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DETERMINING THE IMPACT OF DIGITALIZATION ON FINANCIAL MANAGEMENT AND DEVELOPING MODELS TO ASSESS ITS EFFICIENCY

The object of research is financial digitalization and the effectiveness of its impact on financial management. The problem of defining the mission of digitalization and formalizing its impact on financial management was solved.

The research results are as follows:

– defining the mission of digitalization in management as reforming its information support;

– distinguishing two management systems: digital and management technologies, and the presence of a systemic impact of the first on the second;

– assessing the effectiveness of digitalization taking into account the economic interests of stakeholders through the use of indicators: the effectiveness of investment in financial digitalization (ROI_f), the effectiveness of financial management (E_f), the profitability of equity (ROE);

– the factorial relationship between the indicators: $ROI_f \rightarrow E_f \rightarrow ROE$;

– formalizing ROI_f, E_f, ROE for profitable enterprises and non-profit organizations through factor modeling and eliminating factors not related to digitalization;

– a mechanism for intensification of management processes due to the reduction of time and costs for management, the growth of sales volumes and net profit.

The originality of the results obtained lies in: using a systematic approach to defining the mission of digitalization of management; specifying the category of efficiency through its a posteriori definition and taking into account the interests of stakeholders; formalizing the indicators of the effectiveness of financial digitalization. This approach allowed to solve the above-mentioned problem, which regulates the scientific perception of digitalization of management and the prospects for its implementation. In practical activities, the developed methods will allow to objectively assess the effectiveness of financial digitalization and ensure the activation of investments in digital transformation. But their practical use is possible provided that the management personnel are motivated and the system of management accounting and reporting is developed.

Keywords: *financial digitalization, digital technologies, management technologies, financial management, digitalization effectiveness, information support.*

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1. Introduction

The modern world, in all its manifestations and in all spheres of human existence, is rapidly developing and is filled with the latest technologies and innovative approaches to solving various problems. The digital transformation of modern human activity attracts the most attention. The term "digital transformation" was introduced in 2011 and is defined as "the use of technologies to radically increase productivity or business coverage" [1]. As noted in [2], as a result of the introduction of revolutionary technologies and digital tools, the so-called digital society of the Metaverse is formed, that is, a specific virtual world, which is a fundamentally innovative driver of social development. In other words, "digital transformation is the main factor of economic growth" [3].

This is stated in the work [4], in which it is interpreted as "an irreversible process of introducing digital technologies in the conditions of the development of the era of the digital economy to improve the life of a person, business, society and the state as a whole; as a process of transition from optimization of socio-production relations to digital economy" [4]. In addition, it (digital transformation) is a multidisciplinary phenomenon that includes innovations in various areas, and the interaction between them leads to a significant synergistic effect [5], that is, the effect of digital transformation of any human activity spreads in time and space. The presence of such a colossal effect of digitalization has prompted some scientists to argue about the emergence of digital mechanisms, digital tools and technologies [6, 7], digital solutions and even "digital" management [8]. The spread of such statements causes

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at least surprise, and at most, categorical objections to the possibility of replacing management mechanisms with digital technologies and reducing the leading role of management activities. Because such fundamental theoretical errors in practice can lead to an exaggeration of the importance of digital technologies and, accordingly, a loss of attention to the development of scientific management and a decrease in the effectiveness of its practical implementation. And, taking this into account, there is an urgent need for a thorough research of the hierarchical subordination of management and digitalization with its corresponding scientific substantiation. The world leaders in terms of the level of digital transformation are the USA, Finland, Sweden, Denmark, Germany, France, China and India [9], as well as Singapore, the Netherlands, Great Britain, Norway [4]. Each country independently defines the main goals of the digital transformation strategy. In Iceland, the goal of digitalization is defined as the creation of a "digital country", in Japan – as the development of the Internet of Things and the use of artificial intelligence, in some countries – as increasing the efficiency and competitiveness of the national economy [10]. The state's attitude to digital processes and appropriate state support for digital technologies are too important. It has been most actively implemented in industrially developed countries, in particular: Australia, Austria, Denmark, Singapore and Japan [10]. The publication [11] provides an opportunity to familiarize yourself with the experience of American banks in implementing the latest financial technologies. The study [12] presents the practice of implementing digital technologies in American companies Netflix, Adobe, Starbucks, Romanian UiPath, Polish Allegro, Czech Škoda Auto. Incidentally, it is possible to note that successful Ukrainian companies (the country's largest online retailer Rozetka and the logistics company Nova Poshta) that have implemented digital technologies in their activities are also mentioned [12]. With similar conclusions, the experience of digital transformation in work is also described [7]. The experience of these countries, their governments and individual successful companies is relevant and in demand for digital transformation in other countries. Digital transformation is of particular relevance for countries (including Ukraine) that are oriented towards the European path of development and have chosen European integration [13].

For Ukraine, digital transformation is also significantly relevant due to the problems of martial law [14] and post-war recovery [3, 13, 15]. In Direction 8 "Information and Communication Technologies" of the National Economic Strategy of Ukraine for the period until 2030, approved by the Resolution of the Cabinet of Ministers of Ukraine dated March 3, 2021 No. 179 [16], a certain lag of the country from the European situation and the pace of digitalization is noted, but the presence of the corresponding potential for carrying out planned measures in the future to eliminate the identified brakes and obstacles is indicated. The Law "On Stimulating the Development of the Digital Economy in Ukraine" of July 15, 2021 No. 1667-IX (as amended on January 1, 2025) is aimed at stimulating the development of the digital economy in Ukraine by creating favorable conditions for conducting innovative business, developing digital infrastructure, attracting investments, as well as talented specialists [17]. The Ukrainian government's attention to the prospects for digitalization is also confirmed by the fact that, despite the problems of martial law, in early January 2026, the Verkhovna Rada registered draft law No. 14362 "On Amendments to the Law of Ukraine "On Stimulating the Development of the Digital Economy in Ukraine" and Certain Other Legislative Acts on Improving Instruments for Stimulating the Development of the Digital Economy" [18], which is aimed at increasing the investment attractiveness of digital instruments and launching a new venture financing model – the Diia.City Invest funds. Radical digital changes are planned in the defense of Ukraine, primarily in the application of defense tech (defense technologies in the development, production and implementation of innovative solutions for the military sphere). According to the newly appointed minister, "defense tech will become a key industry of Ukraine in global markets and a driver of the country's economic growth: ... from drones, robotics, cybersecurity to artificial intelligence and new materials, in order to increase the security and efficiency of the army" [19]. Thus, Ukraine sets itself quite ambitious goals, which are objectively necessary at least from the point of view of its preservation and survival as a sovereign and self-sufficient state. From a scientific point of view, these prospects are being studied by domestic scientists, for example, in [14].

