiments. There are passive and active adaptive approaches to management, with the passive approach relying on learning mechanisms, and the active approach involving preliminary modelling of managerial influences. A combined application of these approaches is necessary to maximize the effectiveness of adaptive management.

Within the framework of adaptive program and project management, various tools can be used, such as adaptive logical-structural matrices, flexible financial program frameworks, an evolutionary approach to implementing control actions, etc. It is found that different phases of program implementation involve the use of different methods of adaptive management. For the implementation phase of the program, it is advisable to use learning methods based on the managerial experience gained as well as forecasting

to determine the best managerial influences. The closure phase enables the collection and analysis of information on the program progress for further learning for the implementation of future programs and projects. For the definition phase, it is important to provide possibilities for the application of adaptivity in the further implementation of the program through tools such as adaptive logical-structural matrices, etc. A promising area of research in the context of adaptive management of programs and projects for the reconstruction of engineering infrastructure is the development of new tools and methods of adaptive management, the study of ways to adapt the approach to the specifics of programs and projects in other areas of implementation – social, environmental, etc.

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## Адаптивний підхід до управління програмами і проєктами з реконструкції інженерної інфраструктури

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**Анотація.** Стандартні підходи до управління проєктами та програмами з реконструкції інженерної інфраструктури в умовах турбулентного зовнішнього середовища є малоефективними через брак можливостей адаптації до зовнішніх та внутрішніх впливів. Тому метою статті було охарактеризувати застосування концепції адаптивності в управлінні такими проєктами і програмами, проаналізувати засоби її застосування в процесах управління. Дослідження, наведене у статті, проведено за допомогою наукових методів критичного аналізу, системного аналізу, математичного моделювання, формалізації, аналізу, синтезу, графічного та абстрактно-логічного методів. Визначено основні обмеження при розробці архітектури програм. Досліджено вплив застосування стандартного підходу планування та управління програмами та проєктами з реконструкції інженерної інфраструктури на підвищення вірогідності виникнення ризиків впровадження. Сформульовано завдання управління програмами та проєктами при здійсненні управління як реалізації керівного впливу. Розглянуто концепції активного та пасивного методів адаптивного управління програмами, розроблено комбінований метод, що поєднує в собі попереднє моделювання управлінських впливів та навчання на досвіді здійснення таких впливів. Проаналізовано засоби адаптивного управління програмами, визначено доцільність їх застосування при управлінні програмами з реконструкції інженерної інфраструктури у різних фазах їх реалізації. Результати дослідження можуть застосовуватись менеджерами програм та проєктів з реконструкції або модернізації інженерної інфраструктури для визначення підходів до управління та підбору засобів адаптивного управління для різних фаз впровадження, а також являють собою методологічне підгрунтя для проведення подальших досліджень

**Ключові слова:** організаційно-технічні системи, керівний вплив, ризики, планування архітектури, прогнозування

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# Intellectual and financial business processes optimizing the structure and cost of capital in value based management

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**Abstract.** The primary task for Ukrainian enterprises at the current stage of their development is to develop and implement effective mechanisms to improve the well-being of owners, and, in order to be able to increase the market value, enterprises need to carefully monitor the business processes and take measures to optimize and increase efficiency. The purpose of the work was to generalize the use of intellectual and financial business processes to find the optimal capital structure according to the criterion of maximizing the market value of business. The methods of analysis and synthesis were used to define the optimal approach to determining the cost of enterprise capital, the method of structural and functional modelling of business processes to determine the structure of enterprise capital, as well as the method of systematization to form the areas of application of the CAPM model. The key business processes characteristic of modern Ukrainian enterprises have been built and directions of strategic cost-oriented management of enterprise capital structure in conditions of the external environment instability have been developed, which can be used in the practical activities of enterprises to increase the efficiency of their functioning. The modelling of business processes is combined with the development of directions of strategic cost-oriented management of the enterprise capital structure on the basis of their analysis. The use of an approach to modelling business processes by Ukrainian enterprises can allow planning the financial activities of the enterprise with high accuracy and take into account both strategic and tactical aspects of business development, allowing for the instability of the external environment and the high cost of raising capital. The results of the research can be useful for financial analysts and managers of enterprises of various forms of ownership, as well as for potential investors who consider the possibilities of investing in a certain business and are oriented towards making management decisions based on the analysis of business processes

**Keywords:** discount rate, risk-free interest rate, risk premium, strategy, development, investment

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## INTRODUCTION

Modern operating conditions of enterprises require transition to new models of business processes in management, finance and production with the active involvement of modern intellectual and financial tools. Such changes in business are inextricably linked to the phenomena of digitization (digitalization) and digital transformation, while modern realities of financial management require companies to focus on the main goal – improving the welfare of owners by increasing market value. The cost of capital for Ukrainian enterprises often becomes a restraining factor that prevents the full development of business and reduces the pace of possible development of enterprises in various industries. Ukrainian enterprises are characterized by the need to attract loan capital at a much higher interest rate than in European countries. As a result, companies refuse to raise capital because of its high cost. The search for modern tools for managing the capital structure and its value is one of the priority tasks for Ukrainian enterprises in the modern realities of the Ukrainian economy and the introduction of approaches to cost-oriented management.

