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INTRODUCTION

Dear Readers,

We present the second thematic issue of the Baltic Journal of Legal and Social Sciences, dedicated to contemporary challenges in economics and finance, traditionally unified under the overarching concept of Future Money.

As in the first issue, you will get a chance to discuss the points of modern money's existence, challenges related to macroeconomic perspective in Latvia, the EU, and the global economy, as well as aspects of professional training for financial institutions (which constitutes a fundamental mission of the Baltic International Academy and the Global educational system).

Traditionally, it is focused on examining the impact of digital technologies on the modern economy. It is not surprising that we've just been discussing Industry 4.0, which rapidly transformed human life and the familiar world of financial technologies, and already the expert community is analysing the world of Industry 5.0.

Within just one year of AI technologies that have become a part of our lives and popularized ChatGPT, we get several dozen specialized solutions used by both narrow-profile specialists and scholars and students.

Things are changing so fast that tracking the dynamics and comprehending these developments is possible only through the reflection of experts and scholars who address these themes in their articles.

It is evident that central bank digital currencies (CBDCs) and tokens digitizing real-world assets (RWAs), actively implemented by most countries, serve to a certain extent as a "bridge" connecting the world of virtual finance with our familiar world. Both governments and private experts have recognized the advantages these technologies can bring when implementation is based on regulation and strategic planning. Legislative acts protecting consumers represent a positive signal for all of us, indicating the inevitability of modern changes in the world of finance and economics.

Overall, the principles embedded in Industry 5.0–technology development for humanity rather than technology development for its own sake–cannot fail to inspire optimism.

Naturally, we cannot overlook universal challenges facing the modern economy: demographic problems of the Old World and aspects of the so-called "silver economy," which Europe and other economically developed countries must increasingly address.

For new generations in a world of vast opportunities presented by digital social networks, AI, and mass media, the challenge is in getting skills and the capacity to make correct decisions with limited time resources. These involve aspects of critical thinking and engagement with the digital information world.

The world of recent years is characterized by growing entropy and military conflicts, that make states to respond by modifying their economic approaches and management methods. Expert analysis by scholars, with student participation, will undoubtedly engage readers' interest.

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BANK DEPOSITS IN LATVIA: RECENT TRENDS AND DEVELOPMENT

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Abstract. Bank deposits occupy an important place in the sources of the formation of banking resources, and in many European banks reach 70%. However, recently, due to unstable economic policies, the amount and share of total deposits in the banking system has been declining, which leads to a shortage of long-term banking resources. In this article, the author examines the trends in the development of bank deposits in Latvia, identify patterns in the process of their formation in conjunction with active operations that generate income. The problem of turning deposits into bank assets in terms of the timing, scale, expediency and efficiency of the use of attracted funds was highlighted. The purpose of the study is to analyse and assess the trends in deposit operations in Latvia, as well as their forecasting until 2030. Author used such methods as economic analysis, comparison method, economic grouping, statistical methods, extrapolation method and others. The results of the study can be used by both commercial banks and their customers.

Key words: Bank Deposits, Liabilities, Bank Resources Transformation, Forecast Trends.

Introduction. As is well known, the main source of bank funds are customer deposits. However, with the development of the banking system, the composition of accumulated bank resources has changed. The reason for this was the emergence of new methods that are not traditional for the previous banking system to attract temporarily free cash funds [1].

In modern banking practice, all attracted finance resources are divided into deposits and non-deposit attracted funds by the method of their accumulation. The bulk of attracted resources are bank deposits, that is, funds deposited by bank clients for storage in certain accounts and used by them in accordance with the account regime and banking legislation [2]. Non-deposit funds are considered to be funds that banks receive in the form of loans in order to maintain their liquidity and expand the resource base [3]. The deposit represents the economic relationship between the bank and its client in relation to the transfer of funds to the bank for temporary use. The amount of income (profit) on a deposit depends directly on its type, term and volume [4]. By categories of owners, bank deposits are divided into deposits of legal entities and deposits of individuals. In Latvian banks, deposits of individuals amount for approximately 40% of all liabilities of the banking sector, and this share is steadily growing. The share of deposits of legal entities is about 30% of all liabilities and tends to decrease.

As for demand deposits, in Latvia and other European countries, demand deposits account for more than 70% of all attracted customer deposits. And this means that the share of transformation of current resources into long-term investments is quite high. All this requires new approaches and methods for managing deposits to meet the needs of clients in borrowed funds and ensure the stability of banks.

Concept of Bank Deposits: Literature Review. Commercial banks in their activities attract free funds from customers through deposit operations. By attracting deposits, banks assume obligations and responsibilities for the payment of deposits within the deadlines established in accordance with deposit agreements. Consider the points of view of various authors on the concept of "deposits" and "deposit operations." Deposit operations are operations of banks to attract free funds of clients to deposit accounts in order to form banking resources [5]. The funds attracted to deposit accounts are used by banks mainly for lending to entrepreneurial activities and consumer purposes of those clients who need additional funds [6]. A number of scientists and economists (Begenau, J., Stafford, E., Choi M., Rocheteau G., Andolfatto D., Berentsen A., Martin F.M. and others) define the deposit as follows. Deposit is the amount of money that a client (individual or legal entity) placed with a bank

on a deposit account [1-5]. Customers can use funds placed on deposit in accordance with the rules of deposit accounts established by banks. Deposits can be issued for a specific period – term deposits and without specifying a specific period – demand deposits [7, 8].

Consider the signs of term deposits and demand deposits. Characterizing term deposits, it should be noted that they are issued for a specific predetermined period, when issuing a deposit agreement, deposit interest is charged [9,10]. Term deposits provide clients with interest income and are classified as stable resources of a commercial bank. In turn, term deposits can be simple and special [11]. A simple term deposit is a deposit, interest on which is accrued only on the principal amount of the deposit and is paid to the depositor according to the terms of the deposit agreement. A special term deposit is a deposit, accrued interest on which is attached to the principal amount of the deposit and subsequent interest is accrued on the amount increased by the attached interest of the deposit [12].

The signs of demand deposits will be as follows: demand deposits allow customers to freely carry out various transactions for transferring funds, funds can also be credited to demand deposits at any time [13]. Execution of a demand deposit is accompanied by the conclusion of an account agreement or a demand deposit agreement. Demand deposits are not a source of revenue for customers [14]. Speaking of demand deposits, it should be noted that they can be both interest-free and interest-bearing. This is determined by the terms of the contract between the customer and the bank [15].

Along with the main types of deposits – term and demand, overnight accounts can be opened in banks, savings deposits can be issued, and insurance deposits can be used. What are these account types? Overnight is customer money placed with a bank for a period of 1 day/night (the maximum placement period is 24 hours). Given the short-term nature of these accounts, it should be noted that overnight deposits are characterized by large amounts, since only “big money” can earn in a short period of time. Overnight accounts can be opened with a bank not only by business clients, but also by other banks [16]. Thanks to overnight deposits, entrepreneurs whose working day has ended instruct their banks to transfer their money to those banks where the working day begins. Moreover, the banks themselves, having large amounts of funds in their correspondent accounts, transfer them to overnight. Thus, in entrepreneurship, money works around the clock [17].

Continuing to consider the classification of bank deposits, it is also necessary to note the existence of a savings deposit and an insurance deposit.

Savings deposit – a bank deposit intended for continuous accumulation of funds. A feature of this type of deposit is that the account can be replenished with sufficiently small amounts, and partial withdrawal of funds is possible from this account [18].

Insurance (guarantee) deposit – funds deposited in the bank by customers to the insurance (guarantee) deposit account, which are collateral for loans, payment cards and other requirements of the bank. The funds of the insurance (guarantee) deposit are deposited with the bank, as a rule, for the period until the full fulfilment of obligations to the bank, which are secured by this deposit, or for a fixed, predetermined period exceeding the validity of credit and other similar agreements, which are secured by the insurance deposit [14, 15].

In banking practice, in addition to the traditional types of deposits discussed above, deposit forms such as NOW accounts, ATS accounts, SWEEP accounts and others are also used [8, 19]. NOW accounts (negotiable orders of withdrawal) – a type of sets that occupy an intermediate position between savings and current accounts. Holders of such accounts have the right, when notifying the bank 30 days in advance, to issue negotiable orders of withdrawal (NOW) and use them to make payments [8, 20]. ATS (automatic transfer service) account is a combination of a demand account (checking account) with an interest-bearing savings account (term deposit), which allows you to transfer money from a second account to the first when a check is written to it, or its owner accepts payment. As a rule, this account does not provide for the payment by the client of a commission either for its maintenance or for the transfer of funds [8, 21]. SWEEP account – an account with automatic clean-

ing (transfer of funds), the functioning mechanism of which allows the balance of funds available at the end of the day to be automatically invested in interest assets in the interests of the account holder, and at the beginning of the next day the invested funds and accrued interest are returned to the client's account [9, 20]. This type of account allows the client to take advantage of demand deposits (free transfer of funds), and at the same time receive interest income from investing unused cash balances [19, 20]. All the above-mentioned accounts (NOW accounts, ATS accounts, SWEEP accounts) have an important similarity: they all allow the client (account holder) to make payments and settlements from it, and at the same time use it as an accumulative account. That is, all these accounts combine certain properties of both a demand deposit and a term deposit. And by virtue of this property, they are called hybrid accounts.

Bank Deposit Trend Analysis in Latvia. Bank deposit trend analysis shows changes in deposit volumes and their growth/decline rates over a certain period. Figure 1 shows trends in deposits with commercial banks in Latvia from 2014 to 2024. During this period, we see a sharp decline in deposits during 2016-2019. In 2016, the rate of decline was 8.2% compared to 2015, and in 2017-2019 they continued to fall. Thus, the volume of deposits in the banking sector of Latvia for the period from 2015 to 2019 decreased by 4615 million euros, and the decline rate for this period was 20%. This trend is explained by the tightening of requirements for servicing clients of non-residents of Latvia during this period, in connection with which many banks refused to serve non-residents, and non-residents left the Latvian market. Further, the trend is characterized by instability, and after a slight increase in deposits in 2021, there was again a decline in 2023, the reason for which was the lack of free funds from the population and enterprises of Latvia. These trends reflect the instability of the Latvian economy, and the inability of individuals and legal entities to withstand economic and political shocks.

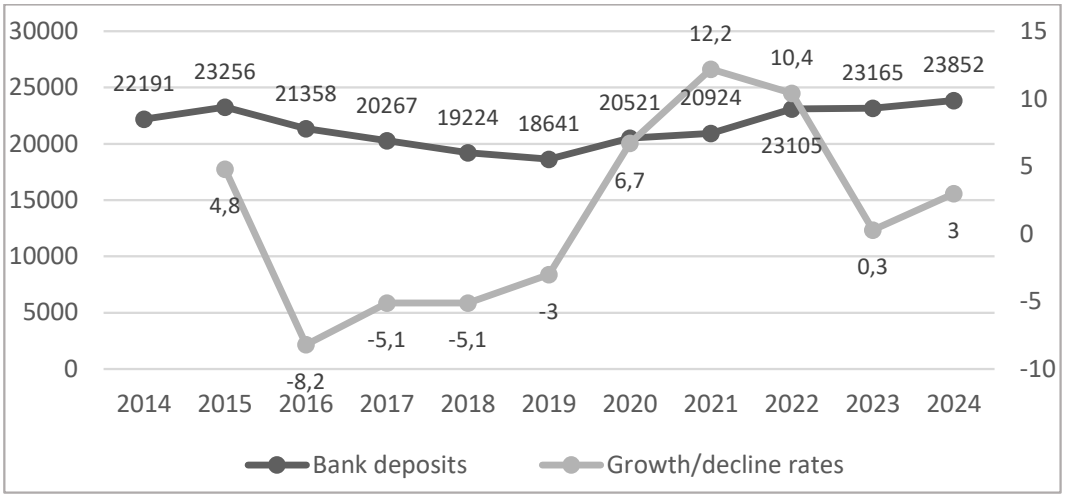

Fig. 1. The total amount of customer bank deposits and growth/decline rates (created by the author based on [22-23]).

The following graph (fig.2) shows that the most vulnerable to external economic conditions were legal entities (private companies), which were forced to withdraw their funds from Latvian banks. The decline in deposits of private companies for the period from 2015 to 2019 amounted to more than 50%. At the same time, household deposits, on the contrary, tended to grow. Figure 2 shows that starting from 2014, household deposits have a gradual upward trend until 2021. During this period, the total growth rate of household deposits amounted to 59%. However, with the increase in prices for energy and other goods, starting in 2022, the growth rate of household deposits slowed down.

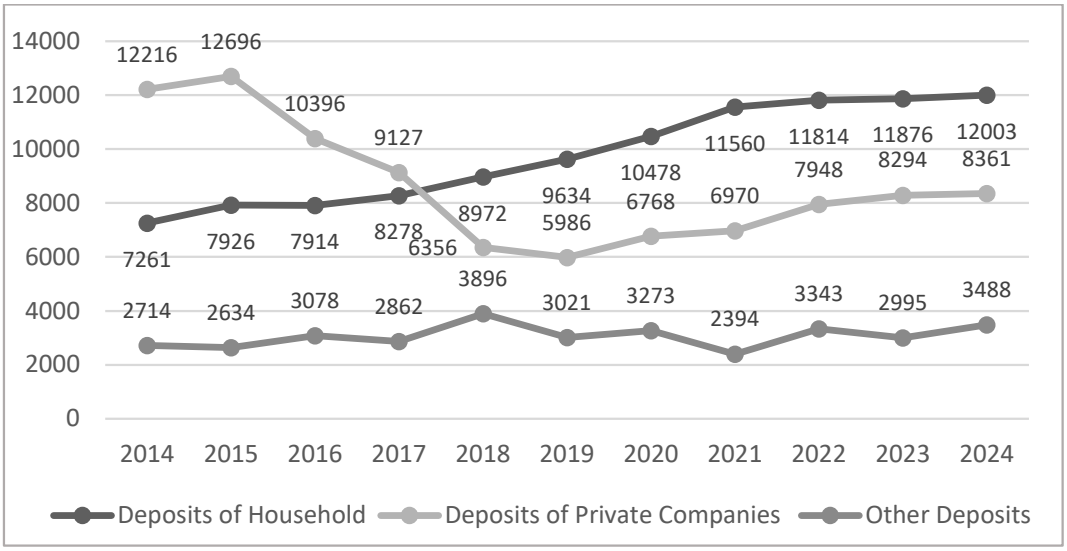

Fig. 2. Trends of bank deposits in Latvia by groups of customers in millions of euros (created by the author based on [22-23])

What types of deposits by maturity prefer to have customers of Latvian banks? As is well-known, in European banking practice, according to the criterion of maturity, deposits are usually divided into the following groups: demand deposits, short-term deposits (up to 1 year), medium-term deposits (from 1 to 5 years), and long-term deposits (over 5 years). The structure of customer deposits in Latvian banks is shown in the figure 3.