However, despite the significant progress of Ukraine's state policy in the field of digitalization, for objective and subjective reasons, there is currently a certain lag in the pace and quality of digital processes, which is recorded both officially in Direction 8. "Information and Communication Technologies" of the National Economic Strategy of Ukraine for the period until 2030 [16] and in scientific publications [3, 9, 10, 20].

The global complex topic, one way or another related to digitalization, has a fairly representative number of various publications in modern scientific literature; scientific developments of scientists who study this topical topic from different positions are devoted to it. There are differences in the implementation of digital technologies in different areas of activity: for logistics, the emphasis is on the speed of service; in finance – on transparency and risk management; in the IT sector – on innovation; in production – on process optimization and cost reduction [21].

The problems of digitalization of the financial sector have only been considered in recent years in many publications, which were studied in this work as basic sources. Thus, digitalization is considered in the context of its features: in small business [22], adaptation in the field of financial services in [23, 24], in riskology [25, 26], impact on information support of management [27, 28]. In financial digitalization, the object of research is defined as financial technologies (FinTex). Their essence is interpreted in [29] as "a combination, on the one hand, of digital technologies, on the other hand, of innovations in the financial sector". In other words, "financial technologies (FinTech) are an industry that combines finance and information technologies to create innovative solutions and services in the financial sector" [30]. Some scholars believe that "FinTech is the technology used by financial services to help companies manage financial assets using special software, including new programs, applications and business models" [31]. In the same context, the interpretation of financial technologies is given in [32]: "Financial technologies are a synthesis of digital technologies and innovations in the financial sector used to provide, expand and distribute financial services by technology companies". Their essence is presented somewhat differently in [33]: "on the one hand, as innovative methods and ways of providing financial services, and on the other hand, as a branch of the economy represented by enterprises offering the corresponding service" [33]. The classification of FinTex is discussed, for example, in publications [29, 32, 34, 35]; the stages of their development are discussed in [20].

Note that there is another fundamental feature of the financial sector in the context of the introduction of modern digital technologies. This feature is due to the rapidity of financial processes and their general prevalence, which provide the greatest positive effect in this area. Therefore, the digitalization of the financial sector under modern conditions is of paramount practical importance. In view of this, the Ukrainian Association of Fintech and Innovation Companies has been operating in Ukraine since 2018, which aims to promote the development of the Ukrainian financial technology market, create a strong fintech ecosystem and increase financial inclusion in Ukraine [36].

The banking sector occupies a special place in the financial sector, therefore the overwhelming number of scientific developments on the intersection of finance and digitalization are devoted to this topic. In this context, banking is considered in the works [1, 11, 15]. In [37], the authors draw attention to the risks and threats of fraud that accompany the digital transformation of banking services, in [15, 38, 39] they point to the growing demand for digital banking services.

Financial digital innovations are constantly improving and developing, which, in our opinion, is primarily influenced by the speed of the cash cycle, and its effective management can be carried out using appropriate fast digital tools. Digital banking has been successfully implemented in Monobank, a digital bank for the mass consumer [13]. It also allows banking institutions to approach cash flows using the marketplace, when the bank sells products from suppliers or partners from other industries, which ensures the creation of purely digital banks that function as an alternative to physical banks [40]. As early as 2021, China, India, the United States, Brazil, Germany and the United Kingdom were named among the world leaders in the implementation of modern technologies in the financial sector [41]. In 2024, it was noted that Poland, Estonia, Israel, Singapore, India, China, and Finland have significant positive experience in financial digitalization [42]. Ukraine, despite its certain successes on this path, faces the threat of falling behind the aforementioned leaders, so progressive foreign experience will be useful for adapting and implementing it in Ukrainian realities, especially in the post-war period.

Quite important, but not yet advanced in a scientific sense, is the problem of assessing the impact of the digital transformation of the financial sector (by the way, as well as others) on the effectiveness/efficiency of its (their) functioning. There is still a lack of such developments. Let's examine further those that can be found in the open access.

The already mentioned work [4] proposes a rather interesting, but complex model for assessing the effectiveness of the digital transformation of the national economy. According to its author's vision, it should consist of four complex development factors: acceleration of economic activity, transformation of resource sectors of the economy, transformation of spheres of life, realization of human capital [4]. In addition, each of these four factors contains 9 internal "subfactors", the importance of which, like the above complex factors, is proposed to be determined by the corresponding weight coefficients. But this work lacks an explanation of these weight coefficients and the prospects for the practical application of this methodology. In [24], a study is conducted of the correlation dependence of the volume of global investments in the global financial services sector on factor indicators that characterize the prospects for its development and the development of the real economy. Based on these results, in order to ensure such a balance, forecasts (pessimistic, pragmatic and optimistic) are provided regarding the feasibility of investing in FinTex.

The approach to assessing the factor impact of artificial intelligence (AI) on "total factor productivity, with which input resources, such as labor and capital, are transformed into output" [43] attracts attention.

In [44], the impact of digital transformations on the rationality of financial decisions is assessed, for which quantitative (econometric modeling, time series analysis, clustering) and qualitative methods (hierarchy analysis and SWOT analysis) are used, as well as simulation modeling. The authors made a successful attempt to comprehensively investigate a rather complex financial sphere and used a powerful mathematical apparatus. However, some reservations should be made regarding the existence of some limitations regarding data quality and requirements for information resources and the complexity of simulation modeling, which complicates the practical application of such an approach and makes it too expensive.