The issue of introducing modern digital technologies into the process of managing business processes at modern enterprises is quite actively investigated both by scientists from Ukraine and by other researchers. For example, in the work of O. Guseva and S. Legominova [1], the authors emphasize that digitalization is becoming a key aspect of the effective development of any modern economy, and it is impossible to achieve positive results at the macro- or microeconomic level without the introduction of modern digital technologies. In the study by T. Demyanenko [2],

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the author emphasizes that in order to develop Ukrainian enterprises and maintain their competitiveness, it is necessary to introduce the latest digital management tools. M. Abou-Foul [3] emphasized the fact that for most modern companies, business processes remain a source of information about opportunities to improve the management system. Also, noteworthy is the idea that modern enterprises can cope with an unstable external environment solely at the expense of information technology [4]. M.A. Afonasova [5], together with her colleagues, focus on modelling business processes and determining the main directions for their improvement, while coming to the conclusion that for most enterprises, the analysis of business processes and the identification of shortcomings in them can ensure positive transformations at the enterprise. In the work of American scientists [6] attention is focused on the fact that the restructuring of management processes under the influence of modern digital technologies will allow more effective use of various types of resources. The scientific work of researchers from Great Britain [7] contains the opinion that today digital technologies are becoming a part of everyday life and can be used in various areas of business development support, from marketing to financial support. However, the researchers do not determine exactly how digital tools should be chosen for the development of a particular area of business development. Researchers I. Krakovskaya and J. Korokoshko [8] focus attention on the fact that one of the main areas of application of modern digital tools is the modelling of business processes followed by their in-depth analysis, which will allow identifying problematic aspects of enterprise activity and specifying potentially promising development links of business entities.

However, despite the close attention of scientists in recent years to the issues of business process analysis and the introduction of digital technologies into the enterprise management system, the process of business process analysis has not been considered as a prerequisite for the development of strategic cost-oriented management of the enterprise capital structure. The purpose of the study is defined as a generalization of the theoretical and methodological aspects of the application of intellectual and financial business processes to determine the optimal capital structure according to the criterion of maximizing the market value of the enterprise.

## MATERIALS AND METHODS

The research used general scientific methods, in particular, methods of analysis and synthesis to define the optimal approach to determining the enterprise capital cost: the analysis helped to break down the researched question into separate and simpler ones, while the synthesis allowed combining different aspects of the problem and examining them as a whole. The method of scientific generalization was used to determine the optimal sequence of actions for managing the capital structure. Further, the method of structural-functional modelling of business processes was used to describe the process of determining the optimal cost and capital structure of the enterprise, which allows visualizing the sequence of actions for capital management and the search for its optimal structure. Separately, the method of modelling business processes was used, based on an in-depth analysis of all processes at the enterprise, in particular those related to financial support and attraction of capital. Ramus software was used to model business processes, which allowed not only building business processes but also detailing them on several levels of decomposition. The method of systematization was used to form the areas of application of the CAPM (Capital Asset Pricing Model) model. The use of this model allows taking into account the risks of investing funds in a certain enterprise or industry, which is especially important in conditions of uncertainty in the external environment. The method of building a strategic map was used to outline the directions for the implementation of the strategy of cost-oriented management of the enterprise capital structure in conditions of the external environment instability, which makes it possible to plan in detail the sequence of actions of the management of the enterprise in the implementation of strategic plans and directions of its development. With the help of a graphic method, the obtained research results are visualized and presented for a visual perception of information. The application of the abstract-logical method helped to form consistent and comprehensive research conclusions.

## RESULTS AND DISCUSSION

Making effective management decisions during the implementation of cost-oriented management is a multifaceted process that depends on the completeness, reliability and effectiveness of information about the results and the environment of the enterprise. It is under these conditions that the role of intellectual and financial business processes in optimizing the structure and cost of capital is actualized, which will determine the effectiveness of innovation activity on the basis of available information resources. The information support of the enterprise depends not only on the availability of information resources, but also on the possibility of introducing information innovations, streamlining information flows, solving problems of their effective information interaction with market participants and the correct reflection of financial business processes.

In the process of managing expenses and capital structure in the system of cost-oriented management, the emphasis is placed primarily on the influence of these components on the enterprise value, moreover, the emphasis should be placed on the formation of an information and financial base for effective management of enterprise value [2]. The process of managing the enterprise value involves the sequential implementation of the following steps: determination of the enterprise value using various approaches; identification of factors affecting the enterprise value; specification of priority directions for improving the company's development strategy, which will be based on a cost-oriented approach to management; development of operational cost management measures of the enterprise; conducting a self-audit and identifying events and management decisions that affect the company's value [9].