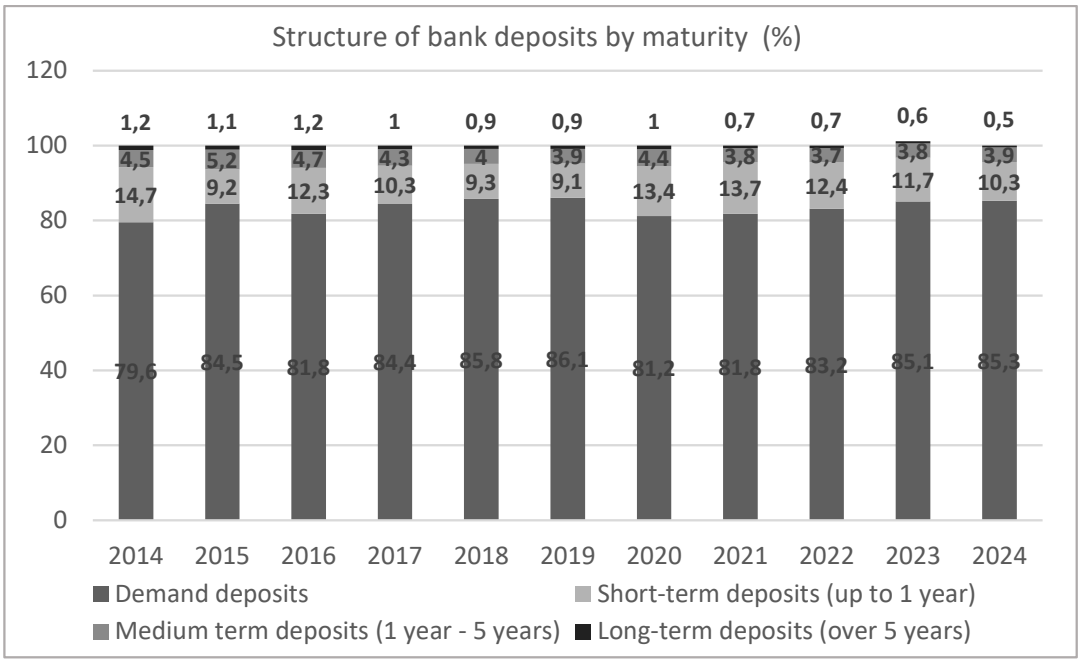

Fig. 3. Structure of bank deposits by maturity (created by the author based on [22-23])

Since household and private company deposits occupy a predominant share in the sources of banking resources in Latvia, author considers how the trends of these types of resources change over time

(figure 4). For the analysed period from 2014 to 2024, there is both a sharp drop and a slight increase in deposits of private companies. The sharp decline in deposits of private companies in the Latvian banking system in 2018 is explained by the withdrawal of non-resident clients from the Latvian market due to tightening requirements of supervisory authorities and the policy of restricting work with the non-resident market segment. Since a significant share of non-resident clients were private companies, their withdrawal from the Latvian market led to a sharp decrease in deposits. In 2018, the rate of decline in deposits of private companies amounted to more than 30%. This negatively affected the total volume of banking resources, and commercial banks in Latvia were forced to look for resources in the non-deposit market. As for household deposits, this market segment continued to develop in Latvia from 2016 to 2020, and their growth rates during this period ranged from 4.6% to 8.8%. But starting in 2021, the growth rate of household deposits slowed down significantly due to rising prices and lower real incomes of the individuals.

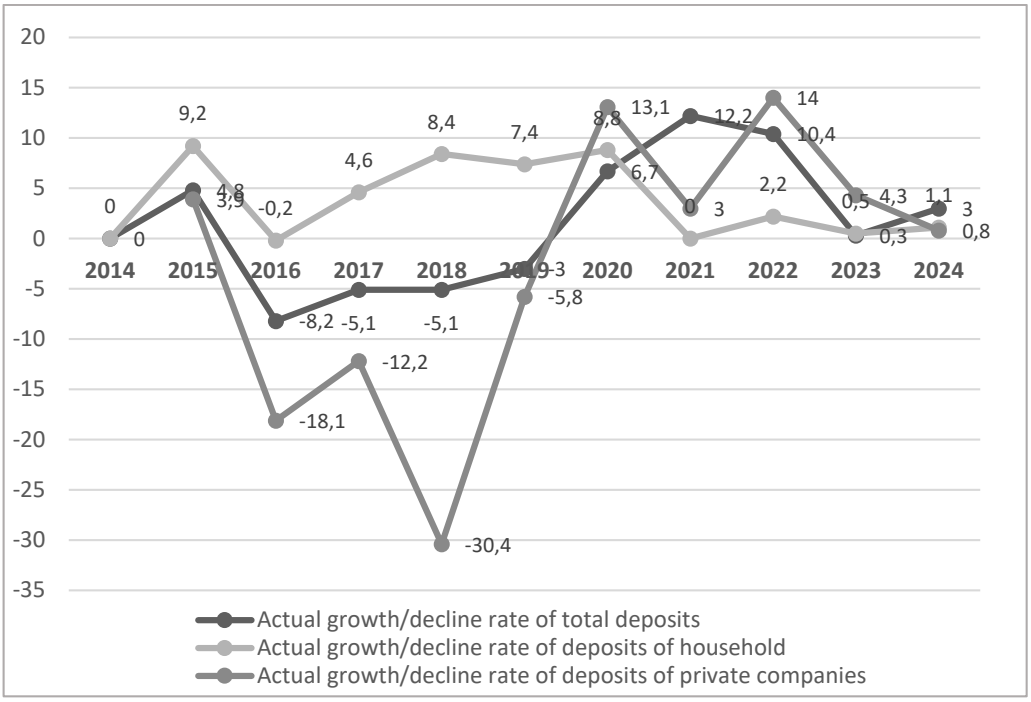

Fig. 4. Actual growth / decline rate in total deposits and in deposits of household and of private companies (created by the author based on [22-23])

Forecast of Deposit Growth Rate in Latvian Banking System. At present, forecasting is becoming an integral part of the management of any company, helping it to keep a certain course, change direction or confidently move forward even in conditions of economic instability. Prediction is the prediction of the future based on accumulated experience and current assumptions regarding it. Forecasting is a complex process in which a large number of different issues need to be addressed. To implement it, various forecasting methods can be used. The most popular forecasting methods are the expert assessment method, extrapolation method, odelling, economic forecasting method, balance method. To predict the growth rate of deposits, we will use the extrapolation method. The extrapolation method consists in studying the persistent trends of the enterprise development that have developed both in the past and in the present and transferring them to the future. Distinguish between predictive and formal extrapolation. Formal extrapolation is based on the assumption that past and present trends will continue in the future; in the forecast case, the present development is linked to

hypotheses about the dynamics of the enterprise, taking into account the fact that in the future the influence of various factors on it will change.

We will make a forecast of the growth rate of deposits in Latvian commercial banks, taking into account historical actual trends over a 10-year period and possible changes in the influence of internal and external factors. Thus, possible trends in deposit growth rates are presented on the graph (Fig. 5).

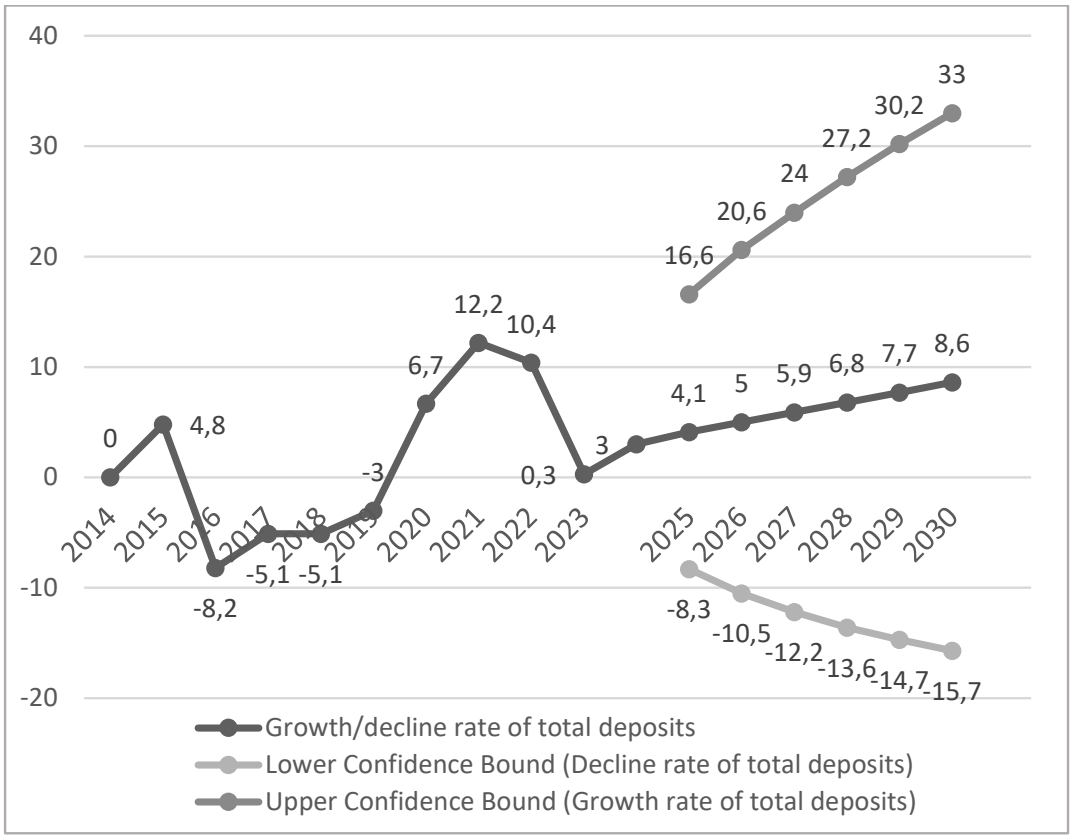

Fig. 5. Forecast of total deposits in Latvia (created by the author based on [22-25])

As can be seen, the average trend has a stable upward trend with an annual increase of 0.9%. While maintaining this trend, the growth rate of total customer deposits by 2030 may reach 8.6%.

The author also made an optimistic and pessimistic forecast of total deposits. According to the optimistic forecast, the annual growth may reach 3-4% and reach 33% by 2030. The pessimistic forecast shows negative trends in terms of total deposits, namely, an annual decline of 1% to 2.2%. Given this trend, the rate of decline in client deposits can range from 8.3% in 2025 to 15.7% in 2030.

Since deposits of households and private companies make up a significant share of total deposits, consider the forecast trends for these types of deposits.

The figure 6 shows that, according to the extrapolation method, the average trends in household deposits, deposits of private companies and total deposits may tend to increase in the future. Thus, the growth rate of deposits of private companies in the absence of financial shocks in the next 5 years may increase with an annual growth of 2.2-2.3%, and by 2030 reach the growth rate of 16.5%. The growth rate of household deposits in the next 5 years may slow down due to continued price growth and inflation. It is assumed that the annual slowdown in the growth rate of household deposits in the next 5 years will be at the level of 0.1%. These trends will affect the total volume of deposits in Latvian commercial banks. According to the forecast based on the extrapolation method, the annual average growth of total deposits in Latvian banks may be 0.8-0.9% and reach 8.6% by 2030.

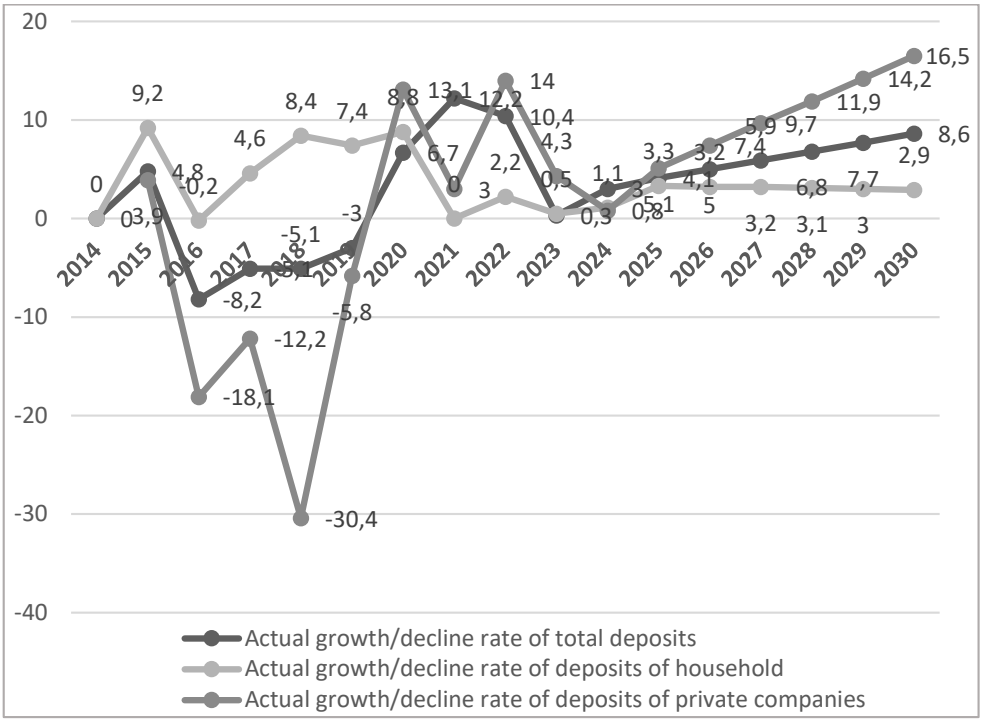

Fig. 6. Forecast of total deposits, household deposits and private companies' deposits in Latvia (created by the author based on [22-25])

Conclusions. As a result of the study, the author made the following conclusions.

The main type of attracted resources in commercial banks in Latvia are demand deposits, which make up 80-85%. The share of deposit sources attracted for specific periods is very small and amounts to less than 20%. Clients of Latvian banks prefer not to invest in banks for specific periods due to economic instability and lack of free funds. Of the deposits attracted for terms, the most popular are deposits up to 1 year.

Latvian banks are transforming current and short-term resources into long-term investments, because of which they are exposed to the risk of unbalanced liquidity.

The growth rate of household deposits has slowed in recent years due to rising prices and rising inflation. Also, a slowdown in the growth rate for this segment is expected in the future, as indicated by forecasts made using the extrapolation method.

Until 2018, non-resident legal entities accounted for a fairly large share of deposits in the Latvian banking sector. But with the tightening of requirements for servicing non-residents, many non-resident accounts were closed, resulting in a significant outflow of deposits from private non-resident companies. However, the forecast results indicate that in the future, in the absence of financial shocks, deposits may grow due to clients of the resident market, as well as due to the reorientation from eastern non-residents to western ones.

Based on the study, the author made several proposals to strengthen the deposit base in the banking sector of Latvia.

1) With a high share of transformation of current and short-term deposits into medium-term and long-term loans and other assets, exercise strict control over the transformation process.

2) Ensure interconnection between assets and liabilities of the bank in maturity and amounts.

2) To strengthen the deposit and resource base, banks need to find opportunities to attract alternative forms of long-term and medium-term funds, such as issuing debt obligations.

3) Expand the possibilities of using subordinated liabilities in Latvian commercial banks.

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DOES MONEY HAVE A FUTURE?

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Abstract. Money is one of the greatest inventions of the human mind and an effective tool of globalization. At the same time, not only monetary globalization contributes to the process of economic globalization, but globalization itself influences the change in the order of functioning of money (globalization of money), reflected in the modernization of their functions. At the heart of such modernization are the phenomena of Ddestuffation and Dereification of Money. Such changes do not change the Essence of Money, but reflect the increasing Entropy of Money, which in the case of Technological Singularity can lead to the abolition of money (which communist utopians could not achieve) as a result of Money Singularity. And yet, it seems that the Law of the Indestructibility of Money will win again.

Key words: Money, Monetary functions, Monetary Globalization, Global Money, Money Entropy, Money Singularity.