Digitalization significantly changes financial management and increases its efficiency. This is ensured by the introduction of digital technologies for detecting financial abuse and fraud [25, 37], the development of financial inclusion and financial literacy [38], and the implementation of financial and digital investments in human capital [45].

It is worth emphasizing that the authors of the above-mentioned works mainly focus on digitalization in macroeconomic terms; and there is currently a lack of work on investments in digital technologies at the micro level.

An attempt to assess the impact of digital transformations on enterprise management was made in a monograph by Ukrainian scientists, which used fuzzy set theory for this purpose [7]. The authors classified and ranked the factors influencing digitalization on financial management, the level of which was measured by linguistic variables: "very low", "low", "average", "high", "very high". This approach allows for a certain inaccuracy and bias in the results obtained, which the authors themselves agree with [7].

The relationship between management and digitalization is studied by scientists in the context of various local issues. The main ones are: the impact of changing approaches to management in new digital conditions [10, 34, 46, 47], corporate culture and its adaptation to digitalization processes [5, 48, 49], interaction between various subjects of digital transformation [27, 50], development of human capital in the context of the implementation of digital tools [51]. It is worth emphasizing that the relationship between management and digital transformation is two-way and is characterized by significant mutual influence, the assessment of which (mutual influence) is currently not sufficiently developed. In the above-mentioned works, theoretical ideas, approaches, statements, etc. prevail; therefore, in our opinion, scientific research should be focused on identifying more practical, if possible, formalized evaluation options for research.

In [22] it is stated that the digitalization of financial management is a multidimensional process, and on the example of small and medium-sized enterprises the impact of digital technologies on financial management and the transformation of the latter in the conditions of activation of modern FinTex is determined. The authors offer their own vision of the formalized impact of digital tools on the efficiency of financial management, which depends on the number and quality of digital tools implemented in business processes, and on the overall efficiency of digitalization. This is a bold step towards initiating research and developing scientific approaches to measuring the efficiency of digitalization. In [34] the goal is to "analyze the significance of digitalization in enterprise management, study its impact on the efficiency of enterprise functioning" [34] and on the efficiency of enterprise management, in particular increasing productivity, reducing costs and optimizing business processes [34]. However, despite such announced goals, the authors do not provide a specific formalized analysis of the impact, but are content only with theoretical ideas and statistical generalizations. Similarly, the lack of a formalized solution regarding the impact of digitalization on management efficiency is observed in other works [14, 52].

The analysis of the impact of digital technologies on the performance of economic activities of enterprises of the agro-industrial complex of Ukraine is discussed in the work [53]. In it, the authors, based on information from agricultural enterprises (clients of manufacturers of digital products for agriculture AGRIChain and Kernel Digital), conclude that there is a correlation between net profit and the number of digital tools. They claim that the correlation coefficient for a group of 41 companies using AGRIChain digital products was 0.776 [53]; and for 34 companies using Kernel Digital products, this coefficient is 0.902 [53]. This indicates a high degree of dependence of net profit on the number of digital tools used in the studied agricultural companies. It is possible to add that the studied sample is representative, therefore, the results obtained in this research can be trusted, despite the practical complexity of the described approach.

The study of the impact of digital technologies on the insurance services market was conducted in [54]. It proposes to use the financial and economic indicator ROI (Return on Investment) to assess this impact, which is a universal measure of the effectiveness of any innovations, not only in financial digital technologies. Let's believe that this approach is fully justified, and its use should be evaluated favorably, but not only in insurance activities, but also in others, when implementing investments in digital technologies.

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Thus, the analysis of scientific works revealed the presence of at least two problems related to financial digitalization. First, there is currently some confusion in the scientific literature and quite often significant inaccuracies are made regarding the definition of role subordination between management and digitalization. Second, it is difficult and currently insufficiently developed to determine the essence and develop methodological approaches to formalizing the effectiveness of financial digitalization. In view of this, *the object of research* is financial digitalization and the effectiveness of its impact on financial management. *The aim of research* is to determine the mission of digitalization and formalize its impact on financial management. This will make it possible to correct the scientific interpretation of the essence of digitalization and determine its place in the financial management system, as well as to invent and substantiate the ways of the impact of digitalization on the effectiveness of financial management with the corresponding publication of a formalized model of its (effectiveness) measurement. For financial managers, the research results will be useful during the practical implementation of digital technologies to activate these processes and improve the quality and efficiency of financial management.

To achieve this aim, the following objectives were solved:

1) to determine the mission of digital technologies in financial management;

2) to adjust the essence of the concept of efficiency from the standpoint of stakeholders' interests;

3) to develop formalized models for measuring the effectiveness of financial digitalization.

2. Materials and Methods

Modern trends in digital development and the scientific underdevelopment of certain of its problems led to the definition of the object of this research, which is financial digitalization and its effectiveness from the perspective of stakeholders involved in these processes. To form the scientific basis of this research, scientific publications were found in the selected thematic area and their content analysis was performed. In the process of studying the subordination of management and digitalization, the methods of abstraction, analysis and synthesis, analysis of cause-and-effect patterns, formal logic, system and structural analysis were used. To formalize the performance indicators and during the development of the corresponding factor models, comparison methods, scientific assumptions, aggregation and disaggregation, elimination and coefficient analysis were applied. A graphical method was used to visually present the research materials.

3. Results and Discussion

3.1. Defining the mission of digital technologies in financial management

In an analytical study of scientific publications devoted to the study of the role of modern digital technologies, the inconsistency of the stated role with objective scientific principles is recorded. If to focus on financial management, then, as indicated, the inconsistency is associated, first of all, with the exaggeration of the role of digital technologies and giving them an unnecessary, unreasonably overstated emphasis in the financial management system. There are quite a few scientific works [7, 8, 19, 52] in which the authors in one way or another try to change/correct the essential approaches to financial management, reducing the latter to digital mechanisms, digital tools and technologies, digital solutions and digital management. Such scientific insinuations minimize the role of financial management as a procedure for making managerial decisions, and therefore are absolutely unacceptable, because they do not correspond to either the essence of digitalization or scientific logic.