One of the key elements of assessing the market value of an enterprise is to determine the value of the enterprise capital, since the net cash flow indicator for the period directly depends on the capital value. With this in mind, company managers need to analyse the current state of the capital market and determine which capital structure is optimal for the company, taking into account the

conditions for attracting loan capital and the cost of obtaining equity capital. The business process of optimizing the structure and cost of capital in the system of cost-oriented management should be considered in more detail (Fig. 1).

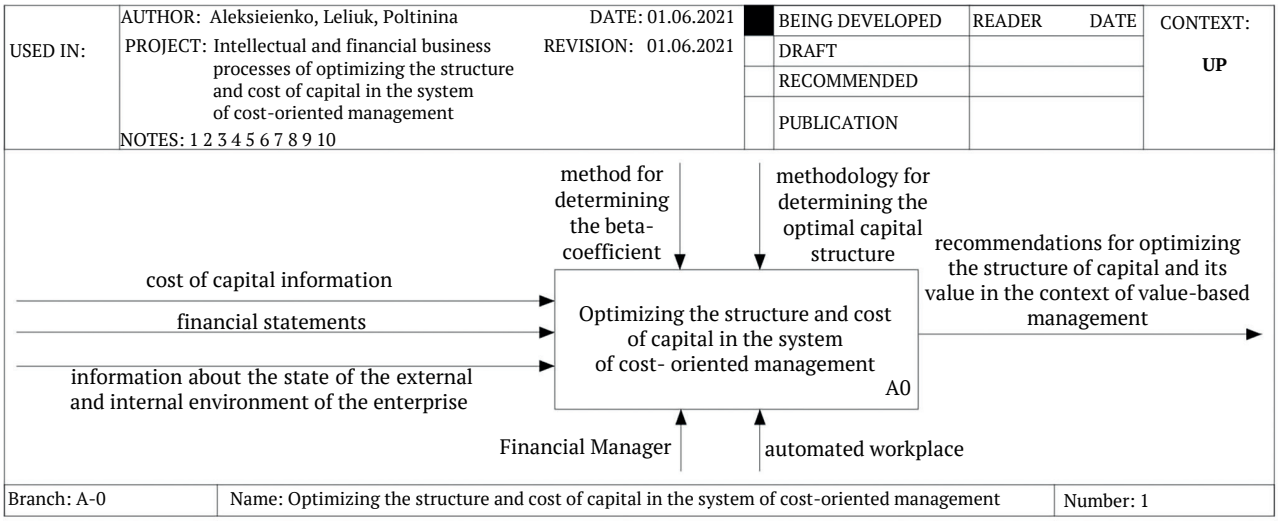


**Figure 1.** The main business process "Optimizing the structure and cost of capital in the system of cost-oriented management"

**Note:** A0 is the level of decomposition

**Source:** made by the authors based on [9]

At foreign enterprises, business process management has been used for a long time, but for Ukrainian companies, this approach is new and requires detailed study. The details of the business process (Fig. 1) are presented in Figure 2.