Introduction. Money appeared in the Pre-Modern period of the development of human society and almost immediately became not only a tool for establishing economic relations within certain societies and states, but also one of the key elements of the Globalization process itself. The invention of money, without a doubt, is considered one of the most important innovations of Mankind. However, determining the priority regarding its appearance remains not only unresolved, but in principle an undecidable question of economic history. It depends not only on the presence or absence of written and archaeological evidence of this event, but also from the interpretation of the very concept of "Money". Most likely, the monetary/coin form of money (that is, "money" itself, as opposed to various forms of intermediary commodities) arose almost simultaneously in the East and the West in the so-called Axial Age , which corresponds to the life of the Buddha (623 –543 BC), Confucius (551–479) and Pythagoras (570–495). (10,*224*) But the real impact of the first money on Globalization processes was – after all – different. It can be said that Pre-Modern Globalization was characterized by the fragmentation of global money on a territorial basis. The three sources of money (Hellenic, Indian, and Chinese civilizations) existed quite separately for a certain time, as did their systems of economic exchange. At the same time, some of them remained an element of domestic economic life and were later "incorporated" into monetary systems of other origins ("Indian" and "Chinese" source – although to varying degrees). Instead, the Hellenic source played the role of "base", and later – and "standard" for monetary systems of different countries. Taking this into account, it can be considered that money arose at the junction of Europe and Asia within the Hellenistic civilization and spread further to the East and West through the mediation of: – primarily wars of aggression, which ensured the territorial expansion of money both in the victorious country (Persia, Rome , the Mongol Empire), as well as its new possessions. The development of trade relations also created opportunities for borrowing the idea of money by other peoples (first of all, along the Great Silk Road – through Central Asia, India, China). At the same time, the decisive role in the emergence of money was played not so much by the market, but by the state and its military needs. Moreover, the connection "state – money" turned out to be so strong that the minting of coins (issue of money), according to Max Weber (*24 ,963-965*) later became one of the basic prerequisites for the formation of the state.

By starting to use money in their lives, Mankind made one of the greatest innovations, which is on a par with the use of Fire or the invention of the Wheel. The role of money in the economic system

of society is difficult to overestimate. In his reaction on John Mill note that there cannot be a more insignificant thing in the whole economy of society than money, the British economist William Carlile wrote: " Rather, it seems to me, money is the pivot of everything in economics. We cannot move a single step towards the elucidation of any of its problems without, etc. Not even could the thought of value have existed in a state of things in which there was no such thing as money." (*5 ,325-326*) So, what is money? "Standard substance"? General equivalent?

Thus, having won the competition with many simple equivalent commodities, precious metals – gold and silver – took the role of money. However, from the moment of its appearance the functioning of money in the economy requires an explanation of its nature, since without this it is difficult to understand and manage the mechanism of money circulation.

People have long been trying to solve the question of essence of money. British economist William Jevons noted: " Currency is to science of economy what the squaring of the circle is to geometry, or perpetual motion to mechanics." *(14,vi*) And although the self-educated French economist Marcel Labordère claimed in one of his letters to John Maynard Keynes that **Man will never be able to know what money is** any more than he will be able to know what God is *(6),* research on this issue will continue in the future. Since people are forced to return to this question again and again not only because they are no longer satisfied with previous answers over time, but also because the very conditions and forms of money functioning are fundamentally changing, which is due to changes in economic structures. One of the last attempts to give a new answer to the question of what kind of money is the theory of money as the capital of a nation, put forward by Patrick Bolton and Haizhou Huang.*(3)* By their opinion, money can be seen as the equity capital of a nation, playing a similar role as stocks for a company. This innovative framework integrates the real and monetary sides of the economy, with a banking sector and debt at its core.

The issue of money is just as inexhaustible as the atom. More precisely, like the topic of human relations. It turns out that after centuries of various studies, we still do not know for sure exactly how (in detail) money appeared. There are only our logical assumptions.

Although, it would seem, everything is so clear. At first, people began to use equivalent commodities... But, in general, equivalent commodities are noticed only in those nations which never invented money. That is, most likely, this is a dead-end version of the development of commodity exchange, and money, after all, arose in a different way. And that is why, at first glance, it seems that money must exist: in this context, it is characteristic that the Strugatsky brothers in their famous fantasy novel "It's hard to be God" mention the existence of money on another planet (the society of which lives in the conditions of our Middle Ages), apparently, not even assuming the idea that an extra-terrestrial civilization might not have invented money.

At one time, the American writer Gertrude Stein claimed that money is the thing that separate man from animals. It seems, however, that in its expansion, money can overcome this barrier as well. The existence of money seems so natural that the British journalist and writer Jonathan Ledgard, a supporter of the idea of "digital self-sovereignty"[1]* – who is actively interested in the latest technologies and cares about the fate of "our smaller brothers" – suggests creating money in general for non-human beings – " animal money" or originally InterSpecies Money (probably meaning that in English the word "specie" means not only "animal species", but also "sound/gold coin"). In his opinion, "animal money", the unit of which will be the "Life Mark", should be issued by a special institution – the Bank for Other Species, the capitalization of which will be carried out by other central banks (following the example of the Basel Bank for International Settlements). Funds issued in this way will be distributed to the benefit of specific animals (identified, in particular, by chips implanted by trained biologists, by photographs, or otherwise) and then debited from their "personal accounts" and to the benefit of organizations, local communities or

[1]* **Self-sovereign identities** (SSI) are digital identities that are managed in a decentralized manner. This technology allows users to self-manage their digital identities without depending on third-party providers to store and centrally manage the data.

specific natural persons (of course, people) who provide the relevant animals with food, medical or other assistance. In this way, it is planned to transfer the charity work to the animal world into the strong hands of the market economy. Simply put, a monetary form of financing environmental protection activities of poor countries at the expense of rich countries is proposed. (*16)*

Also, as we can see, the space of monetary expansion is really limitless – both in depth and in width. And in the "fourth dimension" – Time. Of course, this is also only one of the theories.

Money Phenomenology

Money is one of the most important, complex and even mysterious phenomena of human life. Thus, money is a subject of study from the side of phenomenology.

Of course, speaking of phenomenology, we cannot bypass Hegel's research (*12)*. As one knows, Hegel did not consider the evolution of human societies to be infinite, but assumed that History moves towards a goal (which he calls "God" or "Idea") in the form of social organization that will satisfy the deepest and most fundamental expectations of humanity. After which the "end of History" will come – human activity, of course, will not stop, just there will be no further progress and simultaneously a breakaway from the human essence (*Entfremdung*) and a backdown of Man from himself (*Entdusserung*).

For Hegel, the American and French revolutions were the signals for the “End of History”. He saw the embodiment of the goal in the Prussian state, that is, in the Victory of Liberalism. Instead, for Karl Marx, such a goal was communism. However, he gave victory to another term – the "End of Pre-History" of Humanity, believing that the real history – when people will be able to organize their lives in accordance with social laws (which they will finally know) – will only begin.

It was the allusion to these views that was published in 1992 by the famous work of the American sociologist Francis Fukuyama *(8*), who also saw "the End of History" in the final victory of liberal democracy (although he pointed out that the "end of history" does not come simultaneously all over the World, so that the period of wars and revolutions will continue). All this interests us in connection with a possible analogy regarding the "End of Money": in the Hegelian version, the end of market (chaotic, unmanaged) money comes in the form of the replacement of the Gold Standard with fiat money; for K. Marx, it is the disappearance of money as a measure of the value of commodities under communism; in the case of Fukuyama's "end of history", we can talk about the end of managed (fiat, central bank) money with its replacement by...

Actually, this is the question that will interest us the most.

Another German philosopher Georg Simmel considers money as a remarkable invention of mankind, which does not require additional care, but, on the contrary, gives people the power to own the World. *(21)* And Karl Marx, in his synopsis, known as "Economic-philosophical Manuscripts of 1844" (Ökonomisch-philosophische Manuskripte, 1844 – first published in 1932 after the death of K. Marx) notes: " The inversion and confusion of all human and natural qualities, the fraternization of impossibilities – the divine power – of money lies in its nature as the alienated, alienating and alienating species of man. It is the alienated wealth of manhood.” (*17 ,562*)

From the point of Marx’s view, the phenomenon of alienation means that the forces created by Man turn against him. In this way, the artificial world shows hostility towards people who lose control over the products of their activities. And the greater the human power over nature, the greater its alienation. At the same time, Marx distinguishes the alienation of a person from the results of his work, from the production process, from himself, herself, and from Society. The *alienation of money* with this approach appears only as a kind of alienation of a person from commodities (one of which is Money). The development of philosophical thought in this direction after Marx practically did not change this situation, despite the fact that the list of alienations has significantly expanded.

Nevertheless, Money and Cash Nexus played an important and noticeable role in the process of Economic Globalization. Moreover, Globalization itself has significantly influenced and continues

to influence Money and Monetary Relations, changing them not only quantitatively, but also qualitatively. A decisive factor in the process of Money Evolution is its globalization. Despite the fact that Money has the inherent attribute of overcoming time and space, and therefore Money itself carries the embryo of Globalization.

The **Globalization of Money** is the process of the disappearance of borders in the functioning of money, which is reflected both in the growth of the role of money in the course of the development of globalization, and in the spread of the globalization component in the very essence of money.

In a certain way, this is really the process of "taking off national uniforms", which Karl Marx wrote about. (*18 ,222*) But now it is not about the fact that money appears on the international market in the form of ingots of precious metals, but rather on the contrary – about the fact that "national uniforms" under certain conditions become "international", so to speak, turn into a cosmopolitan camouflage, behind which already it is difficult to distinguish the nationality of modern international currencies.

The logic of Globalization requires that the Global Economy be matched by Global Money, but at this point Globalization entered the New Millennium uncompleted:

Table 1

State of Globalization of Economy and Money

	Non-globalized	**End of XIX century**	**End of XX century**	**Globalized**
Economy	National	National	World	World
Money	National	World (gold)	National (free convertible currencies)	World

Source: designed by the author

That is, the situation in the sphere of the Monetary Relations is "half-hearted" – it has a "mirror image" relative to the situation at the end of the 19th century, but it may not pass to the final phase (correspondence of the World Economy with World Money), as it ultimately did not happen at of the beginning of the 20th century, despite the seemingly victorious course of the Gold Standard and rapid Globalization. (Let us remind that Karl Marx wrote in one of his letters to Fredrich Engels in 1858: " Now, truly, the world market exists. With the opening of California and Japan to the world market, that's it, we have globalization" (Cit.by *2,150*) and even tried to delay its completion in every possible way writing his three-volume "Capital" – for which he received and long ago spent a significant cash advance – hoping for the collapse of capitalism). Nevertheless, the "logic of globalization" was then disrupted by the fear of nationalism.

The situation remains quite difficult and uncertain even now both at the national and international level, and in relation to the development of the economy in general and its monetary sector in particular. The choice, or rather the victory of one or another model of Global Money, will depend on which of them will more fully meet the requirements caused by the quantitative change in the quality of money as a result of the transition from numerous national currencies to a single Global Money.

One could see that the new clash of civilizations leads to polycentrism, the amalgamation of civilizations, which in the monetary sphere finds expression in currency wars (with China), Islamic banking and, in the future, possible manifestations of Dharmic and Taoist monetary traditions.

After all, "cryptocurrencies" and electronic money have already become part of an extensive monetary system, in which they more or less organically intersect and combine with other elements, even such archaic as gold coins.

If we adhere to the moderate anti-evolutionary version of historical dynamics (*8*), it should be recognized as impossible to transfer the biological model of evolution to the development of society,

according to which new varieties simply replace old ones. In social development (including its economic component), something new mainly does not replace the old ones, but is built on top of it (according to Hegel's principle of "dialectical negation").

In fact, we could see such a process in the evolution of monetary relations in the process of Globalization, when various forms of monetary tokens (gold, commercial bank notes, central bank notes, fiat money, electronic money) do not disappear, being replaced by new ones, but are preserved, giving at the same time priority to new forms, more adequate to updated conditions of economic life. Thus, the accumulation of experience is accompanied by a change in the ratio of structural components and their importance for the functioning of the entire mechanism.

Fig. 1. Money Inflation

Source: (flyleaf, 7).

Such changes are taking place under the influence of a number of recent phenomena in the field of monetary circulation, – from financialization to digitalization, – the common feature of which, however, is the explosive quantitative growth of all monetary parameters.

In fact, it is about the same inflation that Alexander Del Mar had in mind: not just "swelling" of the money supply, but its "swelling" due to new components. More precisely, even not "swelling", but "inflating" – if we take into account that as an illustration of the inflationary process, he depicted a "balloon". At one time, the French philosopher René Guénon (*11*) presented his explanation of the crisis of modern civilization, indicating as one of the main manifestations of this crisis the ever-increasing superiority of quantitative characteristics over qualitative ones. And observing the quantitative growth of the concept of money, you can see that money exceeds everything else, and the modern world has loudly admitted that it has nothing more important than money.

Thus, there is an evolution of inflation (swelling) of Global Money – quantitative and qualitative one. **Money** by its nature is always global one (in the fetus, this is its implicit characteristic or feature,) and that is why it **is the most effective globalizer**.

Another, more neoteric option to illustrate this evolution could be the model of the “Expanding Universe” as a result of the “Big Bang”. In this case monetary functions begin to be performed to

a greater or lesser extent by various financial moneyness instruments – gold, bank notes, financial derivatives, cryptocurrencies... Such a "big explosion" also causes corresponding qualitative transformations, including the emergence of "cryptocurrency". (See: *15*)

All these changes should to be reflected in the order in which money performs its functions, which, reflect the Essence of Money in the specific conditions of its functioning. Therefore, first of all, we will turn to the analysis of changes in monetary functions in order to try to find out whether there are any cardinal changes that may indicate essential changes of the Money itself.

Modern money, obviously, is not classical money at all, which acted as a means of exchange of products in accordance with their value.

Modernization of Money Functions

In the conditions of a market economy (regardless of the degree of its development and globalization), money remains an absolute necessity. But the categories "money" and "monetary commodity" are not the same, as is well known. And the monetary commodity as money was only a real reality (for *laissez faire* capitalism), which, on the one hand, was really necessary, and on the other – accidental. This reality could not be different in content, since it is determined by the essence of the relations fundamental to this category, but it can be different in form. Monetary *commodities* (gold and silver) are only a *separate* manifestation of the *general* concept of "Money".

In this regard, from our point of view, the category "monetary commodity" includes an element of both general (money) and special (commodity). And this duality of the basis could not but manifest itself in the form of *duality* of all the functions performed by the monetary commodity. Thus, all monetary functions performed by gold, on the one hand, were indeed the functions of money, but on the other hand, they were also the functions of commodity.

As long as the concepts of "gold" and "money" were identical, this duality remained hidden. But once the demonetization of gold took place, the commodity and monetary functions are separated. Gold, being an ordinary commodity, continues to perform (or can potentially perform) a number of functions inherent in it as a commodity. ***Money functions in their pure, not "gilded" form continue to be performed by money as a special commodity***.

But monetary functions are performed in new, modernised way.

Dereification of the function of *Measure of Value*

The fulfilment of the function of a measure of value in modern conditions not by gold, but by fiat/credit money is, without a doubt, the most controversial and theoretically quite complex issue in the discussion about Modern Money. It can be called, perhaps, even the main issue of discussion due to the fact that it is precisely this function that is fundamental one for money However, in the case of classical money, although gold was a value equivalent, and therefore also a measure of value, what was important for money was not what it could measure, but that it could *co*-measure different values (make them *commensurated* ones). Due to the fact that social relations do not immediately reach the required level of development, initially the function of a measure of value is performed by such money that guarantees universal recognition by itself, by its value – namely, gold. As the level of socialization of production grows and the state strengthens, the need to use the cumbersome “golden mechanism” for pricing disappears. With the demonetization of the “yellow metal”, the movement of commodity prices is completely detached from their former gold basis.