The essence of eradicating these misconceptions boils down to the following. Digitalization, despite its unconditional effectiveness in modern realities, cannot be a panacea for the future development of management. It is necessary to radically change these interpretations of digitalization and prevent the replacement of financial management with digital processes and avoid similar scientific relapses in further research on this topic. In principle, it is possible to defend the position that boils down to the following: digitalization does not REPLACE management processes, but CHANGES their information base. Unfortunately, there are too few such scientific positions among scientists at the moment; on the contrary, as it is proven, there is a certain euphoria regarding the prospects of digitalization in management. Management is based on the use of relevant information suitable for implementing management procedures. It is information support that underlies the adoption and implementation of all management decisions and serves the entire management process. Digitalization significantly changes not only information support, but also all processes related to its use in management processes. That is, it makes sense to distinguish two subsystems of technologies in management processes: management and digital (Fig. 1). The first (management) has a classic "content", determined by the quality of management and those who carry it out; the second system (digital) is created and exists only to service the first and is, in fact, subordinate to the first. In this sense, digital technologies, which are an attribute of digitalization, cannot replace management as such, but only change the specified subsystem of information services. The first system can be considered a recipient (customer and consumer), the second – a donor (supplier) of information. The subsystems named in this way (information recipient and donor) are interconnected and interdependent in a single system of financial management and together affect the effectiveness of the latter.

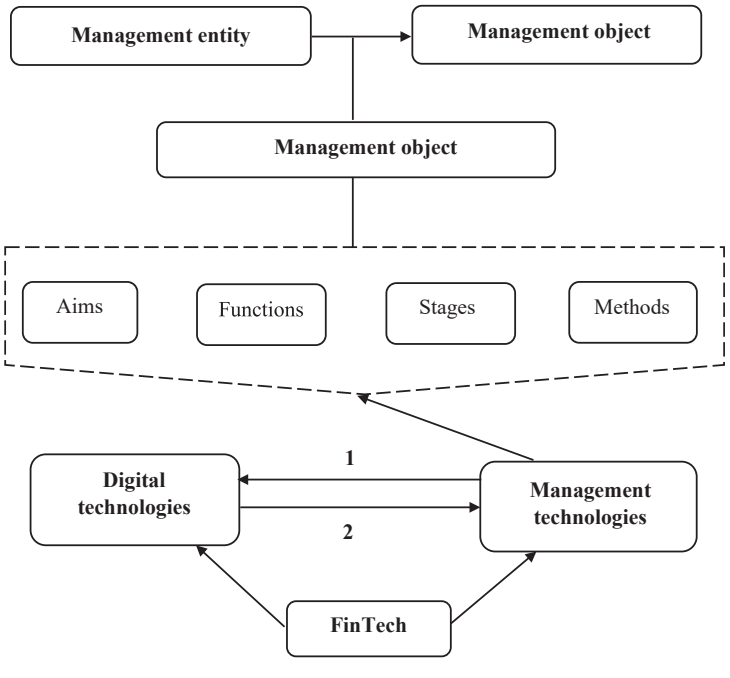

Fig. 1. FinTech in the financial management system

Digitalization provides the conditions for the realization of the potential of financial management, but does not affect this potential, because management technologies are determined by the quality of management in its classical perception. Financial management has its own inherent goals, for which the corresponding functions are used at all

stages of management and special methods of such management. Digital technologies, characterized by the state and movement of information, also depend on management decisions; that is, the formation of information support is a specific function of management, which is presented as direction 1 in Fig. 1; and digital technologies provide better conditions for the realization of management potential (direction 2 in Fig. 1).

Information support at the same time affects all elements of financial management; let's note in passing that in management the value and importance of information are much higher than in the natural sciences. Certain requirements are imposed on information, such as: relevance, adequacy, quality, reliability, sufficiency, relevance, timeliness, compliance with which is ensured by management decisions, that is, it depends on management (and not on digital) technologies. Therefore, from this point of view, let's fix the priority of management technologies over digital ones.

3.2. The essence of the effectiveness of financial digitalization from the perspective of stakeholders' interests

Based on the previously presented ideas, it is necessary to determine the essence of the concept of efficiency in the context of the impact of digitalization on the effectiveness of financial management. Digitalization and the main aspects related to it were discussed above; therefore, let's consider it appropriate and useful to speak about efficiency as such, and only after that – to consider the effectiveness of digitalization processes.

Efficiency is a classic economic category that has been known to science for quite some time and is studied by scientists from different positions, in different directions and levels of detail, for which various indicators of its (effectiveness) measurement are used. In principle, theoretical approaches and practical developments in determining and measuring efficiency in economic science are sufficiently developed. The classical and generally defined interpretation of the efficiency of the functioning of any economic entity is the ratio of the final results achieved by it to the resources spent by it on these achievements. This thesis was formed in economic science as a priori knowledge, and does not cause any doubts or (especially) disputes. At the same time, let's believe that this a priori interpretation is not enough, and in the specific conditions of application of the term efficiency, it is necessary to add a specification of this concept. These specific conditions are related to the economic interests of specific interested parties (stakeholders). However, the specification and detailing of the concept of efficiency have not reached a generally recognized interpretation. There is still no clear definition in the interpretation of the essence of efficiency, and there are significant differences among economists in understanding the methods of its accounting, criteria and indicators.

Economic reality in modern conditions has a fairly diverse representative number of stakeholders who have their own interests, as well as their own goals and spend appropriate resources to achieve them. The economic interests of different stakeholders very often do not coincide, and sometimes they can be opposite and even conflicting. Therefore, the category of efficiency can be implemented, adapted and realized in practice only from the point of view of the interests of specific stakeholders; and, therefore, it (the category of efficiency) can be considered a priori only on a theoretical basis. When it comes to its practical application, the concept of efficiency is increasingly approaching a posteriori definition. However, this aspect of the study of the category of economic efficiency has not yet received a clear scientific emphasis and recognition. But, when it comes to efficiency, it is necessary to find out for whom it is being assessed, and proceed exclusively from the interests of certain persons.