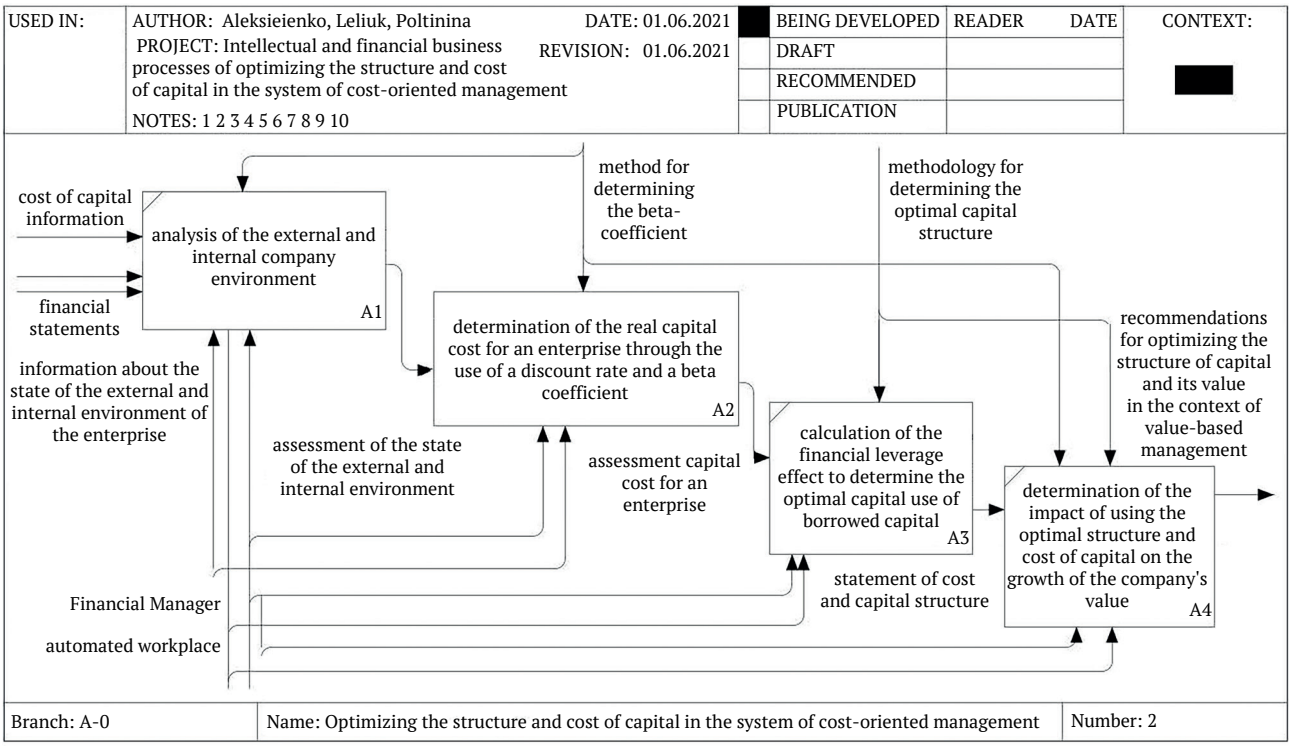


**Figure 2.** Detailing the components of the business process "Optimizing the structure and cost of capital in the system of cost-oriented management"

**Note:** A1-A4 are levels of decomposition

**Source:** made by the authors based on [9]

It should be noted that it is important for Ukrainian enterprises to constantly determine the cost of capital, taking into account the risks of the external and internal environment. A tool that allows taking these risks into account is the CAPM model. In this model, the discount rate (discount) is a coefficient used to determine the present value of cash flows that are projected for the future. In the context of valuation, the discount rate characterizes the rate of return on invested capital and the rate of return in the post-forecast period, according to which, on the valuation date, the buyer can invest in the acquisition of the object of valuation to compensate for all their investment risks. The discount rate takes into account the premium for the risk of investing in the evaluated enterprise: the greater the risk, the higher the discount rate.

The discount rate performs three main functions that can be considered in the context of managing the company's financial activities: it reflects the rate of return from discounting future cash flows to their present value on the valuation date; indicates the level of risk that the investor has in the process of investing in the analysed enterprise; reflects the cost of capital raised by the enterprise for a short or long period. Scientific sources provide different approaches to determining the discount rate and consider the peculiarities of the application of each of the approaches, the main of which are given in Table 1.

**Table 1.** Characteristics of discount rate calculation methods

| Method name | General characteristics |
|---|---|
| Cumulative construction method | Takes into account all possible calculated compensations for risk. Involves taking into account a significant number of possible potential risks. |
| The comparative sales method | Based on the determination of cash flow from operating activities and the analysis of financial indicators for a number of similar enterprises, a comparative approach is used. |
| Method of related investments | It can be used both for equity and loan capital, as well as allows the use of a model for calculating the weighted average cost of capital. |
| WACC (weighted average cost of capital) method | Provides for the determination of the tax shield and the calculation of the value of each component of the capital involved, taking into account the real market situation and the real conditions of financing the enterprise. |
| Method of internal rate of return | It can be applied in one of two formats: simple and modified. The discount rate is calculated based on the determination of the internal rate of return on capital invested in the enterprise. |
| LIBOR (London Interbank Offered Rate) method | Calculations are based on the value of the monetary unit and each specific currency in which the company conducts operations. |
| CAPM method of capital assets | It is determined on the basis of data on the capital market and the level of risk of investing in a certain enterprise or enterprises of a certain industry. |

**Source:** made by the authors based on [10-17]

Depending on the chosen method of determining the discount rate, it is necessary to define the directions of minimizing the risks of the company's financial activity, among which the key role should be given to determining the risks of attracting capital from various sources. Capital structure management refers to the decision-making process that identifies the proportionate mix of debt and equity financing used by a company to finance its operations and investments. While capital structure decisions are important to the company's financial health and growth, they involve certain risks.

Financial risk: when a company relies heavily on debt financing, it increases its financial risk. Debt requires periodic interest payments and principal repayments, which can strain a company's cash flow, especially during economic downturns or periods of high interest rates. If a company defaults on its debt obligations, it may face financial difficulties, bankruptcy or a downgrade in its credit rating. Interest rate risk: companies with a significant amount of debt are exposed to interest rate risk. Changes in interest rates can affect the cost of loans and debt service. If interest rates rise, the company's interest expense may increase, leading to higher finance costs and potentially impacting profitability. Credit risk: capital structure decisions affect a company's credit risk. When a company borrows, it becomes obliged to repay the principal and interest. If a company's financial condition deteriorates, it may find it difficult to meet its debt obligations that leads to default or a downgrade in its credit rating. This can make it more difficult and expensive for the company to raise funds in the future.