It has become obvious that changes in the value of goods do not correspond with the movement of their “gold prices”, and the economic reality of today has become not “gold” prices, but credit-money prices. This is quite logical, since in reality money now is not gold (or any other money, which is at the same time not only a *special*, but also an *ordinary* commodity), but fiat/credit money. This money isn’t just representatives of real money in circulation. It is itself a monetary commodity, exclusively *special* commodity.

Gold, even in modern conditions, has not lost its ability to perform the function of a measure of value, since the properties that allowed this metal to perform it earlier have not undergone any

changes. But there were important changes in the external conditions for the functioning of gold as money. These changes led to the loss of the yellow metal's ability to serve as a measure of value. In other words, in the economy of modern capitalism, the ability of gold to act as a measure of value is *formal*, not *real*.

As known, commodities come into circulation already having a value. And in the process of exchange, the need arises not to determine exactly what value is contained in this or that product, but to find out how many times it is more or less than the value contained in the product offered for exchange. Consequently, the function of money is ultimately the commensuration of values, and the function of the measure of values is only its particular manifestation at a certain stage of development of production relations.

The mechanism for measuring values, carried out through fiat money that have only a conditional value, was presented by Rudolf Hilferding in his well-known interpretation of the formula of the so-called "law of monetary circulation" ("The law that the quantity of the medium of exchange is determined by the sum of the prices of commodities in circulation and the average velocity of circulation of money…").(*13,37*)

The value of a commodity cannot be measured in gold. The ratio in which goods are exchanged for each other (including exchange for gold as ordinary commodity), – i.e., their exchange value, – is determined spontaneously in the conditions of the market economy. As soon as the exchange of goods takes on a certain regularity, goods enter the market, having not only value, but also exchange value, completely independent of whether it will be measured in money or not. It turns out that for pricing, not only the value of money, but also the value of goods does not matter. *Only their exchange value is important*. And since goods enter the market with an exchange value, determining the value of a monetary unit is no longer difficult.

Thus, the value of all fiat/credit money in circulation is nothing more than the exchange value of all commodities. It is precisely the credit and fiat banknotes, which together represent the exchange value of all goods, that are now the basis of pricing. So, that the price of any product is determined by the ratio C/C`` (where C means cost production or value of any simple commodity and C`` – cost of production or the value of the monetary unit itself, i.e. its *exchange value,* but the value of the material from which it is made). The *exchange value* (value) of a unit of an instrument of circulation turns out to be dependent on the average level of exchange values that goods possess already by virtue of the fact that they are produced under the conditions of commodity production, when they (exchange values) turn from possibility in fact, with necessity (i.e. inevitably). The prices of goods depend on the exchange value of the instruments of circulation, i.e., ultimately, they are a reflection of value.

The acting of the Law of value is thus in no way violated, since the sum of commodity prices is still equal to the sum of commodity values. However, the mechanism for establishing such equality is radically changing. If previously, in the case of monetary circulation, it was achieved exclusively due to the action of the hoarding mechanism, i.e., due to changes in the amount of money in circulation, now, in modern conditions both elements become elastic: as the numbers of monetary units in circulation, as the value (exchange value) of a monetary unit.

Accordingly, changes continued with the mechanism of performing its functions with money. The function of commensurement of values is manifested through the function of a medium of circulation. And since the virtualization or dereification of the means of circulation itself is gradually taking place, the co-measurement function is also dereificated (i.e. it is carried out virtually).

Convergence and dereification of functions of *Medium of Circulation and Means of Payments*

Unlike the function of a Measure of Value, the performance of fiat money as a Medium of Circulation did not cause much controversy. There isn't, probably, any economist with a serious reputation who would think that returning to gold standard is a really wise idea. The displacement of gold by fiat money received its further continuation in the development of a relatively new phenomenon – the process

of removing from circulation a significant part of carriers of monetary functions (banknotes, checks, etc.). And the further IT development (in particular, phone-banking with its subsequent modification in the form of mobile-banking, cryptocurrency, CBDC etc.) only strengthened the transition to a "cashless society".

The era of "electronic money" or, as author has proposed to call it, the "*Destuffation of Money*"[2]** has begun – that is, the disappearance of the physically embodied (stuff) form of money signs. And today we can claim that the purely technical process of destuffation of money signs is becoming more and more clear as an exercise of a more significant transformation in the form of dereification of the very function of money as a Medium of Circulation.

Thus, performance of fiat money as a Means of Payments becomes possible precisely because it becomes a Measure of Values and the basis of pricing, and also functions as a Medium of Circulation. In other words, in modern conditions, fiat (credit) money becomes an independent Means of Payments because the entire course of development of economic relations turns it into an exchange equivalent, the sense of which is the Meaning of Payments as such.

It has to be noted as well, that complex derivative instruments were created in order to reduce the riskiness of market operations in conditions of uncertainty and high price volatility. In this regard, the analysis and consideration of monetary policy perspectives is an important area of study of various factors of activity in the derivatives market. Money market derivatives are generally highly liquid, allowing traders to use them cheaply, quickly and with minimal price impact. This feature provides a connection between monetary policy and the turnover of derivatives.*(23,65)* According to Dick Brian and Michael Rafferty, derivatives are, in fact, "*behind the scenes*" *money*, which ensure that different forms of assets (and money) are not commensurated by government regulation (for example, regarding a fixed exchange rate), and with the help of competing forces. (*4,153*)

Dereification of the *Instrument of hoarding* function

The function of a Means of Hoarding is not fundamental in the system of monetary circulation. Everyone knows well that hoarding was formed and are formed by accumulating not only gold (or other monetary commodity), but also other high and stable values, which are primarily precious metals and gem stones. The only thing that remains unchanged is that among their components there is necessarily a commodity that functions as money, and that it is never their only component. That is, *money is not only an abstract value, it is not only a means of hoarding. But hoarding (treasures) are not only money.*

All of the above allows us to conclude that hoarding by their nature are not money, but money, due to its properties of a special commodity-equivalent representing an abstract value, is hoarding (treasure). This function is one of the specific functions of money, because hoarding act as supply and output channels of money in circulation. From the point of view of monetary circulation, hoarding is primarily the accumulation of medium of circulation. One can say that the specific, technical function of money is the accumulation of monetary reserves. The function of accumulation again becomes the function of real (now – credit) money, but its content is the accumulation not of "deadened" (immobilized) value, but of a completely different form of social wealth – loan capital. Its accumulation is the regulator of the modern monetary system based on credit. Credit money as would take the baton from gold in the matter of capital accumulation.

Dereification and separation of functions of *World Money*

In the conditions of Monetary Globalization, World Money is subject to general modernization in the form of separation, that is, split, disintegration of previously mixed functions. More specifically, we are talking about the internationalization of the sub-functions of World Money: previously they were performed at the international level on the basis that the monetary commodity (gold) performed

[2] ** The term was coined by the author more than forty years ago to denote the process of disappearance of material (physical) carriers of monetary functions. (*19,48*)

them at all national levels, and therefore, according to the principle of consensus, it functioned both as a measure of value and as a means of payment, and as a means of accumulating wealth (hoarding) at the international level as well. In the new conditions, national credit money performs the specified functions only on the relevant national markets and the sub-functions of World Money can no longer be performed by them according to the principle of consensus. Now they perform in their pure, international form.

a*) sub-function of the international co-measurement of values*

So far, in accordance with the practice that has developed in the world market, prices are mostly set in only a few currencies (first of all, in US dollars), depending on the role of the issuing country in the market of a given product (for example, the presence of international commodity exchanges), as well as taking into account the practice of making payments – in order to minimize currency risks in case of incompatibility between the currency of the price and the currency of payment.

That is, goods, the value of which is measured in national credit money, enter the international market, where they are compared through the cross-rate to the international currency of the price (say, the dollar), after which the total price is averaged on the basis of competition and the world price is established (which is converted into national currencies, again at the existing exchange rate).

b) sub-function of the international means of exchange

It is necessary to take into account the fact that in international commodity circulation, gold and silver acted not as a medium of circulation, but as a general means of exchange, which functioned only simultaneously in both developed forms – a means of purchase and payment. Moreover, the relationship between them on the world market becomes reversed, that is, the function of the means of payment is the leading one – since in foreign trade, the direct exchange of goods for money is relatively rare at the same time: most often it is separated in time and, thus, the basis of payments is credit (loan) agreement.

c) sub-function of the international materialization of wealth in general

Gold is still part of the international liquid reserves in quite significant amounts (especially being listed at the market price). But in the composition of foreign exchange reserves, credit money plays a dominant role, mainly in the form of government bonds denominated in US dollars. Such a structure is based on the role that belonged to the US economy in the global market. We say "belonged" because some weakening of the economic position of this country in recent years has led to a vivid manifestation of the contradiction inherent in the use of the dollar as a reserve currency. This is nothing but a manifestation of the contradiction between form (national currency) and content (world money).

They tried to solve the problem by increasing the share of international liquid funds – units of account such as SDR and ECU. However, not too much use of them as a means of international settlements, in the end, forced to actually abandon this idea. So, the problem is still not solved.

End of Money?

With such understanding, *there is no modification of monetary functions* – i.e. modification, transformation of these functions into something new, which has certain additional new properties. Simply, since the monetary commodity gold is replaced as money by credit and fiat money, the form of performance of monetary functions also changes, that is, *their modernization occurs* – the depth and essence of the function does not change, but it is performed in a way that meets the new conditions, the conditions of Late Modern Globalization. And such *Modernization* takes place, as we will try to prove below, in the form of *dereification*, *not modification* – that is, changes that overcome, get rid of reification and return functions to their abstract quality, which until now was hidden by the material shell of monetary material. It is with this change in the form of performance of monetary functions that new phenomena in the process of functioning of money are defined by us as the further **evolution of money.**

At the same time, the Twentieth century was marked for money by practical attempts to realize the utopian dreams of abolishing money. It is not only about the promise of the Russian Bolsheviks to build public latrines out of gold in the largest cities of the world. The Cambodian "Red Khmers" (*Khmer Kror-Horm*) did abolish money (albeit not for long) during their bloody tyranny in the late Seventies. (*19*)(*22*) But the most advanced was, of course, the Soviet project of *modifying* monetary functions – which was supposed to lead to their abolition. As one of the ideologists of such a policy explained, under *real* socialism "... there is an intensive process of transformation of commodity production into non-commodity, and money into non-money". (*1,56*) Accordingly, monetary functions were gradually transformed into non-monetary ones: the function of a measure of value became a function of direct accounting of socially necessary time; the function of the means of circulation is the function of direct distribution of material goods; the function of the means of payment – in the function of the means of distribution according to work; the function of the means of accumulation (the former Marx function of the means of creating treasures) is the function of the means of saving labor income. Under socialism, of course, the fundamentally new nature of commodity-money relations determines the new nature of Money. Thus, it was argued that ***under socialism, money is not money*** not only in the quantitative, but also in the qualitative sense. Which, in the end, corresponded to reality.

However, despite all attempts to eliminate money, its complete disappearance was never achieved, although, as we have seen, its functions were significantly undermined. And therefore, due to the *law of the indestructibility of money* in the countries of "real socialism", the process of *palingenesis*[3]*** *of money* had to inevitably begin.

And this *Restoration of Money,* i.e. the Integration of Post-Communist countries into the Global Monetary World really took place.

But does the collapse of the communist attack on money mean that there is no longer any prospect of its abolition?

Analyzing the development of money and the monetary system, one cannot fail to see the tendency of gradual growth of chaos as a result of the deviation of the monetary system and its subsystems from the reference (classical) state, when the deviation is manifested in a decrease in the level of organization, efficiency of functioning, rates of development of the system, etc. In other words, one can clearly see the process of **Monetary Entropy**. In turn, monetary entropy has two components: *entropy of money* and *entropy of the monetary system*. The functioning of money is chaotic as the above-described modernization of its functions takes place. The entropy of the entire monetary system increases as the transition from minting coins from a clearly defined, standard monetary commodity (gold, silver) to system of currency issue by central and commercial banks, and then to the emergence of decentralized cryptocurrencies.

At the same time, as evidenced by the practice of natural development, the increase in entropy does not lead to a complete collapse ("*heat death*"), since countermeasures (the so-called "negative entropy" or negentropy) gradually begin to act.

Thus, we meet the problem of predicting the future transition to a new state of negentropy. In other words, understanding what transformations should be expected in the nature of money and in the international monetary system.

However, moving on to the question of predicting the future of money, it should be noted that there is an opinion that soon money will simply become a relic of the past and disappear altogether. In this case, we are not talking about Communist Utopias, but about the fact that the probable technological singularity[4]*** will have as one of its consequences the abolishing (more precisely, the meaninglessness of existence) of Money as an economic category. In other words, ***Money Singularity*** –

[3]*** **Palingenesis** (from the Greek *palin* – again, back and *genesis* – origin, birth) – rebirth.

[4] *** **Technological singularity** is a hypothetical moment in the future when technological development becomes, in principle, uncontrollable and irreversible, which gives rise to radical changes in the nature of human civilization

hypothetical moment in the future when development of Money becomes, in principle, uncontrollable and irreversible – will be the "end of the history of money" by analogy with the concept of Fukuyama: for the next "thesis" in the "spiral of development" there will be no corresponding "anti-thesis", and therefore no "synthesis" will occur.

Of course, we do not know 1) whether the technological singularity will come at all and 2) what kind of consequences it may lead to. One of the possibilities of the technological singularity is the emergence of a post-scarcity society, in which there will be a surplus of resources and the needs of every member of society will be fully satisfied (a variant of capitalist communism, when even an unconditional basic income will appear to be an unacceptable minimum for satisfying needs). And then, indeed, the need for money will disappear as a means of distributing life resources among people. And even after the singularity comes, a fundamental change in values can take place shift from material benefit (represented by money) to other values such as knowledge, creativity or other elements that cannot be quantified in monetary terms.

But "post-singular communism" may turn out to be just as much of a phantasm as its predecessors: if the singularity doesn't lead us to a point where resources are unlimited and scarce, then the need for a system to manage the distribution of those resources will persist. In this case, money will continue to serve as a medium of exchange, a unit of account, and a store of value.

In any case, the change will not happen overnight, so there will most likely be a transition period during which Mankind will still use money, and it is quite possible that the concept will simply evolve and not disappear completely. In particular, thanks to the development of Artificial Intelligence and technology, there may be a shift towards a more decentralized and autonomous society, where traditional centralized financial systems will become obsolete. In a world dominated by super-AI, the economic structure may be completely different and incomprehensible to human beings. Artificial Intelligence can operate on the basis of algorithms and principles that optimize the allocation of resources and productivity in a way that renders traditional concepts such as "Money" obsolete.

However, no matter what the AI thinks about this, the decision will be made by a Man.

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DIGITAL TRANSFORMATION OF FAMILY OFFICES: TECNOLOGIES, AGGREGATION PLATFORMS, AND THE ROLE OF AI

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Abstract. This article explores the digital transformation of family offices through the integration of specialised technological platforms and AI-based tools. It analyses leading digital solutions for financial reporting, investment management, and data aggregation, with a focus on platforms such as Asora, EY Nexus, Asset Vantage, and Addepar. The research is based on a comparative analysis of platform functionality, market penetration, and the degree of artificial intelligence and machine learning integration. Findings show that platforms enabling automated reporting and asset monitoring improve operational efficiency, while AI-powered solutions enhance personalisation and client experience. Particular attention is given to asset aggregation platforms, which reduce data fragmentation and enable consolidated financial insights. The study relies on data from industry reports (e.g., UBS, EY, Campden Wealth) and official product documentation.