In this regard, let's give a brief comment on some approaches to determining economic efficiency from different positions, i. e. as: productivity, profitability, profitability, effectiveness, etc. At first glance, such a spread of approaches may seem somewhat strange and raise some questions, but it is quite correct; the fact is that none of the options lacks an explanation for the existence of such a discrepancy. And this is precisely what, in our opinion, is lacking in the published scientific statements regarding the category of efficiency. If efficiency is associated with someone's interests and goals, then various options for assessing efficiency become understandable and justified. Thus, productivity is important when it comes to the use of labor, profitability – when assessing the implementation of profit plans, return on assets – as a measure for assessing the quality of management activities, etc. Even such an indicator as return on equity, which in any case meets the interests of owners, can be detailed for at least two fundamentally different reasons. Firstly, owners who are more interested in obtaining faster results on their capital, when using net profit, are oriented towards its distribution for their own consumption (for example, to form a dividend fund from it). Secondly, owners who, on the contrary, have strategic plans and are interested in the further development (increase) of their property, make a decision to accumulate net profit in equity items (replenishment of the reserve fund, increase in retained earnings, increase in authorized capital). Therefore, situations arise when even the interests of one group of stakeholders may not coincide. In any case, each decision made has its own grounds, goals and evaluation indicators of the effectiveness of achieving those goals. When assessing the effectiveness of financial digitalization, interested parties are financial managers who are aimed at achieving better financial results at the lowest possible cost, because, as stated earlier, digital technologies create better conditions for the realization of managerial potential. Managers make and implement their decisions in the interests of owners, who are also interested in improving the quality of management and are the ultimate stakeholders in the implementation of digital technologies.

In the context of non-profit activities, there are some peculiarities in determining stakeholders. Non-profit (non-profit) organizations do not receive profits and operate to serve or satisfy the needs of their consumers. Therefore, in the context of digitalization of their activities, they aim to improve the quality of their services and reduce the costs of their implementation.

It is worth noting that the profitability of equity and the efficiency of non-profit activities in general are influenced by quite a few different factors, so it is too difficult to isolate the impact of digitalization on these indicators. Most likely, this is precisely why there are currently too few developments regarding such isolation, and attempts to do so are clearly lacking. As the analysis has shown, there are only primary directions for finding a solution to this problem. It is possible to agree that "it is methodologically incorrect to reduce digitalization to a purely technical optimization of business processes and the provision of public services, which supposedly guarantees and automatically leads to increased efficiency of business and public administration. Without changing the outdated, inefficient economic and political system, the expected results cannot be obtained. Therefore, digital technologies can become a lever for increasing efficiency only on the basis of systemic changes" [55]. Therefore, this work will also not become some kind of panacea, but will be the next step in studying the prospects of financial digitalization.

3.3. Measuring the effectiveness of financial digitalization

Therefore, the effectiveness of digitalization is a rather vague and controversial concept. The analysis of scientific sources made it possible to identify only two works [22, 54], which should be paid attention to and which became a certain initial basis for developing a methodology for analyzing the effectiveness of financial digitalization.

The authors of [22] offer their own vision of the formalized impact of digital tools on the effectiveness of financial management (E_f), which depends on the number and quality of digital tools implemented in business processes, and on the overall effectiveness of digitalization (E_{total}), which is presented as follows [22]:

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$$E_f = f\left(D_t, I_t, A_t\right), \quad (1)$$

$$E_{total} = b_1 \cdot E_f + b_2 \cdot C_t + b_3 \cdot E_{cost} + b_4 \cdot ROI, \quad (2)$$

where D_t – level of digitalization (quantity and quality of digital technologies used in business); I_t – investments in digital technologies (costs for implementing new technologies); A_t – adaptation of personnel to digital tools (percentage of trained employees); C_t – changes in cash flows due to digital investments and level of digitalization; E_{cost} – savings in management costs due to digitalization of management processes; ROI – return on investment in digitalization of management processes; b_1, b_2, b_3, b_4 – coefficients that determine the weight of each element in the overall assessment.

Regarding this proposal, presented in [22] and represented by formulas (1) and (2), it is worth noting the following: this is a serious theoretical attempt to understand and assess the significance of digitalization of management and at the same time a significant impetus for continuing scientific research in this direction. But this approach is too complicated in its practical application. In addition, formula (2) contains a fundamental inaccuracy, namely the fact that the synergistic systemic relationship of the factors E_f, C_t, E_{cost}, ROI is not taken into account.

It is advisable to simplify and bring these basic methodological options closer to practical understanding and use.

In this work, the key statements are as follows:

– digitalization affects only the conditions for the implementation of managerial potential, but does not change it, because the subsystems of managerial and digital technologies function as an information recipient and donor, respectively;

– the effectiveness of digitalization in finance is related to the economic interests of stakeholders, for which financial managers, in fact, change management processes to achieve their goals in the most effective way;

– the results of financial digitalization are under the multifactorial systemic influence of a large set of different factors; therefore, assessing its effectiveness will require certain assumptions;

– the aforementioned assumptions when assessing the effectiveness of digitalization objectively require the application of the elimination principle, which is necessary to abstract from the influence of other (unrelated to digitalization) factors;

– the practice of implementing digitalization requires a separate consideration of two fundamentally different situations: when financial digitalization is implemented in the context of a commercial enterprise and in a non-profit organization.

If financial digitalization is implemented in the context of a commercial enterprise, then managers who were provided by the owners with funds (or other property) in the authorized capital and delegated powers to manage them must use it to improve the well-being of the owners. Therefore, owners assess the effectiveness of the use of their property by managers by the profitability (by net profit) of equity.