Market perception: investors and stakeholders closely monitor a company's capital structure decisions. If a company's capital structure is considered risky or unbalanced, its reputation and perception in the market can be negatively affected. This could lead to lower investor confidence, limited access to capital markets and potentially higher borrowing costs in the future. Lack of flexibility: companies with high levels of debt may face limited financial flexibility. Debt obligations may limit a company's ability to invest in growth opportunities, implement strategic initiatives or respond to unforeseen changes in the business environment. It may also limit a company's ability to withstand economic downturns or periods of financial instability. Ownership dilution: raising equity capital to improve the capital structure may dilute the ownership of existing shareholders. This can reduce their control over the company and potentially lead to conflicts of interest between different shareholders.

It is important for companies to carefully assess and manage these risks when making capital structure decisions. Factors such as the financial strength of the company, industry dynamics, market conditions and risk tolerance should be considered to find the appropriate balance between debt and equity financing. Seeking professional advice from financial experts or consultants can also help reduce these risks. Cost-oriented management of an enterprise capital structure focuses on maximizing shareholder

value by optimizing the combination of debt and equity financing. Strategies commonly used in cost-oriented capital structure management are presented below [18].

Optimizing the cost of capital: the primary objective of cost-oriented capital structure management is to minimize the total cost of capital. This involves determining the optimal mix of debt and equity that minimizes the weighted average cost of capital (WACC). By analysing the cost of different financing options and considering factors such as interest rates, credit ratings and tax implications, companies can aim to achieve the most cost-effective capital structure. Assessment and balancing of risks: cost-oriented capital structure management involves assessing and balancing the risks associated with different sources of financing. Companies should assess their risk tolerance, industry dynamics and financial stability to determine the appropriate level of leverage. By carefully analysing and managing financial risks, companies can find a balance between debt and equity to optimize their capital structure. Management of long-term debt: companies seeking cost-oriented management of their capital structure often focus on maintaining a reasonable level of long-term debt. Long-term debt usually has lower interest rates than short-term debt and provides stability in the capital structure. This allows companies to plan long-term investments, reduces refinancing risks and improves financial flexibility.

Cash flow management: effective cash flow management is critical to cost-oriented capital structure management. Companies must ensure that their cash flows are sufficient to cover debt service obligations. By effectively forecasting and managing cash flows, companies can reduce the risks of financial distress and ensure the stability of their capital structure. Diversification of funding sources: cost-oriented capital structure management involves diversification of funding sources. Excessive reliance on a single source of financing, such as bank loans or equity issuance, can increase risks and limit flexibility. Companies may explore alternative financing options such as bonds, convertible securities, mezzanine financing or strategic partnerships to diversify their capital structure and optimize their financing mix. Regular review and correction. Capital structure management is not a one-time solution, but needs to be regularly reviewed and adjusted based on changing market conditions, business needs and risk profiles. Companies should periodically review their capital structure, taking into account factors such as changes in interest rates, changes in industry dynamics, growth opportunities and the company's overall financial condition.

It is important to note that the optimal capital structure is different for each company and depends on factors specific to the industry, market conditions and the stage of development of the company. Consultation with financial experts or advisors who specialize in capital structure management can provide valuable information and recommendations tailored to a company's unique circumstances [19]. For most companies, it is critically important to track strategic directions of development and the formation of optimal tactical measures for the implementation of strategies. It is important to determine the directions of strategic cost-oriented management of the capital structure of the enterprise in conditions of instability of the external environment. The distribution of the goals of cost-oriented management of the capital structure should be rationally carried out according to the following main perspectives: finances, customers, internal processes, training and growth, long-term development prospects (Table 2).

**Table 2.** Directions of strategic cost-oriented management of enterprise capital structure in conditions of external environment instability