Key words: automation of reporting, investment analytics, client experience, operational efficiency, digital platforms, machine learning tools, data aggregation, portfolio monitoring.

Introduction. Family offices are specialised structures for managing the wealth of UHNW (Ultra-High-Net-Worth) individuals or families, performing investment, administrative and inheritance functions. The average number of employees in family offices is 8, ranging from 4 in small offices to 14 in large ones. Investment management is the primary focus of small family offices, although many operational processes are outsourced. Nevertheless, employees are usually overloaded with work, which increases the likelihood of errors, which is unacceptable in any business, especially in companies of this type. In today's era of increasingly complex financial markets and data, the introduction of digital technologies and solutions based on artificial intelligence (AI) and machine learning (ML) is becoming a key factor in improving the efficiency of family offices. Many traditional family offices have historically relied on manual processes and outdated tools (such as Excel), which has led to inefficient operations, data fragmentation and slow management decision-making (Campden Wealth, 2024, p. 11), (Gooch, 2024). The modern world is constantly evolving, and the emergence and rapid development of artificial intelligence have brought significant changes to business approaches. The use of modern digital technologies provides powerful advantages to companies operating in the asset management sector, allowing them to significantly reduce the time spent on customer service, whether it be the processes of onboarding new customers, developing investment strategies for customers, communicating with counterparties and customers, documentation, including pre-filling contracts using data from CRM systems, thereby reducing business costs and increasing revenues through both the intensification of marketing processes and the attraction of new clients, as well as reducing the time spent on current operational processes, preparing reports, investment strategies, communicating with clients and onboarding. Lagging in digitalisation carries risks: according to a Deloitte survey, nearly 17% of family offices directly cite insufficient investment in technology as one of their main risks (Gooch, 2024).

In contrast, the transition to modern digital solutions promises to increase productivity, reduce operating costs and ensure the long-term preservation of family capital (Battaglia Trovato, 2025). Companies that use modern technologies have a significant competitive advantage over their compet-

itors and, at the very least, can successfully develop in a highly competitive environment. This study analyses global trends in the digital transformation of family offices and the role of advanced AI/ML-based solutions in improving their performance.

Research objective: to investigate global trends in the automation of family office activities at the current stage of economic development, which modern digital technologies, software and solutions based on AI and ML affect the efficiency of family offices, and to determine the size of the market for modern software for family offices, the pain points and needs for implementing such technologies, and the potential benefits they can gain from implementing such technologies. In addition, to identify a new paradigm shaped by digital solutions based on artificial intelligence and a physical-digital approach, and to assess the benefits and risks that these innovations bring to financial institutions. The study aims to determine how digital transformation based on artificial intelligence and a hybrid customer-centric experience is redefining competitive advantages in the family office industry. In addition, it will assess the strategic implications for companies that are delaying digitalisation and explore future regulatory and ethical challenges associated with personalisation and automation based on artificial intelligence.

Methodology: The study is based on a review of current literature and industry reports for 2024–2025, including Deloitte Family Office Insights 2024, EY/Wharton Global Family Alliance Survey 2024, and Campden Wealth. (2024). The Family Office Operational Excellence Report 2024 and UBS Global Family Office Report 2025&2024, Morgan Stanley The Future-Ready Family Office: Evolving with Purpose 2025, Capgemini World Wealth Report 2025&2024, as well as analytical materials from leading consulting companies. An analysis of statistical data on the level of digitalisation of family offices, their priorities and challenges was conducted. In addition, specific examples of software solutions (Addepar, Advent, Masttro, Canoe, Black Diamond, Eton, Total Return, Asora, EY Nexus, Asset Vantage, etc.) were considered, and a comparative analysis of their functional capabilities was conducted. The research methodology is descriptive and analytical (desk research): data was collected from secondary sources, as well as from the websites of technology solution providers for family offices regarding their functionality and customer feedback on their effectiveness. Based on the information obtained, key global trends, market needs and gaps in existing offerings were identified, and conclusions were drawn regarding the prospects for further development of the digitalisation of family offices.

Global trends in the digital transformation of family offices. Global reports from recent years show that family offices are going digital faster than ever. Deloitte (2024) says that 43% of family offices worldwide are developing or implementing a comprehensive tech strategy this year (Gooch, 2024). This is a response to the realisation that almost three-quarters of family offices surveyed admit that they have either underinvested (34%) or only moderately invested (38%) in the technologies necessary for modern business (Gooch, 2024). This 'technology debt' has been accumulating for years, but now family offices are forced to catch up in order to remain competitive and ensure an adequate level of control. About 17% of offices directly cite technological lag as a risk to their operations, and administrative and compliance tasks still consume a significant portion of staff time (up to 19% according to some estimates, and up to 27% in North America (Battaglia Trovato, 2025).

Priority areas for digitalisation. Family offices are currently focusing on implementing technology primarily in the areas of security and risk management, as well as investment operations. The most common types of technologies used by family offices are cloud applications/services (87%), virtual meetings (82%), mobile communication applications (71%) and identity and access management systems to protect their own systems and data (61%) (Gooch, 2024). According to Deloitte, 65% of family offices have already achieved at least an average level of technology adoption for security/risk control purposes, 49% for investment operations, 47% for direct investment support, 35% for tax and estate planning, and 28% for client engagement (Gooch, 2024). This indicates that the basic

elements of digital infrastructure (cloud, remote communication, cybersecurity) have already been implemented in most offices. In addition, more than half of family offices (55%) actively use data analytics to support investment decisions, and 42% to optimise operational activities (Gooch, 2024). Thus, data analytics is becoming a standard tool, helping to identify trends and improve the quality of data-driven decision-making.

Initial implementation of AI/ML. A separate trend is the cautious introduction of artificial intelligence into family offices. The slow adoption of such modern technologies is linked to the tradition of confidentiality in the family office sector and concern for client data protection, which has had little impact on this sector in determining which artificial intelligence technologies should be implemented immediately and which require further development. According to Deloitte, just over one in ten family offices (12%) have already started using AI-based solutions, primarily to automate routine tasks, optimise portfolio management and improve risk management (Gooch, 2024). Although this figure is still low, it confirms the emerging interest in AI as a potentially 'transformative technology'. Data from a Wharton GFA (2024) survey conducted in collaboration with EY confirms that generative AI is still on the sidelines of core processes: only 10% of family offices reported that they already use AI tools to generate investment ideas and themes, while 56% do not yet feel any impact of AI on the investment management process, and 25% are not at all confident about its impact (Stover, Fankhauser & McKibbin, 2024). In other words, most family offices are still just looking at AI, waiting for more mature use cases.

According to a UBS study, the situation may change in the next five years, with family offices around the world planning to integrate artificial intelligence tools to improve operational efficiency. The most popular areas are financial reporting and data visualisation automation (69%), text analysis (64%) and portfolio analytics (62%) (UBS, 2025). In some regions, these figures exceed 75%, particularly in South-East Asia and North Asia. These figures demonstrate growing confidence in technology as a tool for improving transparency, accuracy and speed of service in wealth management.

At the same time, AI has already come to the fore in terms of investment themes: family offices are increasingly considering investments in related areas as a strategic priority. According to UBS (2025), almost three-quarters of family offices surveyed (75%) expect the banking and financial sector to be the primary beneficiary of generative artificial intelligence, alongside pharmaceutical companies (65%) and the healthcare sector (62%). At the same time, generative AI as an investment niche consistently ranks third among priorities, behind only healthcare and energy transition (UBS, 2025, pp. 28–29). These data indicate not only interest in the topic but also the active adaptation of investment strategies to disruptive technologies, within which AI is playing an increasingly important role.

Comparable conclusions are presented in a Morgan Stanley analytical note (2025), according to which modern family offices are increasingly integrating innovative trends into their investment policies, primarily generative AI and clean energy. The document notes that, given the long-term nature of investments and the high level of risk, offices are seeking not only to expand their sources of income but also to update their asset allocation strategies and find reliable sources of data for informed decision-making. Accordingly, investing in AI is seen not as a short-term fad but as a strategic vector of digital evolution for family offices aimed at strengthening competitiveness (Morgan Stanley, 2025, p. 28).

Growing need for digitalisation. Industry surveys unanimously confirm the significant demand for digital transformation among family offices. The Simple Family Office Technology 2024 report showed that 89% of family offices feel that their current technology stack is insufficient and in need of strategic improvements, and nearly half (49%) of respondents planned to launch or were already launching a new digitalisation strategy within the year (Simple, 2024). Similarly, EY notes that the younger generation of capital owners actively expects the automation of routine processes and broader use of outsourcing and AI to reduce the workload on staff (Stover, Fankhauser & McKibbin, 2024). In other words, the drivers of change are not only risks and inefficiencies, but also the evolution of

family office client demands: today's wealthy families (especially their NextGen) are seeking more technologically advanced approaches to wealth management. This is driving a shift from the outdated model of 'artisanal' management to a digital transformation strategy for family offices.

Operational priorities for technology – driven transformation in Family Offices. The above trends indicate that family offices are aware of the need for technological change. In this section, we will look at specific areas where digital solutions and AI/ML address existing needs, and back this up with data from reports:

Reducing manual work and consolidating data. Many family offices still face the problem of fragmented accounting systems and over-reliance on Excel. According to Campden Wealth (Operational Excellence Report 2024), 40% of family offices cited 'over-reliance on spreadsheets' as one of their top technology challenges, while 38% cited manual aggregation of financial data as a significant challenge (Campden Wealth, 2024). This not only takes up employees' time but also increases the risk of errors and makes it difficult to get a complete picture of assets. Digital platforms that automatically collect data from bank and investment accounts into a single system address this need by providing a single source of truth for family finances. As a result, routine operations (transaction reconciliation, report generation) can be performed faster and with fewer errors. The practical effect is illustrated by an example: the MyFO platform claims to save clients about 40 person-hours per month for every $100 million of net capital through automated data collection and reporting (Battaglia Trovato, E., 2025).

Improved risk management and real-time monitoring. Family offices manage diversified portfolios of assets around the world, making real-time risk control and access to up-to-date information critical. Inadequate technology can be costly here. A case in point: one family office, unable to assess its exposure to a bank on the verge of bankruptcy in real time, suffered significant losses (Battaglia Trovato, E., 2025). Such situations highlight the need for automated monitoring of financial news and positions. This solution could warn a family office about problems with a counterparty or asset before losses become irreversible. Modern platforms offer tools for monitoring news and market events with customisable alerts: for example, using AI to analyse news feeds and social media can help identify events that affect the portfolio (reputational risks, asset price changes, etc.). Therefore, automated news monitoring remains one of the unmet needs that is becoming increasingly in demand.

ESG analytics and sustainable investing. Another pressing need is for tools to assess non-financial investment performance, particularly environmental, social and governance (ESG) criteria. Family offices have traditionally focused on financial returns, but in response to the demands of younger generations and societal trends, there is growing interest in sustainable investing. According to a study by Ocorian, 94% of family office professionals agree that ESG principles are a key factor in determining a family's investment priorities (Ocorian, 2023). Furthermore, according to UBS, nearly 49% of family offices consider climate change to be one of the main long-term threats (on the 5-year horizon). However, in practice, implementing an ESG strategy requires high-quality data and analysis. In the UBS Global Family Office Report 2024, 37% of respondents explicitly stated that better data analytics for measuring the impact of investments would significantly help them achieve their sustainability and impact investment goals (UBS, 2024). This points to a lack of convenient tools that aggregate ESG metrics, ratings, and sustainability news and integrate them into the decision-making process. Family offices are looking for solutions that allow them to automatically assess a portfolio in terms of ESG risks and alignment with family values. Thus, ESG analytics is a strategic niche where demand exceeds supply: specialised solutions (from data providers and fintech start-ups) are emerging on the market, but many offices do not yet have integrated tools for ESG monitoring.

Integration with CRM/ERP and a single 'dashboard'. A family office often serves as a hub not only for investment management but also for coordinating many non-traditional tasks, from

managing the family business to philanthropy and family legacy. This necessitates the integration of various systems: financial, accounting (ERP), customer relationship management (CRM), etc. Ideally, a family office manager wants to have a single information dashboard that consolidates financial indicators, family member data, trusts, charitable projects, event calendars, etc. In practice, however, many offices work in 'silos' (isolated software environments) where, for example, investment accounting is kept separate from the family's operational business accounting, and contacts and documents are stored in yet other systems. Integration with CRM would allow, for example, automatic synchronisation of information about family members, advisors, partners, philanthropic activities, as well as financial decisions. Modern platforms are beginning to offer such capabilities: for example, solutions such as EY Nexus provide two-way data exchange – client information from the CRM system can be updated on the advisor's desktop or in the financial application in real time (EY, n.d.). In other words, if a family office uses CRM to manage contacts and interactions, this data can be automatically reflected in financial planning tools, eliminating duplicate entries and providing a holistic context for decisions. Integration with ERP (e.g., the family business accounting system) is also critical when the family office controls the family's operating companies – the financial results of the businesses must be factored into the overall wealth picture. Currently, the integration of disparate systems is another gap noted in the industry. Surveys show that less than 30% of family offices use comprehensive cybersecurity solutions or cyber risk insurance (Stover, Fankhauser & McKibbin, 2024), which indirectly indicates a lack of attention to comprehensive IT infrastructure. However, the trend is changing: more and more ecosystem platforms are trying to offer modules for different tasks or easy integration via APIs so that family offices can assemble their own 'set' of services to suit their needs.

AI/ML applications in Family Office Software: selected use cases. The market for technological solutions for family offices has been actively developing recently. Both specialised start-ups and solutions from large consulting firms are emerging, aimed at automating family capital management. Let us look at a few examples of such platforms and compare their functionality. For comparison, ten modern platforms were selected that provide family offices with a wide range of digital capabilities, from data consolidation and analytics to back-office process automation. Table 1 summarises information about each platform, including the developer, functionality, AI/ML support, and application percentage (if available). Brief feedback from direct users (in italics) illustrates the practical effect of implementing these solutions.

Table 1

Comparative characteristics of platforms for family offices: functionality, AI use, and user reviews

Platform (developer)	Key features and functionality
Asora (Asora Ltd.)	*"The security features and data protection were relevant in driving our decision-making process, and we are thoroughly impressed with the overall experience."* – Omnia Capital Partners. A multifunctional SaaS platform for single– and multi-family offices with a focus on automated data collection and online reporting. Provides a single secure space for all family financial data with continuous encryption. Consolidates banking, investment and alternative assets in real time, offers customised analytical dashboards and on-demand report generation. Built-in algorithms perform data cleansing and enrichment, minimising manual work (Asora, 2024). The platform supports document tagging, transaction tracking and alerts, as well as mobile access. Although Asora does not claim to have separate AI modules, its automatic data cleansing and aggregation mechanisms use advanced algorithms to recognise formats and anomalies, improving reporting accuracy.