To study the change in the profitability of equity under the influence of financial digitalization, investments in financial digitalization and their effectiveness, the effectiveness of financial management and the profitability of equity are used. The logical causal (factorial) relationship between them is shown as follows

$$ROI_f \rightarrow E_f \rightarrow ROE, \quad (3)$$

where ROI_f – efficiency of investments in financial digitalization; E_f – efficiency of financial management; ROE – profitability of equity.

As noted above, the welfare of owners is the receipt of dividends (current goals) or the growth of equity (strategic goals), but in both situations the source of its (welfare) improvement is net profit. To eliminate (eliminate) the influence of factors not related to the distribution of net profit, certain assumptions were made. For this purpose, a restriction was introduced on the absence of the use of net profit for financial sanctions, charitable contributions, material incentives from profit, etc. Also, changes in the authorized capital due to additional contributions or withdrawals by owners and changes in equity during the revaluation of assets, free receipt of property, etc. were not taken into account. These and similar situations are not typical and usually arise as exceptions; especially since the distribution of net profit NP is primarily determined by the decision of the owners in the company's charter or their annual meeting. Net profit NP_E, which is aimed at increasing the equity capital EK and ensures its growth over time, meets the interests of strategically targeted owners; and the effectiveness of this use is measured by the ROE_E indicator. The part of the net profit NP_S distributed among the owners allows owners, for whom current goals are a priority, to receive an appropriate return on their shares in the authorized capital SK, which is estimated by the ROE_S indicator. Accordingly, for the first and second groups of owners, it is advisable to formalize the weighted average ROE profitability of their capital in the following way:

$$ROE_E = NP_E / EK = NP \cdot d_E / EK, \quad (4)$$

$$ROE_S = NP_S / SK = NP \cdot \left(1 - d_E\right) / SK, \quad (5)$$

$$ROE = ROE_E \cdot \beta_E + ROE_S \cdot \beta_S = NP \cdot d_E / EK \cdot$$
$$\cdot \beta_E + NP \cdot \left(1 - d_E\right) / SK \cdot \beta_S, \quad (6)$$

where d_E – the share of retained (capitalized) profit in net; β_E, β_S – respectively, the coefficients that determine the weight of ROE_E and ROE_S in ROE.

In the factor model (6) NP is the intensive factor that most significantly affects the resulting ROE indicator and is associated with the quality of financial management. In turn, the effectiveness of financial management E_f is generally influenced by a fairly large number of different factors of both objective and subjective nature, and the result of financial management is a complex effect of their action. However, to determine the impact on the effectiveness of financial management only of digitalization processes, let's abstract (by the elimination method) from those factors that do not relate to digital technologies. The potential of financial management in the context of digitalization is realized through the growth of net profit under the influence of digital technologies (NP_{dig}) and the possible reduction of management costs (Mg_{dig}), and its effectiveness should be assessed as

$$E_f = NP_{dig} / M_{gdig}. \quad (7)$$

The numerator and denominator of formula (7) change during the digitalization of management processes. First, sales volumes increase when digital marketing technologies for promoting goods are implemented, which ensures an increase in sales revenue (SR_{dig}) and, accordingly, net profit (NP_{SR}). Second, net profit increases due to the intensification of management processes and relative savings in management costs (NP_{mendig}). Therefore

$$NP_{dig} = NP_{SR} + NP_{mendig}. \quad (8)$$

Determining the growth in sales revenue under the influence of digital marketing technologies (SR_{dig}) is a complex process that requires a certain assumption about the elimination of other factors. If ROS is the return on sales over net profit, then the increase in net profit will be equal to

$$NP_{SR} = SR_{dig} \cdot ROS. \quad (9)$$

At the same time, the impact of digital technologies on management costs means the intensification of management processes, which is more noticeably manifested in financial management.

This is explained as follows. Financial management is associated with cash flows, which are the most mobile of all management objects. It is the mobility of these management objects that also requires a reduction in the time for making appropriate management decisions. This is clearly illustrated in Fig. 2, and the thesis implementation of this was published in the work [56].

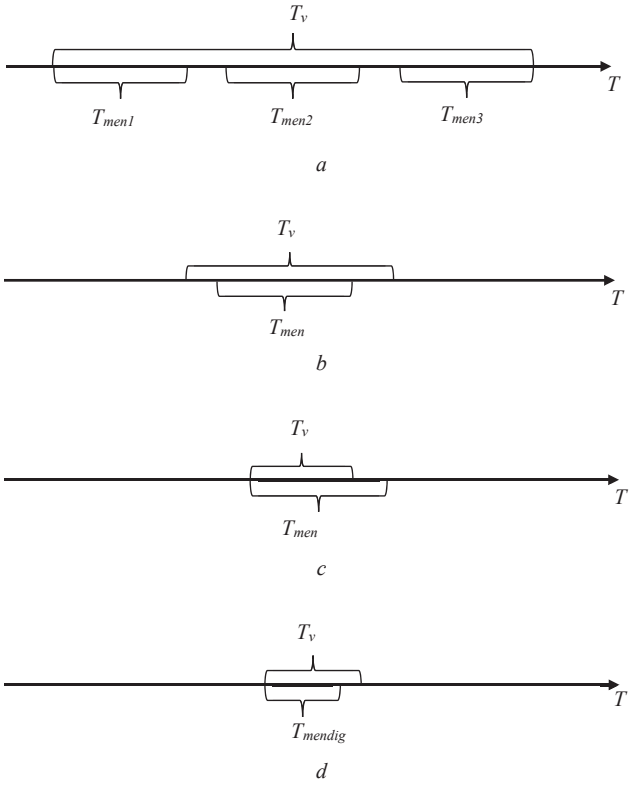

Fig. 2. Digitalization in the context of reduced time limits for making management decisions: *a* – management in times of slow change, when $T_v >> T_{men}$; *b* – reduction of time T_{men} for managerial reaction when T_v is reduced; *c* – critical situation in management when T_v is less than T_{men}; *d* – management in the context of digitalization when $T_{mendig} < T_{men}$