| Perspective | Indicator | Goal | Method of achievement (initiative) |
|---|---|---|---|
| Finance | Autonomy coefficient | Improving the efficiency of the use of equity capital | Expansion of sales system |
| | Equity manoeuvrability ratio | | Increase in share of own funds |
| | Cost of production | Cost reduction and asset control | Use of advanced types of raw materials, energy carriers |
| | Asset turnover ratio | Improving the efficiency of the use of current assets | Reduction of the time of finding funds in receivables |
| | Funding ratio | Capital structure optimization | Reduction of accounts payable |
| Customers | Return on sales ratio | Increase in sales | Increasing the level of marketing research aimed at accelerating the promotion of goods from the producer to the consumer (including market research, formation of the correct pricing policy, organization of effective advertising, etc.) |
| | Product profitability ratio | Increase in market share | Expanding the range of products, ensuring a high level of customer service |
| | Market share | | |
| Internal processes | Share of investments in production facilities | Use of the latest equipment | Purchase of modern equipment, automation of production |
| | Land bank area (ha) | Increase in enterprise profitability | Increasing the enterprise land bank |
| | Return on assets ratio | | |
| Training and growth | Staff turnover rate | Increasing the level of employee motivation | Development of motivation system<br>Improvement of marketing service |
| | Share of employees receiving bonuses | Increasing the level of employee motivation<br>Improving employee qualifications | Development of motivation system<br>Improvement of marketing service |
| | Share of employees with higher education | | In-depth study by management employees and specialists of the enterprise of a certain field of activity |

Table 2, Continued

| Perspective | Indicator | Goal | Method of achievement (initiative) |
|---|---|---|---|
| Long-term development prospects | Share of capital investment in total invested capital | Increase in the amount of funds invested in enterprise capital development | Search for investors and identification of possible reserves of self-financing of strategically important projects within the enterprise |
| | Amount of reinvested profits | | |

**Source:** made by the authors based on [20-21]

The formation of strategy is of great importance for a company, as it provides direction for achieving its long-term goals and ensuring its competitive advantage [21]. There are several reasons that emphasize the importance of strategy formation. Strategy formation determines the direction and purpose of the company, while the strategy sets clear goals, outlines the path to their achievement, and directs the efforts of employees towards a common vision. A clearly defined strategy ensures that everyone in the organization is working towards a common goal, promoting focus, efficiency and coordination. Strategy formation helps companies identify and use their unique strengths, resources and opportunities to gain a competitive advantage in the market [15]. Strategy formation plays a crucial role in resource allocation. It allows companies to determine how to allocate their limited resources, such as financial capital, human capital, and time, in the most efficient and effective manner. A well-designed strategy ensures the allocation of resources in areas that have the greatest potential to create value and achieve strategic goals (Fig. 3).