Continuation of table 1

Platform (developer)	Key features and functionality
EY Nexus (Ernst & Young)	*"We need to use more sophisticated technology platforms and automate more of our back-office functions."* – Founder, single family office (Campden Wealth, 2024). A scalable cloud platform for business transformation, created by EY for financial institutions and private wealth. Nexus integrates different systems (CRM, portfolio accounting, planning) through a single interoperable foundation, providing a 360° view of the client and all their assets. For family offices, this means the ability to consolidate disparate data (banking, investment, and administrative) into a shared space, simplifying the delivery of personalised recommendations and reports in real time. The platform includes modules for monitoring investment goals, end-to-end bi-directional data exchange between CRM and other applications, as well as product and service management, resulting in a significant reduction in time-to-market for new offerings. AI/ML in the EY Nexus ecosystem manifests itself through analytical components and partner solutions: the platform supports the connection of AI modules for customer behaviour analysis, data processing automation (e.g. NLP for text document analysis) and predictive modelling. However, Nexus's primary focus is on the flexible integration of different systems on a single digital foundation (EY, n.d.).
Asset Vantage (Asset Vantage Ltd.)	*"Asset Vantage offered the best combination of security, data integrity, and end-user capabilities at an affordable price."* – Tectonic Advisors (case study). A cloud-based wealth management platform created by a family office for the needs of family offices. It combines consolidated asset reporting (public and private investments, bank accounts, real estate, etc.) with an integrated accounting system (double-entry accounting, general ledger) in a single solution. It provides automated transaction reconciliation and supports multi-currency accounting for complex multi-tiered ownership structures (Asset Vantage, 2023). The platform provides flexible portfolio analysis tools that take into account financial metrics, risks, and performance indicators. Users highlight the platform's strong focus on data security and access control. Asset Vantage integrates artificial intelligence elements, including intelligent transaction matching and automatic reconciliation (matching intelligence), to accelerate the closing of financial transactions. The company is also experimenting with generative AI. In 2023, Asset Vantage announced a partnership with Alkymi to use the Alpha LLM model to search and analyse data in financial documents quickly. This allows, for example, questions to be asked of an extensive array of reports and answers to be returned with references to sources, enhancing analytics capabilities. In this way, Asset Vantage offers a combination of traditional robust accounting functionality and modern AI innovations to improve family office productivity.
Addepar (Addepar Inc.)	*"We can now translate fund performance into what it means for the individual."* – Chuck Lesem, Fremont Group. One of the most popular family wealth management platforms (Campden Wealth, 2024). Addepar provides a single view of all family office investment assets – from public securities to real estate, private equity, funds, collections and cryptocurrencies – with detailed disclosure of ownership structures. Key features include data aggregation from multiple accounts and systems, powerful portfolio analytics (return and volatility calculations, look-through to underlying assets), and flexible customisation of reports and dashboards to suit the needs of different family members or advisors. The platform is known for its high performance in processing large amounts of data and its convenient API for integration with other services (Addepar, 2024). In recent years, Addepar has been intensively implementing artificial intelligence and machine learning into its infrastructure. In 2025, the company acquired the start-up Arcus to integrate AI/ML into its platform further. The new capabilities are expected to include intelligent data management, automatic detection of anomalies in financial transactions, simplified data reconciliation, and predictive analytics to support investment decisions. According to management, Addepar aims to provide "adaptive intelligence" to users – that is, tools that learn from accumulated data and suggest optimal actions to family office analysts. In this way, Addepar simplifies the complexity of wealth management and is gradually evolving into a context-aware platform that supports family offices in an increasingly dynamic financial environment.

Continuation of table 1

Platform (developer)	Key features and functionality
Advent (Geneva®) (SS&C Advent)	*"Geneva has always been an exciting experience and [is a] user-friendly tool with modern-day needs."* – G2 review, 2025. Advent Geneva is a renowned investment accounting and bookkeeping platform that has been the industry standard for significant funds and family offices for many years. It provides real-time portfolio accounting and general ledger support for any asset class, multi-currency and complex ownership structures. For family offices, Geneva solves the challenges of accurate accounting for alternative investments, interest and dividend accruals, partnership management and fund management (LP/GP structures) – with automated distribution of income among beneficiaries and report generation for each participant (SS&C Advent, 2020). The current version of Geneva (following the acquisition of Advent by SS&C) is actively being enhanced with AI-based innovations. In particular, the Tamale RMS (Research Management System) module uses NLP and machine learning to automatically tag analysts' notes and files, saving them time. In addition, SS&C has implemented AI algorithms in data quality control tools. For example, the Lumis component in the Geneva environment uses ML to improve the quality and integrity of data entered into the system. SS&C Advent's management notes that its development strategy is that "every product must include an element of artificial intelligence" to improve customer efficiency. Thus, Advent Geneva, traditionally strong in accounting, is evolving by adding AI tools to automate routine tasks (e.g., document recognition, risk forecasting) to remain relevant to the needs of modern family offices in the digital age (SS&C, 2020).
Masttro (Masttro Inc.)	*"It's been incredibly useful to pull up the Consolidated Portfolio Analysis with our clients and use live benchmarks to evaluate investment manager performance."* – Saul Dyne, Stonebridge Family Office. Masttro positions itself as a "WealthData" platform built by family offices for family offices. It provides a global consolidated view of a family's net worth, covering all asset classes – from public securities to direct investments, real estate, collections and even liabilities – in a single interactive system (Masttro, 2025). The platform features a user-friendly interface and extensive options for visualising ownership structures (Wealth Map tool). It supports automatic data aggregation from banks, brokers and custodians around the world, normalising different formats and currencies. An important feature of Masttro is Document AI, an integrated machine learning module for processing alternative investment documents. With its help, the platform ingests PDF documents (capital calls, fund reports, distribution notices, etc.), recognises key data and automatically enters it into the system, significantly reducing the manual work of analysts. This allows family offices to track the results of private market investments promptly. In addition, Masttro is implementing AI to provide interactive analytical insights to clients. For example, users can compare the performance of several banks or funds in a portfolio, identifying where the portfolio outperforms the market and where it lags. As users note, Masttro allows them to "get everything in one platform," consolidating scattered international data regardless of jurisdiction or company structure. Data encryption and flexible access settings ensure privacy and security, critical aspects for UHNW clients.
Canoe (Canoe Intelligence)	*"By leveraging an integrated solution with complete flexibility, our team spends less time with operational duties surrounding alternative investments and more time supporting our advisors in building their business."* – Matthew Woodward, AdvicePeriod. Canoe Intelligence specialises in automating alternative investment workflows using AI. The Canoe platform uses machine learning to automatically collect, recognise and organise data from unstructured documents related to private markets (e.g. fund reports, capital calls, communications from investment managers). The system connects to investor portals and email, automatically downloading PDF documents, after which ML algorithms classify the documents by type, extract key metrics (contribution amounts, valuations, etc.), verify the data, and upload structured information to an internal database or third-party family office systems. This eliminates the need for manual entry of numerous metrics and reduces operating costs. According to Canoe, implementing their platform allows them to process 20 times more stock documents per employee compared to the manual process. The platform integrates with systems such as Addepar and Black Diamond for seamless uploading of cleaned alternative data directly into the overall portfolio report. Leading firms are already using it: many of the world's most prominent family offices (including Blackstone's private equity funds and others) are Canoe customers. In 2024, Canoe announced $36 million in funding from Goldman Sachs to develop its proprietary AI technologies further and expand globally. This underscores the market's confidence that Canoe's AI solves the pain points of family offices – namely, the slow and labour-intensive data processing of alternative investments – by transforming them into fast, scalable workflows.

Continuation of table 1

Platform (developer)	Key features and functionality
Black Diamond® Wealth Platform (SS&C Advent)	*"We've long relied on ... Black Diamond ... to serve clients more efficiently and intelligently."* – Doug Turner, Diversified Trust. Black Diamond Wealth Platform is a modern cloud-based wealth management platform from SS&C Advent, designed to meet the needs of wealthy families and their financial advisors. It offers a fully integrated, all-in-one solution for family offices: consolidated portfolio accounting and reporting, data aggregation from multiple financial institutions, a built-in accounting and billing system, and a convenient client portal. Black Diamond supports the tracking of complex multi-asset portfolios, providing tools for rebalancing, cash flow management, billing and expense control. The platform has an open API architecture, which allows it to be integrated with other systems (CRM, planning, etc.) – for example, with Salentica CRM solutions and others from SS&C – to create a comprehensive technology stack (SS&C, 2025). The latest versions of Black Diamond feature the Black Diamond CRM module, which simplifies the work of advisors by automating customer interaction tracking and business processes (workflow). Although the platform's own AI capabilities are currently limited to analytical dashboards, the SS&C ecosystem integrates external AI solutions into Black Diamond. A notable example is the partnership with Canoe Intelligence: Black Diamond customers can automatically import alternative investment data processed by the Canoe AI platform. This significantly improves the efficiency of private asset management without manual input. Overall, Black Diamond serves as a central hub for family office operations, allowing employees to work in a single environment. As users emphasise, Black Diamond's advantage is its "deep integration, innovation and advisor-focused technology" (Diversified Trust, 2025), as confirmed by the recent unification of all SS&C wealth solutions under the Black Diamond Wealth Solutions brand.
Eton (AtlasFive) (Eton Solutions)	*"These AI-powered solutions will streamline family office operations and enhance risk management."* – Satyen Patel, Eton Solutions. AtlasFive® from Eton Solutions is a comprehensive ERP platform for family offices that combines more than 20 modules for family financial management (investment accounting, bookkeeping, reporting, document management, trusts, tax accounting, etc.) in a single environment. The main idea behind AtlasFive is "one source of truth": all data on family assets and liabilities is stored in a centralised database, ensuring consistency of information and eliminating duplication or human error (Eton Solutions, 2023). The platform is cloud-based and focused on high security (certification, encryption) given the sensitivity of UHNW clients' data. In its latest updates, Eton Solutions is betting on artificial intelligence as an integral part of its offering. In 2023, the company launched EtonAI™ , an integrated AI engine that leverages the capabilities of large language models (LLMs) to accelerate the work of the family office team. EtonAI allows employees to ask questions in natural language to the AtlasFive system (e.g., "What are the unrealised gains from private investments today?") and receive instant answers based on available data, significantly saving time on report preparation. Also presented is EtonGPT™ – a generative AI trained on internal family office data that can extract information from documents, fill in templates, and assist in the preparation of analytical notes (Eton Solutions, 2025). According to the company, the use of these AI tools can increase the productivity of a family office by 2-4 times (by automating routine tasks). AtlasFive, together with AI modules, provides proactive transaction monitoring (notifying of deviations), recommendations for cash flow optimisation and even preliminary analysis of investment opportunities based on specified criteria. This changes the operating model of a family office: less time is spent on data entry and report preparation, and more on strategic analysis and family interaction (Eton Solutions, 2025). Currently, the AtlasFive platform is used by over 700 families worldwide, managing approximately $936 billion in assets, demonstrating the growing demand for integrated AI-driven solutions in the family office industry.

End of table 1

Platform (developer)	Key features and functionality
Total Return (SS&C GlobeOp)	*"Total Return consolidates complex partnership accounting and portfolio reporting in one platform." – (user feedback).* Total Return is a time-tested back-office system designed for alternative investment funds and family offices. Developed by GlobeOp (now a division of SS&C), it offers a complete set of tools for investment accounting: real-time portfolio management, multi-currency general ledger, accounting for complex financial instruments (derivatives, multi-tiered ownership structures), as well as partnership accounting for fund structures with income distribution between participants (LP/GP). The system automates fund valuation (NAV), commission calculation, profit allocation and detailed reporting for each partner or beneficiary. Total Return's architecture is built on a single database, eliminating the need for reconciliation between different modules and reducing operational risks. For family offices, this means the ability to keep accounts for multiple entities (family, trusts, funds) in an integrated environment where all transactions are linked and reflected consistently. Although Total Return does not have explicit AI components in its classic implementation (the system was created back in the 2000s), SS&C is now adding RPA and ML-based automation elements to its solutions. In particular, SS&C's Intelligent Automation can be connected to Total Return to accelerate manual processes such as initial data entry or transaction reconciliation (SS&C, 2023). The main strength of Total Return is its reliability and proven functionality: the platform has been chosen by many family offices and hedge funds that require high accounting accuracy and the ability to customise it to their own methodologies (SourceForge, 2025). Thanks to its scalable architecture, Total Return can be deployed on local servers or in the cloud, giving offices flexibility in their choice of infrastructure. Overall, it is a workhorse for the back office that integrates with front-office analytical tools, providing a solid foundation for the digital transformation of family office financial operations.

Technological innovations are radically changing the way family offices operate, making them more efficient, transparent and flexible. As can be seen from an analysis of leading platforms, modern solutions offer an integrated approach: consolidation of all family financial data in a single digital space, automation of routine processes (from information gathering to report generation) and flexible adaptation to the specific needs of each family.

It is worth noting that an increasing number of providers are incorporating AI elements into their products, such as algorithms for detecting anomalies in transactions, cash flow forecasting, or even chatbots for responding to user queries.

An important part of this transformation is the introduction of artificial intelligence and machine learning. Although these AI features are still in their infancy, they point to the industry's evolution towards 'smart' family offices. Artificial intelligence modules in family office platforms are already performing tasks that previously required significant human resources: automatic reading and entry of data from financial documents (e.g., Canoe, Masttro), error and anomaly detection (Addepar, Advent), assisting in decision-making through predictive analytics, and even responding to user queries in a dialogue mode (Eton AtlasFive). Artificial intelligence expands the capabilities of the family office team, allowing it to focus on strategic capital management issues rather than technical data processing.

Thus, combining tools for financial reporting automation, portfolio analysis, and asset aggregation with artificial intelligence creates the foundation for transforming the family office's operating model, improving control, flexibility and customer service quality.

The choice of software depends on the size of the family office, its geographical location, the complexity of its needs and its budget.

Towards intelligent Family Offices: opportunities, barriers, and unmet needs.

Increased efficiency. When implemented wisely, digital technologies can dramatically improve the efficiency of family office operations. Automating routine tasks (data collection, reconciliation, reporting) frees up skilled staff time for more strategic work, such as investment analysis, searching for new opportunities, and working with the family. As noted, the savings can be measured in tens of person-hours per month. In addition to direct productivity gains, the quality of decisions improves: up-to-date consolidated data allows for faster, more informed decisions and avoids mistakes due to incomplete information. Equally important is the reduction of operational risks: digital systems reduce dependence on individuals and the 'human factor' ensure data backup and access control. This is especially critical for family offices with a small team, where the loss of a key employee or a mistake could have serious consequences.