Modern reality is characterized by the transience of all processes that are objects of management in management. In Fig. 2, T_v denotes the time interval from the current moment to the onset of a catastrophic state, which leads to the destruction of the management object. Such conditions require an appropriate managerial response and a certain time (let's denote it as *Tmen*) for making and implementing managerial decisions. When *Tv* decreases (it can sometimes even approach zero, which is most often observed in the study of cash flows) and its pressure on time for management, the latter also becomes smaller and closer to zero. That is, in order for the manager to have time to timely adopt and ensure the implementation of its plans, it must have enough time until the critical moment comes, when managerial actions lose their meaning. In times of slow change, when *Tv* >> *Tmen*, the manager had enough time to maneuver in terms of adopting and implementing its actions. Moreover: *Tmen1* is characteristic of preventive, *Tmen2* – pragmatic and *Tmen3* – conservative management. If *Tv* is reduced, this also causes a decrease in the time *Tmen* for managerial response (Fig. 2, *b*). But, if *Tv* > *Tmen*, then the manager still has the opportunity to maneuver in time with its actions, although the range of such maneuver is reduced compared to the situation in Fig. 2, *a*. The critical moment mentioned above occurs in the situation in Fig. 2, *c*, if *Tv* becomes smaller relative to *Tmen*; and the greater the difference between them, the more threatening the situation and, accordingly, the management problem becomes. Solving the problem and avoiding the threatening consequences of reducing *Tv* is possible by reducing the time for managing the situation, which is achieved through the introduction of digital technologies. If *Tmendig* is the time for making and implementing management decisions in the context of digitalization, then *Tmendig* < *Tmen* (the situation in Fig. 2, *d*). Improving management under these conditions indirectly takes into account other factors, such as: the number and quality of digital technologies used in business, the adaptation of personnel to digital tools (1), as well as the availability of better justification for management decisions, because all this is based on digital information support.

Therefore, obtaining additional net profit as a result of digitalization of management processes is defined as

$$NP_{mendig} = \left(T_{men} - T_{mendig}\right) \cdot NP_t = \left(T_{men} - T_{mendig}\right) \cdot M_{gt} \cdot T_r, \quad (10)$$

where NP_t – specific (for one time period *t*) net profit; Mg_t – specific (for one time period t) management costs; T_r – tax corrector.

Having performed the procedure of disaggregation of the components of formula (8), let's transform formula (7) into the formula

$$E_f = \left[SR_{dig} \cdot ROS + \left(T_{men} - T_{mendig}\right) \cdot M_{gt} \cdot T_r \right] / M_{gdig}. \quad (11)$$

If to take into account the possible increase in net profit $NP_{mendig,}$ then the return on equity, determined by formula (6), increases by

$$ROE_{dig} = \left[SR_{dig} \cdot ROS + \left(T_{men} - T_{mendig}\right) \cdot M_{gt} \cdot T_r \right] \times$$
$$\times \left[d_E / EK \cdot \beta_E + \left(1 - d_E\right) / SK \cdot \beta_S \right]. \quad (12)$$

The factorial definition of the *ROE* and E_f indicators makes it possible to formalize the indicator of the effectiveness of investments in digitalization ROI_f. If the result (effect) of digitalization, as noted above, is an improvement in the ROE_{dig} indicator, and the costs of obtaining it are investments in digital technologies. If, including the cost of additional fixed assets, personnel training, etc., then:

$$ROI_f = ROE_{dig} / I_f, \quad (13)$$

$$ROI_f = \left[SR_{dig} \cdot ROS + \left(T_{men} - T_{mendig}\right) \cdot M_{gt} \cdot T_r \right] \times$$
$$\times \left[d_E / EK \cdot \beta_E + \left(1 - d_E\right) / SK \cdot \beta_S \right] / I_f. \quad (14)$$

Formulas (11)–(14) are, in fact, such that they can be used, respectively, to assess the impact of digitalization on the efficiency of financial management, the increase in the profitability of equity and the efficiency of digitalization itself in the context of a commercial enterprise.

However, for a non-profit organization, the goal and processes of digitalization are somewhat different. Non-profit organizations (often state institutions) exist to provide certain services to their stakeholders and spend financial (state) resources on these processes. It is worth noting that the problems of digitalization of public services are now very relevant for Ukraine. At least there are such serious reasons for this: the functioning of public finances under martial law; the actualization of budget management reform in the context of Ukraine's European integration; ensuring transparency regarding accountability in the use of foreign financial assistance and eradicating corruption in the state; introducing digitalization in the military and defense sectors; a sharp increase in the number of individuals and legal entities affected by Russian aggression against Ukraine – stakeholders receiving state services

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and who did not exist before; streamlining the volunteer movement through digitalization. Only the main stimulating requirements for studying the effectiveness of digitalization in the non-profit sector have been mentioned; but this list could be continued.

Therefore, it is necessary to find out how the indicators from formula (3), namely ROI_f, E_f, ROE, change in the conditions of non-profit activity. Let's call these indicators respectively: ROI_{fnp}, E_{fnp}, ROE_{np}. A non-profit organization is not related to generating sales revenue and profit, it must perform its functions and provide quality services to all stakeholders, in digital conditions or without them, and then formulas (11), (12), (14) are transformed as follows:

$$E_{fnp} = \left(T_{men} - T_{mendig}\right) \cdot M_{gt} / M_{gdig}, \quad (15)$$

$$ROE_{np} = \left[\left(T_{men} - T_{mendig}\right) \cdot M_{gt}\right] / \left(T_{men} \cdot M_{gt}\right) = 1 - T_{mendig} / T_{men}, \quad (16)$$

$$ROI_{fnp} = \left(T_{men} - T_{mendig}\right) \cdot M_{gt} / I_f. \quad (17)$$

These formulas allow to assess the prospects for the implementation of digitalization financed by non-profit (budgetary) organizations.

3.4. Discussion

The ideas put forward in the work and the developed factor models are of scientific importance, as they will contribute to the regulation of the scientific attitude to the digitalization of management, will make it possible to objectively assess the prospects and results of its digitalization.