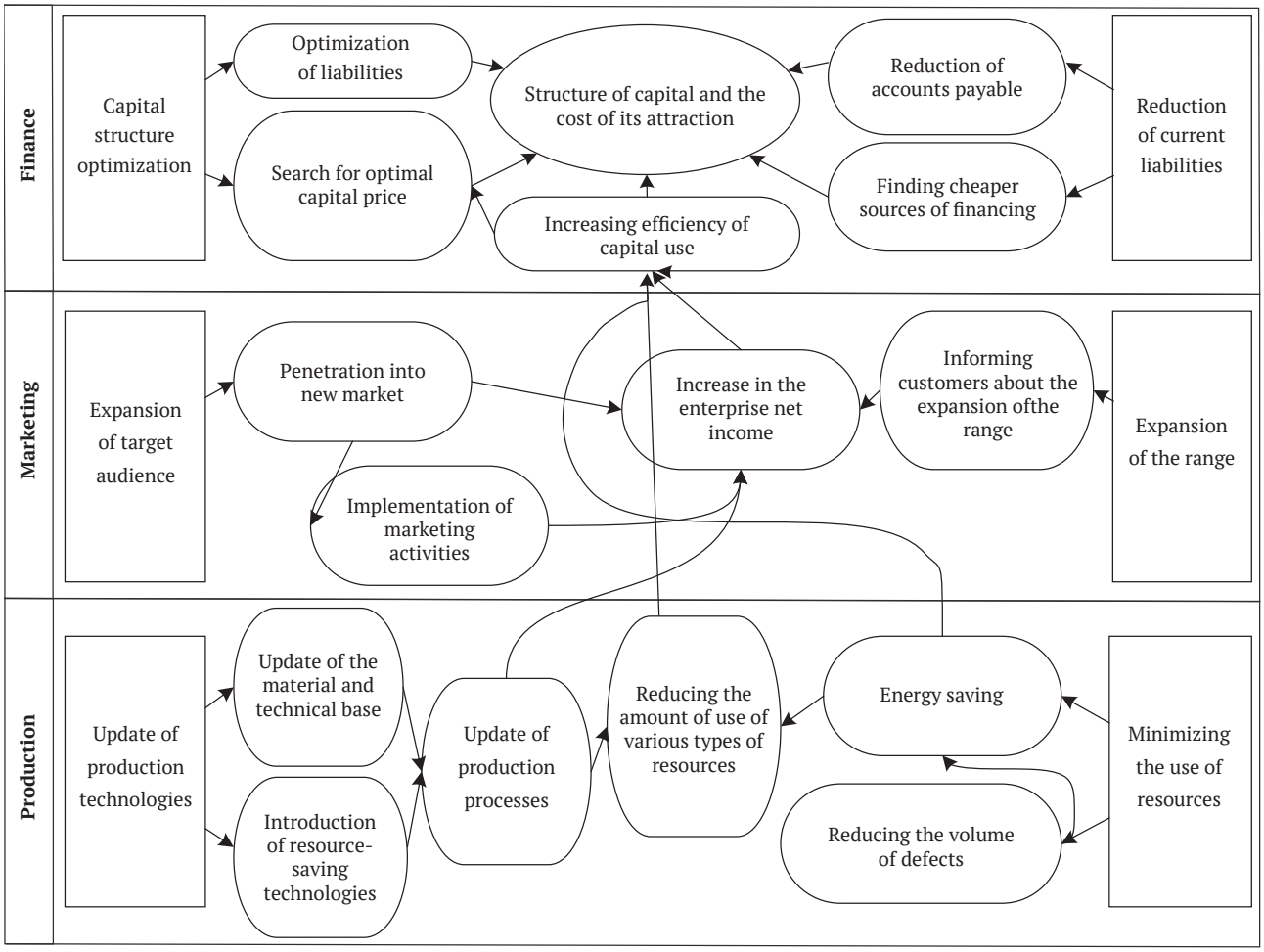


**Figure 3.** Strategic map for the implementation of the strategy of cost-oriented management of enterprise capital structure in the conditions of external environment instability

**Source:** made by the authors based on [11; 14; 15; 21]

After the development of the strategic map, the issue of the optimal discount rate indicator for Ukrainian enterprises in the conditions of an unstable external environment remains uncertain, so the investor independently determines the discount rate based on market analysis, the level of risks and potential opportunities for the development of this or that industry. For example, a rate of 12% is used for projects implemented in areas where there is

a market and business is developing [17]. The possibility and feasibility of attracting debt capital to the activities of the enterprise depends on the value of the cost of capital indicator. Determining the feasibility of debt capital should be carried out using the financial leverage effect indicator, which is calculated using formulas (1; 2).

$$\text{Financial leverage effect} = (1\text{-income tax}) \times \times \text{ROA-wacc}) \times (\text{Total Debt} / \text{Equity}) \quad (1)$$

$$\text{Total Debt} = \text{Short Term Debt} + \text{Long Term Debt} \quad (2)$$

Determination of the feasibility of debt capital, and, as a result, the adoption of such management decisions should be carried out using the effect of financial leverage. Constant monitoring of changes in the cost of capital and its comparison with the profitability of assets is particularly important for Ukrainian enterprises in the conditions of an increase in the cost of capital. Given the unstable nature of the development of the Ukrainian economy, it is worth expecting an increase in the cost of capital for enterprises, which additionally indicates the expediency of using the described methodical approach to assessing the cost and optimizing the capital structure.

The issue of capital structure management is becoming more and more relevant not only for Ukrainian enterprises, where the cost of capital remains quite high in recent decades, but also for Western companies, where the cost of capital is increasing starting from 2020, after the development of crisis phenomena caused by the pandemic. The leading countries of the world increase the discount rates of Central Banks and no longer have the opportunity to finance business with "cheap" capital [16]. However, it is worth noting that the accounting rate takes into account only macroeconomic risks, and it is not worth relying on it when analysing the cost of capital for Ukrainian enterprises. Other methods and approaches to determining the cost of capital, which were analysed in this work, should be used. In particular, it has been proven that the correct determination of the cost of capital through the discount rate will allow enterprises to more carefully and rationally plan their financial activities. In turn, planning financial activities today is increasingly implemented through modelling of business processes. Researchers in the field of digital economy Y. Ostropolska [4] and M. Graham [16] share the opinion that business process modelling can become a tool that allows identifying problematic aspects in enterprise management and forming directions for further improvement of management systems in general, and finding optimal capital structure in particular. As a result, simulated business processes can become the basis for further development and implementation of strategic business development plans. At the same time, scientists T. Demyanenko [2], I. Zhuravlyova [10], L. Ardito [18], who consider business processes from an economic and financial point of view, realize that qualitative modelling of business processes and their analysis at all levels of detail provides information about the state of the enterprise as a whole. And the article supplemented this idea and proved that the modelling of business processes can become the basis for building a strategy for the further development of the enterprise and finding the optimal direction for managing the capital structure. Scientific literature [4; 17; 20] also pays considerable attention to the development of enterprise development strategies, however, most researchers are of the opinion that forming a strategy is worthwhile for those companies that develop in stable conditions and have a predictable external environment. However, the article proves that even in the conditions of an unstable external environment, it is possible and necessary to develop an enterprise development strategy that will allow a more balanced and quick response to changes in the external environment, in particular to changes in the cost of capital or increased risks. In this context, it is also proposed to take into account the risks of the external environment when determining the cost of capital and to have some measures to minimize these risks in the arsenal, which is also detailed in the process of conducting the research. At the same time, the approach is innovative, which refers to the orientation of business processes and strategic development precisely on the growth of the value of the enterprise, as a strategic goal of business in the conditions of an unstable external environment. Representatives of the scientific community, namely B.L. Dey [7], W.C. Lucato [13], E.R. Banalieva and C. Dhanaraj [14] also express the opinion that the cost of capital directly affects the market value of the enterprise, but the article develops this idea and proves a close connection between the discount rate and the search for the optimal capital structure.