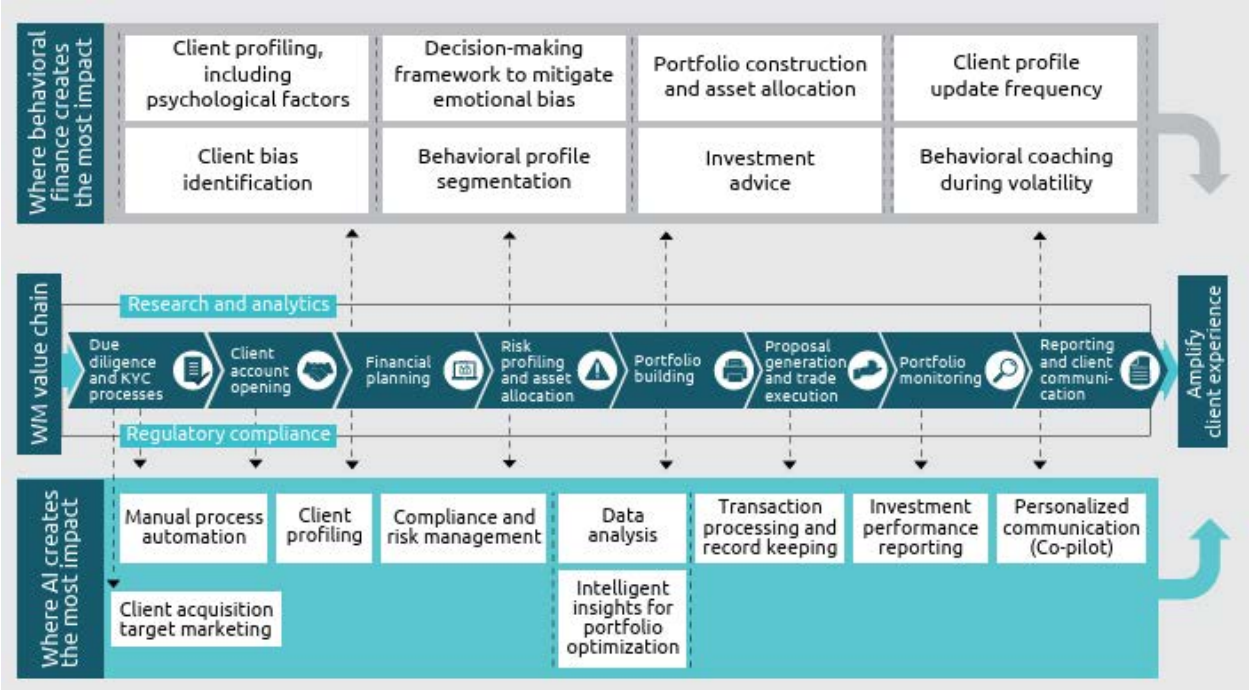

Figure 1
AI and Behavioural Finance Impact across the Wealth Management Value Chain

Source: Capgemini. (2024). *World Wealth Report 2024: Intelligent strategies for winning with the ultra-wealthy – Bridge wealth management and family office strengths to fuel growth*. Capgemini Research Institute. Retrieved from https://www.capgemini.com/insights/research-library/world-wealth-report-2024/

The framework proposed in the World Wealth Report 2024 (Capgemini, 2024) demonstrates how the combination of artificial intelligence (AI) and behavioural finance tools can transform key stages of the value chain in wealth management. This approach is structured on three levels, reflecting both the operational sequence and areas of potential technological impact.

The **core level** represents the traditional sequence of operations in wealth management, from due diligence and account opening to financial planning, risk profiling, portfolio construction, investment proposals, asset monitoring, reporting and client communication. This introductory level provides the logic of the process, on which technological interventions are superimposed.

The **top level** illustrates the stages where AI has the most significant impact. This primarily involves psychological profiling of clients, identification of behavioural biases, segmentation of cli-

ents according to their emotional and rational behaviour patterns, formulation of recommendations for decision-making and portfolio construction, as well as dynamic updating of client profiles and provision of personalised support during market turbulence. These tools enhance the customer experience by enabling the creation of highly accurate, contextualised solutions.

The **lower tier** demonstrates the added value provided by behavioural finance. Key areas include automation of manual operations, personalised customer targeting, compliance and risk management, data analytics and insight generation for investment portfolio optimisation. Communication tools also play an important role, particularly co-pilot-style interaction formats that encourage deeper customer involvement in the decision-making process.

Thus, the model outlines not only the technological but also the strategic potential of integrating AI and behavioural finance into family office practices, with an emphasis on personalisation, transparency, regulatory compliance and improved wealth management efficiency.

Cost and barriers to implementation. It should be acknowledged that the transition to new technologies is not without challenges. Responses from respondents in the aforementioned surveys indicate caution and apprehension among family offices regarding new solutions. This is partly due to security concerns (will confidential financial data be secure in the cloud?) and partly due to the lack of an 'ideal' product on the market designed specifically for the needs of family offices (Battaglia Trovato, 2025). Many platforms were initially designed for other target audiences (banks, funds) and only adapted for family offices, so users encountered fragmented functions, complex configuration, and slow onboarding (Battaglia Trovato, 2025). However, the situation is changing: new start-ups (such as Asora, Landytech, etc.) are entering the market with a focus on family offices, and large players (EY, Northern Trust, BNY Mellon) are building or offering entire ecosystems for their UHNW clients.

Financial considerations are also holding some offices back: the cost of implementing a comprehensive platform can be significant, especially for smaller single-family offices. In addition to licence fees, the costs of data migration, staff training and possible customisation must be taken into account. This is where platform-as-a-service models and the gradual introduction of modules come in handy, as well as the cost-effectiveness of scaling: multi-family offices can spread the costs across many families. It should be noted that technology costs are increasingly seen as an investment rather than an expense: preserving wealth across generations requires institutionalising processes, and technology is an integral part of this process. As one expert figuratively put it, 'digitisation is the glue that binds the wealth of different generations together,' without which the modern family office will be unable to survive generational change or withstand the challenges of the times (Battaglia Trovato, 2025).

The impact of AI and analytics. The role of artificial intelligence and machine learning deserves separate discussion. Although the actual use of AI by family offices is still limited (as we have seen, 10–12% are actively trying these solutions (Gooch, 2024) (Stover, Fankhauser & McKibbin, 2024)), the prospects look promising. Shortly, the most valuable solutions will be those based on 'narrow AI': algorithms for predicting financial indicators, systems for detecting anomalous transactions or fraud, and intelligent compliance assistants (e.g., monitoring compliance with regulatory requirements and sanctions lists for counterparties). In addition, there is growing interest in the use of generative AI for processing text information: family offices are drowning in streams of analytical reports, news, legal documents, and here AI assistants can take on preliminary analysis, summary preparation, or even the drafting of reports for clients. As noted in a Morgan Stanley study, there are already tools that use AI to read financial reports and automatically update portfolio data, saving analysts time (Morgan Stanley, 2025). Such capabilities are still viewed with caution, but the positive experience of early adopters (such as the CIO of a Florida family office, who noted significant time savings thanks to AI reporting tools (Asseta HQ, 2024)) will encourage wider adoption.

It is also important to emphasise that automation does not replace the human factor, but enhances it. Family offices are not just about numbers, but also about trust, family values and a personalised

approach. Therefore, technological transformation must be balanced: routine processes are automated, but the family continues to receive personalised service and attention. According to experts, the successful offices of the future will be those that manage to combine technological innovation with human expertise in reporting (Asseta HQ, 2024). The family office environment will not promote the maximum replacement of people by machines, but rather an increase in the 'intelligence quotient' of each employee through AI-based tools. For example, young professionals will be able to learn and make decisions faster with AI-generated analytics at their fingertips. At the same time, managers will be able to focus on strategic issues by relying on automated alerts about deviations or opportunities.

Unfilled niches and opportunities for innovation. Based on the analysis, several areas can be identified where demand from family offices exceeds current market supply (i.e., there are niches for the development of innovative services):

– *Automated information monitoring* – from financial news to legal changes that may affect family assets. Currently, offices rely on manual news reviews or third-party advisors; AI systems could monitor relevant events 24/7 and send alerts (especially important for risk management and reputation protection).

– *ESG data and planning* – as mentioned, tools for assessing the impact of investments on the environment and society. Possibilities include automatic compilation of an ESG profile for the portfolio, tracking the carbon footprint, checking companies for compliance with sustainability criteria, and generating proposals for improving the ESG performance of the portfolio.

– *Integration with family business systems* – further development of CRM/ERP integration ideas. For example, suppose a family owns an operating business. In that case, the family office can receive key business metrics (EBITDA, cash flows) in real time in its wealth management system to make decisions with this context in mind.

– *Personalised learning and generational continuity* – digital platforms for educating the next generation of family members in financial literacy, family business history and values. Some offices are already experimenting with private 'family portals' or even interactive social media-style learning modules (Battaglia Trovato, 2025). This is a promising niche at the intersection of technology and the soft skills required by family offices.

– *Cybersecurity and privacy* – given the growth of cyber threats, solutions tailored to family offices (e.g., darknet monitoring for family data leaks, secure messengers for intra-family communication, etc.) have great potential. Surveys show that information security has become a top priority alongside investment risks (Stover, Fankhauser & McKibbin, 2024), so innovative offerings are also to be expected here.

Conclusions. Digital technologies, including AI and ML, are playing an increasingly crucial role in improving the efficiency of family offices. Global research for 2024–2025 confirms that most family offices have recognised the need for digital transformation and are actively investing in technology to catch up (Gooch, 2024). The implementation of modern platforms is already yielding tangible results: reduced operational complexity, faster access to consolidated information, improved risk control and regulatory compliance. Although the penetration rate of AI/ML is still low, the first cases demonstrate their usefulness in specialised tasks, from reporting automation to investment analysis (Asseta HQ, 2024). Shortly, we can expect to see more rapid growth in the use of AI solutions in family offices as the technology matures and competition drives innovation. At the same time, it is important to emphasise that digitalisation is not an end in itself, but a tool: its success is measured by how well it helps to preserve and grow family capital, ensure generational continuity and flexibility in the face of new challenges.

The promise of AI/ML solutions is directly supported by market demand. As the study showed, family offices themselves point to problem areas (excessive manual work, lack of analytics, risks without IT) and are ready to invest in solving them. Some technologies – cloud services, mobile

platforms, basic analytics – have already become standard in the industry (Gooch, 2024). The next wave is likely to be associated with the spread of more 'advanced' solutions: AI algorithms that act as 'digital employees' of the family office, as well as ecosystem platforms that connect various aspects of wealth management (investments, business finance, family education, philanthropy). The outlook for technology providers is also attractive: the family office market is growing as new wealth emerges and existing dynasties branch out, so demand for innovative B2B solutions in this segment will increase.

The integration of personalised AI-based strategies into capital management is transforming the financial advisory paradigm. The implementation of such solutions not only increases customer satisfaction but also contributes to the growth of assets under management and improved customer engagement. Effective implementation of these approaches requires a balance between algorithmic efficiency and interpersonal interaction, data transparency, proper change management, and consultant training. Further technological developments, including federated learning and quantum computing, are opening up new opportunities for scaling personalisation, especially in segments with insufficient coverage by traditional financial services. AI-driven personalisation is thus becoming a key competitive advantage, enabling deeper customer engagement, improving service efficiency and adapting to changing expectations for financial support (Bandi, 2025).

In summary, a modern family office that wants to 'survive and thrive' in the 21st century must evolve into a technologically savvy, flexible organisation. This means investing not only in stocks and bonds but also in digital infrastructure and intelligent systems that will become the foundation for successful family capital management for generations to come.

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TOKENIZATION OF REAL-WORLD ASSETS (RWA): A BRIDGE BETWEEN TRADITIONAL FINANCE AND BLOCKCHAIN

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Abstract. This article explores the phenomenon of tokenization of real world assets (RWAs) as a key trend in the development of the modern financial ecosystem. The mechanisms of transforming physical and financial assets into digital tokens on the blockchain are analyzed, the advantages and risks of this approach are considered, and up-to-date data on the growth of the RWA market are presented. Research indicates that the market for tokenized assets is demonstrating exponential growth, having reached USD 176 billion in 2024, with projections estimating an increase to USD 16 trillion by 2030 [1,2].

Key words: real world assets (RWAs), tokenization, blockchain, decentralized finance (DeFi), digital assets, smart contracts, CBDC, GovTech.

Introduction. Tokenization of real world assets (RWAs) is the process of converting physical or financial assets (such as real estate, bonds, or gold) into digital tokens on the blockchain, enabling the creation of a digital representation of a real asset while preserving its economic value.

Each such token represents ownership rights or a share in the underlying asset and can freely circulate within the digital ecosystem. Tokenization enables the transfer of traditional investment instruments into the Web3 infrastructure, providing transparency and automation. RWAs connect two worlds – the classical financial sector and decentralized technologies [3].

This area became especially relevant in 2023–2024, when leading institutional players began actively exploring and implementing tokenization models. Companies such as BlackRock, Franklin Templeton, and Société Générale became pioneers in the field of digital bonds and tokenized funds [4].

Moreover, regulators have begun to establish a legal framework for tokenized assets, recognizing their real value and legal validity.

With the growing interest in RWAs from DeFi platforms such as MakerDAO, Aave, and Ondo Finance, this approach is becoming one of the most promising directions in the development of the financial industry, enabling the convergence of traditional finance (TradFi) and decentralized finance (DeFi).

As a result, new models of collateral, lending, and liquidity based on real world assets have emerged. This opens access to investments for millions of users, including those who previously had no opportunity to participate in equity or debt markets. Financial inclusion is becoming a reality thanks to the ability to invest even small amounts in tokenized real estate, bonds, or commodities.

This also lowers entry barriers for startups, small businesses, and emerging economies that previously found it difficult to attract capital. For investors, RWAs represent a more stable and secure form of investment compared to volatile crypto assets. At the same time, they retain all the advantages of blockchain technology: transparency, automation, and the absence of intermediaries.

The relevance of RWAs research is driven by the rapid growth of interest from institutional investors, major banks, and regulatory bodies. According to data from the Tokenized Asset Coalition, the total value locked in tokenized assets reached USD 176 billion in 2024, representing a 32% increase compared to the previous year [1].

The aim of this article is to provide a comprehensive analysis of the current state of the RWA market, identifying key trends and prospects for the development of tokenization as a tool for transforming the financial landscape.

It is important to understand that RWAs are not a temporary trend but a fundamental direction in the development of digital finance. Through this solution, the real integration of the crypto economy into the global financial system takes place. For banks, funds, and institutional investors, RWAs become the entry point into Web3. For blockchain communities, they represent an opportunity to move beyond speculation and approach practical applications of technology in the economy [5].

Basic theoretical and practical provision. The concept of tokenization of real world assets (RWAs) began to be actively discussed within the crypto community starting in 2017, riding the wave of interest in Initial Coin Offerings (ICOs) and the possibilities of smart contracts. The first experiments with tokenization of RWAs took place between 2017 and 2020, when pilot projects emerged in the fields of real estate, art, and commodities. Among the early projects were platforms such as RealT (real estate tokenization in the USA) and Maecenas (art). These initiatives demonstrated that ownership rights could be transferred via blockchain, but also revealed numerous legal and technical limitations. Since 2019, a noticeable shift toward the institutionalization of RWAs has occurred [6].

Financial companies began experimenting with tokenized securities, especially in the bond sector. In 2020, the French bank Société Générale became one of the first to issue a tokenized bond on the Ethereum platform [7].

This became an important precedent for the legitimization of such instruments. In parallel, attempts began within the DeFi environment to use tokenized assets as collateral. MakerDAO, for example, started considering the acceptance of RWAs to back its stablecoin, DAI. This move demonstrated that DeFi can interact with the traditional economy on a profound level. Since 2022, there has been growing interest in the tokenization of government debt – particularly U.S. Treasury bonds. Franklin Templeton and BlackRock have begun developing and testing funds in which shares are represented as tokens. This has turned RWA tokenization from a mere technical experiment into part of the infrastructural solutions on Wall Street [8].

In 2023, BlackRock invested in projects developing tokenized ETFs backed by real assets. This sent a strong signal to the market: RWAs are not only an innovative component but also an institutional one from a strategic perspective.

In 2023, the Centrifuge initiative emerged, combining tokenized invoices, loans, and inventories with DeFi. Projects such as Goldfinch and Maple began providing loans backed by real assets. The term “DeFi 2.0” appeared, referring to integration with the real economy through RWAs. Tokenization became a way to increase liquidity for businesses that had previously faced difficulties in raising capital.