To determine the mission of digitalization in financial management, two subsystems of technologies are separated: managerial and digital (Fig. 1). The systemic connection between them is reduced to the impact of digitalization on management technologies; and the key idea of their combination in the financial management system is that digitalization does not replace management processes, but changes their information base.

The research of the impact of digitalization on financial management necessitated a fundamental rethinking of the category of efficiency. The existing scientific concept of efficiency in this research is considered from the perspective of specific stakeholders. The beneficiaries of the implementation of financial digitalization are identified as owners, financial managers and investors. Taking into account their interests, three indicators were selected: the effectiveness of investments in financial digitalization, the effectiveness of financial management, and the profitability of equity. The factor relationship between them is illustrated by formula (3). The analysis of the factors of these indicators and their disaggregation made it possible to form a number of factor models (4)–(17), of which a proportion (4)–(14) assess the effectiveness of digitalization of financial management of enterprises, the remaining (14)–(17) assess the effectiveness of digitalization of financial management of non-profit organizations.

The detailing of the role of digitalization in management is shown through the limitation of time for management procedures in the conditions of rapid changes in financial management objects. Fig. 2 clearly illustrates the time change of management procedures in modern conditions and graphically proves the role of their digitalization.

So, as a research result: the mission of digitalization in financial management is defined; the essence of the efficiency category is specified; indicators for assessing the effectiveness of financial digitalization were substantiated and their formalization was carried out with the development of factor models.

The practical significance of the results obtained is that their publication will ensure the strengthening of the professional interest of practicing managers in the digitalization of management processes, will positively affect the effectiveness of digital and management technologies and the activation of investments in digital transformation. The methodology for assessing the effectiveness of financial digitalization and its formalization will provide a qualitative justification for business plans and investment projects on the digital transformation of management.

However, at the same time, the results of the work have certain practical limitations, and some assumptions were used in its implementation.

The limitations are due to the fact that the implementation of the results obtained in practice may cause reservations from some managers who avoid taking responsibility for their activities. Such motives may be due to the desire to increase the significance of digital technologies and reduce the role of management, and, as a result, to shift the emphasis of management responsibility to its digital support. In addition, the use of the developed factor models may raise some questions regarding obtaining upstream information, since it is not available in a suitable form in accounting and reporting documents. However, such difficulties are not significant, so they will not interfere with the practical assessment of investments in digital transformation.

The ideas put forward in the work and the results obtained are based on the use of abstract assumptions regarding the elimination of the influence on the studied indicators (return on equity, financial management efficiency and financial digitalization) of other factors that were beyond our attention in this research. For example, the effectiveness of financial management is significantly influenced by internal factors: its organizational support, the state of planning, accounting and analysis systems, professional competencies and even the risk appetite of financial management, etc., and external factors: general economic conditions, the state and competition in the industry market, government support, etc. Abstraction from all these factors in our research is explained by the lack of their direct connection with the processes of digitalization, because these internal and external conditions would be present and would operate even without digital technologies.

Prospects for further research are determined by the need to focus scientific attention on the subordination of management with its information support and to prevent the replacement of the former by the latter. It is also important to continue scientific research on the quantitative assessment of the effectiveness of financial digitalization.

4. Conclusions

1. To define the mission of digital technologies in financial management, the following was done: a certain euphoria was recorded regarding the exaggeration of the role of digitalization and the spread of the idea of perceiving its essence as the process of forming the so-called "digital management"; a scientific justification was provided for the inadmissibility of such a replacement and defining the mission of digitalization only as a change (reform) of information support for management; two systems were separated: digital and management technologies, and the influence of the first on the second was proven, which ensures the improvement of the quality of management and its efficiency. This will make it possible to separate digitalization from management in science and consider it as a separate object of research, but provided that its role in management is reformed information support.

2. To adjust the essence of the concept of efficiency from the standpoint of the interests of stakeholders, the idea was proven that the category of efficiency can be considered a priori only on an abstract theoretical basis, but the concretization of this concept brings it closer to an a posteriori definition; that is, efficiency should be considered and used in practice only from the perspective of the interests of specific stakeholders. Therefore, to assess the effectiveness of financial digitalization, it is proposed to proceed from the economic interests of stakeholders (managers, owners, investors) who receive economic benefits

from this or are somehow involved in financing digital transformation. This approach has theoretical significance in terms of adjusting the essence of the concept of efficiency and bringing it closer to the possibilities of practical application.

3. The development of a formalized model for measuring the effectiveness of financial digitalization is based on taking into account the interests of stakeholders, which in a formalized form is proposed to be taken into account by the following indicators: the effectiveness of investments in financial digitalization (*ROIf*), the effectiveness of financial management (*Ef*) and the profitability of equity (*ROE*); and the logical causal (factorial) relationship between them is shown as follows: *ROIf → Ef → ROE*. The indicated indicators were estimated for profitable enterprises and non-profit organizations, taking into account their specifics and the influence of their features on their formalization in the corresponding factor models. Factor modeling of *ROIf, Ef* and *ROE* indicators was done with the elimination of factors that are not related to the implementation of digital technologies, which made it possible to assess the impact of digitalization exclusively and only and to assess its role in financial management. With the help of factor models, it was proven that financial digitalization of management processes creates conditions for saving management costs, increasing sales volumes and net profit, and finally – for intensification of financial management. Factor models of evaluation indicators of the effectiveness of financial digitalization can be used in practical management activities. They will make it possible to reasonably assess the prospects of real financial digitalization projects.

Conflicts of interest

The authors declare that they have no conflicts of interest in connection with the current research, including financial, personal, authorial or any other that could influence the research and results presented in this article.

Financing

The research was conducted without financial support.

Data availability

The manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

Authors' contributions

Valentyna Antonenko: Conceptualization, Methodology, Investigation, Writing – original draft; ***Olena Lyzunova***: Formal analysis, Project administration, Resources, Supervision, Writing – original draft; ***Olha Popova***: Formal analysis, Methodology, Writing – review and editing; ***Leonid Katranzhy***: Data curation, Investigation, Resources, Software, Validation; ***Andrii Lytvynenko***: Data curation, Visualization, Supervision.

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