Determination of the optimal cost and capital structure for modern Ukrainian enterprises is almost the most important task, taking into account the instability of the external environment and the need to accumulate resources to ensure development in turbulent conditions. In view of this, modeling of business processes related to the formation and use of capital can become exactly the tool that can significantly enrich the management processes of Ukrainian business entities.

## CONCLUSIONS

As a result of the research, it has been proved that the processes of managing the cost and capital structure in the system of cost-oriented management of the enterprise are combined and enriched through the use of modern tools of intellectual and financial business processes. At the same time, the achievement of the common goal of managing the cost and capital structure, as well as the value of the enterprise, is the basis for the development and implementation of the enterprise value management strategy.

It has been proven that business process management is a set of methods for organizing tasks that are repeated in the company, based on constant analysis, measurement and optimization of processes. This management approach has long been used at foreign enterprises, while for Ukrainian enterprises it is quite new and requires special attention. The article builds business processes aimed at optimizing the capital structure. At the same time, it has been proven that the simulated business processes can become the basis for the development and further implementation of the company's development strategy. In the conditions of an unstable external environment and a constant increase in the cost of capital, the strategic priorities of the development of Ukrainian enterprises are focused on optimizing the capital structure and reducing the costs

of its attraction. As a result of the research, it has been determined that discount rates are a key indicator in the process of modelling business processes to optimize the capital structure. Accordingly, a comparison of different approaches to determining the discount rate is given and various types of risks that can be included in the calculation of this indicator are taken into account. The need for strategic planning of cost-oriented management of the capital structure of the enterprise in conditions of the external environment instability is also proven, and a strategic map of the implementation of this process is built, which allows focusing attention on the main directions of tactical and strategic development of the enterprise in the context of managing the capital structure. The use of an approach based on modelling business processes to manage the capital structure will allow taking into account the current state of the enterprise and its opportunities to attract capital from different sources and at different costs. The direction of further research for scientists who will be interested in the issues of modelling business processes and capital structure management can be to determine the possibilities of using innovative technologies to manage the use of resources, in particular, lean production or building scenarios for various business processes.

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## Інтелектуальні та фінансові бізнес-процеси оптимізації структури та вартості капіталу в системі вартісноорієнтованого управління

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**Анотація.** Першочерговим завданням для українських підприємств на сучасному етапі їх розвитку є розробка та реалізація дієвих механізмів підвищення добробуту власників, при цьому, аби підприємство мало змогу нарощувати свою ринкову вартість, йому необхідно ретельно слідкувати за бізнес-процесами, що присутні на підприємстві та вживати заходів для їх оптимізації та підвищення ефективності. Метою роботи було узагальнення теоретико-методологічних аспектів використання інтелектуально-фінансових бізнес-процесів для пошуку оптимальної структури капіталу за критерієм максимізації ринкової вартості бізнесу. Використано методи аналізу та синтезу для визначення оптимального підходу до визначення вартості капіталу підприємства, метод структурно-функціонального моделювання бізнес-процесів для визначення структури капіталу підприємства, а також метод систематизації для формування сфер застосування моделі CAPM. Побудовано ключові-бізнес процеси, характерні для сучасних українських підприємств, та розроблено напрями стратегічного вартісноорієнтованого управління структурою капіталу підприємства в умовах нестабільності зовнішнього середовища, які можуть бути використанні в практичній діяльності підприємств для підвищення ефективності їх функціонування. Поєднано моделювання бізнес-процесів із розробкою на основі їх аналізу напрямів стратегічного вартісноорієнтованого управління структурою капіталу підприємства. Використання підходу до моделювання бізнес-процесів українськими підприємствами може дозволити планувати фінансову діяльність підприємства з високою точністю та враховувати як стратегічні, так і тактичні аспекти розвитку бізнесу, зважаючи на нестабільність зовнішнього середовища та високу вартість залучення капіталу. Результати дослідження можуть бути корисними для фінансових аналітиків та керівників підприємств різних форма власності, а також для потенційних інвесторів, які розглядають можливості вкладання коштів в певний бізнес та орієнтовані на ухвалення управлінських рішень на основі аналізу бізнес-процесів

**Ключові слова:** ставка дисконтування, безризикова відсоткова ставка, премія за ризик, стратегія, розвиток, інвестування

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