In 2024, the market volume of tokenized bonds and assets exceeded USD 6 billion, according to data from Galaxy Digital. Government regulators began developing frameworks for Security Token Offerings (STOs) and the recognition of digital rights.

2024 became a turning point for the RWA industry. Key development indicators [1, 9, 10, 11]:

1. total market volume: USD 176 billion (32% year-over-year growth);
2. growth of non-stablecoin assets: 53% in 2024;
3. number of RWA tokens: over 185 tokens with a total capitalization of USD 10.62 billion.

The launch of the BlackRock USD Institutional Digital Liquidity Fund (BUIDL) in March 2024 is of particular significance, as it attracted over USD 1 billion in assets under management within a short period, becoming the largest tokenized Treasury bond fund [12].

Initiatives are emerging from central banks and the IMF, viewing RWAs as a component of the future financial infrastructure. The infrastructure for working with tokenized assets has improved, with the emergence of custodial services, auditing, and legal frameworks. Marketplaces for tokenized assets have also begun to appear, such as Ondo Finance, Backed Finance, and OpenEden [13].

Many protocols have begun developing sub-DAOs or subsidiary structures to manage RWA products. Integration with real-world identity has also intensified – through KYC/AML, e-signatures, and notarial protocols. In DeFi, it has become common to see stable yields based on tokenized U.S. Treasuries. RWAs are no longer viewed as a niche topic and are increasingly seen as a strategic bridge between TradFi and Web3. The history of RWA tokenization is a journey from experimental ideas to the infrastructure of a new digital capital.

In evaluating the types of assets eligible for tokenization, the following key categories can be identified:

Real estate: includes residential, commercial properties, and infrastructure assets. Tokenization enables the fractionalization of high-value assets, making them accessible to a wider range of investors.

Digital tokens can represent shares of residential apartments, commercial properties, hotels, or warehouses. This allows investors to purchase a fraction of real estate for a relatively small amount, such as USD 100, making the market more accessible. Projects like RealT and Lofty.ai are already implementing this model, providing monthly rental income to token holders. Another important direction is collateralized commercial real estate, where properties serve as security for token issuance. This creates opportunities for lending to small and medium-sized enterprises.

Financial instruments: Treasury bonds, corporate bonds, loans, and equities. This category shows the most dynamic growth, especially in the segment of U.S. government bonds.

Tokenized bonds are being issued by major institutions such as Franklin Templeton and Société Générale [13,14]. This enables investors to access a faster, more transparent, and more efficient version of traditional securities. Loan tokenization is employed by platforms such as Centrifuge and Goldfinch, where companies gain liquidity and investors receive yields [15].

Commodities: Gold, oil, agricultural products. Tokenization of commodities enables more efficient pricing and trading.

Tokens can represent one ounce of gold or one barrel of oil, as well as volumes of investment-grade wine or whiskey stored in certified warehouses. This allows participation in commodity markets without logistical complications. Examples of such solutions include Paxos Gold (PAXG), Tether Gold (XAUT), and tokens issued by Digix.

Intellectual property and artworks: NFT tokenization of works of art, music, patents, and other intellectual property assets.

Many galleries and investors tokenize paintings, sculptures, and collectible items (books, watches, cars, and more). Each token represents a share of ownership or rights to income from future sales. This lowers the entry barrier to elite investment segments and increases liquidity. Platforms such as Maecenas and Particle are opening the contemporary art market to a wider audience.

Infrastructure assets: energy facilities, transportation infrastructure, and utilities.

Investors can finance the development of physical supply systems or utility infrastructure. This is particularly relevant for emerging economies and ESG projects. For example, the Energy Web Token project enables tokenization of participation in energy markets [16]. Tokenization of equipment, machinery, and vehicles is also possible, with options for subsequent leasing or resale. There is a growing practice of issuing tokens backed by these assets, transforming them into sources of liquidity for businesses.

Thus, RWA tokenization covers almost the entire spectrum of assets: from securities to energy solutions (such as solar panels) and museum exhibits. This technological flexibility makes the technology relevant and scalable for both institutional and retail investors.

Aspects of the synergy between RWAs, central bank digital currencies (CBDCs), and the development of digital governance solutions (GovTech) require detailed study, but it is impossible to overlook the promising prospects of such interconnection. Potentially, these are the drivers of a revolutionary transformation of the existing public administration architecture.

This represents an opportunity for modernization and, importantly, for overcoming issues such as corruption through the implementation of proper and transparent managerial actions:

1. creation of transparent digital registries of state-owned property;
2. development of national blockchain infrastructures for managing digital property rights;
3. simplification of privatization (or leasing) procedures with increased levels of oversight;
4. automation of public procurement and contracts through smart contracts with digital monitoring of execution and compliance with established requirements;
5. implementation of eID (digital identity) as a mechanism for verifying ownership rights and participation in governance voting of tokenized assets;
6. possibility of involving investors in government-established funds (e.g., tokenized shares in state assets), where CBDCs are used as a means of payment, and the active portion of the portfolio is implemented in the form of RWAs.

It is expected that such a model, combined with an adequate system of public education, will significantly increase public trust in institutional structures and stimulate domestic investments.

Integration of RWA and CBDC solutions into government digital platforms will strengthen the digital sovereignty of the state and have a positive impact on the macroeconomy:

1. enhancement of monetary policy through direct digital transfers;
2. creation of tokenized "green" ESG bonds and investment mechanisms for sustainable development;
3. growth of domestic liquidity and capital accessibility, including with control mechanisms such as "conditional funding," where access to funds is granted only upon strict fulfillment of specific conditions encoded in smart contracts.

To analyze aspects of practical application of RWAs, it is necessary to examine the tokenization mechanism.

Tokenization is the process of converting a real asset into a digital token on the blockchain, while maintaining the legal and economic connection to the original asset.

The tokenization mechanism of RWAs includes the following key stages:

1. identification and valuation of the asset: determining the asset's value and legal status;
2. creation of a legal structure: establishing a Special Purpose Vehicle (SPV) to ensure the legal connection between a token and an asset;
3. token issuance: creation of digital tokens using smart contracts;
4. blockchain registration: recording ownership rights in the distributed ledger;
5. trading and management: enabling a secondary market and managing the asset.

The key participants in the ecosystem are:

1. custodians: ensure the secure storage of assets and their digital representations. They play a critical role in maintaining trust in tokenized assets;
2. oracles: provide reliable information about asset prices and conditions in the external world for smart contracts;
3. tokenization platforms: Centrifuge, Mantra, Ondo Finance, Tokeny, Securitize – provide the technological infrastructure for the creation and management of tokenized assets.

Tokens are issued on the selected blockchain platform – which may be Ethereum, Polygon, or Avalanche.

Tokens are encoded in a smart contract with conditions for ownership, transfer, and yield distribution. Each step is verified by ecosystem participants such as custodians (asset holders), oracles

(data providers), legal partners, and smart contract developers. Investors purchase tokens through the platform, gaining access to the real asset in digital form.

Smart contracts are essential for secure operations: they automatically distribute income, block transactions if conditions are not met, and record ownership rights. Oracles connect data from the external world – such as prices, revenues, and collateral status – and transmit it to the blockchain. For example, if a token represents real estate, an oracle may provide information about the property's value based on appraiser data [17].

All of this ensures transparency, automation, and trust throughout the process. Platforms such as Centrifuge employ decentralized procedures to connect real assets to DeFi. Ondo Finance focuses on the tokenization of bonds and corporate instruments, collaborating with institutional investors [18].

The tokenization process requires compliance with regulatory requirements, especially when issuing security tokens. Mechanisms such as whitelists and trading restrictions for non-qualified investors may be applied. The legal framework can vary by jurisdiction – MiCA is actively developing in Europe, while SEC regulations apply in the United States. It is important that token holders have clear rights, including redemption, income, or voting rights [19].

Overall, the tokenization mechanism is a coordinated interplay of technology, law, and finance. It paves the way for the creation of a global, 24/7, barrier-free investment space. More advanced formats are to be expected, including fractional tokenization with flexible governance, automatic asset inheritance, and multi-chain accounting.

The current practical application of RWAs significantly changes how people invest in, buy, sell, and manage assets. One of the key advantages is ownership fragmentation, meaning the ability to divide an expensive asset into small digital shares. For example, if a house is valued at USD 500,000, it can be divided into 5,000 tokens worth USD 100 each: anyone can become a "fractional investor." This opens the door to real estate, art, or securities markets for students, freelancers, and residents of countries with limited investment access.

Tokens enable peer-to-peer buying and selling of assets directly between participants, without banks, brokers, or notaries. Smart contracts automatically execute transaction conditions: transfers, income distribution, and ownership transfers. This reduces costs and speeds up operations – transactions that previously took weeks now take minutes.

Successful practical examples include implemented projects that fully leverage the advantages of technologies embedded in RWAs:

1. a platform where one can purchase a share of luxury real estate for USD 100 and receive rental income. All documents are stored on the blockchain, and rental payments are made automatically once a month;

2. implementation of factoring functionality using tokenization of accounts receivable: small businesses issue tokens backed by unpaid invoices and receive liquidity from investors. Investors, in turn, earn interest when the client pays the invoice.

Such models are applied in agriculture (tokens for future harvests), energy (solar panels), equipment (leased machinery), and even education (prepaid courses).

For companies, this is a way to raise capital faster without traditional lending. For investors, it opens access to new types of income previously unavailable.

Tokenization is useful for asset management–for example, through DAO infrastructure, where token holders vote on building repairs, rent changes, and other important decisions. This makes investments not only more accessible but also more democratic. The system is transparent: everything is visible on the blockchain–who bought what, who voted on what, and when payments will be made.

Blockchain also simplifies auditing and regulatory compliance. Regulators can track the movement of funds and shares in real time, reducing the risks of money laundering and fraud.

Equally important is that tokens are easy to transfer or sell on the secondary market. If you have invested in a tokenized asset, you are not obligated to hold it for years–you can sell your share at any time.

Mass adoption of tokenization also promotes financial inclusion – meaning that more people in developing countries will gain access to global financial markets.

Even educational institutions can issue tokens backed by future income streams or tuition payments, forming a type of informational "social card" about students. A pilot project is being actively implemented at V. N. Karazin Kharkiv National University, and similar initiatives are underway in South Korea (company Letitu), with positive outcomes expected. In African countries, startups are emerging where farmers tokenize their harvests, and students can purchase "education tokens" that pay off after gaining employment.

Thus, RWA tokenization is not just a trend but a powerful tool for transforming the entire economic model–from traditional investments to crowdfunding, microfinancing, and social entrepreneurship.

All of the above allows for a systematic analysis of the potential risks associated with the technology under study.

One of the main advantages of real asset tokenization is increased liquidity. Thus, tokenization of traditionally illiquid assets provides:

1. ownership fragmentation: the ability to purchase shares in high-value assets;
2. 24/7 trading: global markets without time restrictions;
3. reduced spreads: more efficient price discovery.

Lowering entry barriers: this aspect can be characterized as a form of investment democratization:

1. minimum investments: the ability to invest from USD 100 in real estate;
2. geographic accessibility: investments in assets worldwide;
3. simplified procedures: automation through smart contracts.

Thanks to fragmentation, people can invest even with USD 10 or USD 100, without waiting to accumulate large capital. This is especially important for young people, students, and residents of developing countries. Investing becomes not a luxury but a real opportunity for everyone.

Transparency of RWAs is a significant step forward compared to the traditional system and can be considered a factor of operational efficiency:

1. transparency: all information is available in the distributed ledger;
2. cost reduction: elimination of intermediaries in various processes;
3. transaction speed: instant transactions instead of multi-day procedures.

All data on assets, transactions, and rights are recorded on the blockchain and accessible at any time. This helps prevent double sales, fraud, and "dark zones" in reporting. Platforms can publish ownership registries, yield schedules, and payment timetables – all verifiable.

Additionally, tokenized assets can interact with DeFi protocols. For example, a real estate token can be used as collateral in DeFi to obtain a loan or participate in yield farming. This makes assets more flexible: you not only own them but can also leverage them within the digital economy.

The possibility of passive income arises: many platforms allow staking of RWA tokens to earn interest income, akin to the concept of traditional deposit placements. This can include rent, dividends, interest on debt tokens, etc. Thus, tokens transform a passive asset (for example, a building) into working capital.

Finally, interoperability is a key feature. Tokens can be used across different blockchains (via bridges), in various applications, and are easily integrated into the DeFi ecosystem. This opens up new use cases – from automated refinancing to insurance of tokenized assets.

Despite its clear advantages, the market for tokenized RWAs faces a number of serious challenges – risks. One of the key issues is regulatory uncertainty.

The main regulatory challenges include:

1. uncertainty of legal status: differences in regulatory approaches across jurisdictions;
2. compliance requirements: the need to adhere to financial regulations;
3. taxation: challenges in determining the tax status of tokenized assets.

In many countries, there is no clear legislation defining the status of RWA tokens, especially when they represent shares in physical assets. The lack of a unified legal framework limits scalability and deters institutional investors.

One of the most significant risks is the risk of legal recognition (or non-recognition) of ownership. In some jurisdictions, a token representing real estate or a bond is not considered valid proof of ownership. This can lead to problems in court or in disputes between parties. There is currently no synchronization between on-chain data and offline property registries [20].

Technical vulnerabilities also pose a significant threat; such risks include:

1. smart contract security: risks of hacking attacks and coding errors;
2. dependence on oracles: issues with the reliability of external data;
3. scalability: limitations of blockchain throughput.

Smart contracts governing tokens may contain bugs or be vulnerable to hacks. There have been cases in DeFi history where hackers exploited vulnerabilities to steal hundreds of millions of dollars. Additionally, there are risks of infrastructure failures, especially when using new or unstable blockchains.

Operational risks should also be highlighted:

1. custodial risks: issues related to the storage and management of assets;
2. over-collateralization: the need for excessive collateral backing;
3. secondary market liquidity: risks of low trading activity.

Some platforms use over-collateralization (e.g., collateral at 150%), which reduces capital efficiency. Others hold real assets through custodial intermediaries, who must be trusted – thus, some decentralization is lost. If a custodian turns out to be dishonest or is subjected to sanctions, token holders may lose access to the underlying collateral.

It is also important to consider the insufficient liquidity of some tokens, especially in "young" projects. An investor may not find a buyer when wanting to exit a position. This is particularly critical in cases of force majeure – liquidity may vanish precisely when it is needed most.

Finally, insufficient platform transparency (e.g., hidden terms, unaudited reserves) can lead to a loss of trust. That is why choosing the right infrastructure and conducting thorough project audits are crucial steps before investing in RWAs.

Tokenization of RWAs holds immense potential to transform the global financial system. One of the key development directions will be integration with central bank digital currencies (CBDCs). This will link traditional financial systems with blockchain infrastructure, ensuring more reliable settlements and regulatory compliance. For example, using e-CNY or the digital euro for transactions involving tokenized bonds will enhance trust in RWAs.

According to a report by Boston Consulting Group, the market volume of tokenized assets could grow from USD 3 billion in 2023 to USD 16 trillion by 2030 [2]. This growth is driven by interest from banks, investment funds, and technology startups, as well as increased transparency of blockchain solutions. Tokenization helps to "digitize" traditional instruments and make them accessible to a global audience. This creates the foundation for a new financial architecture – fast, open, and accessible.

Special attention is given to sustainable financing. The tokenization of “green” bonds, investments in climate projects, and environmental infrastructure is already being tested in the EU and the UAE. Platforms such as Flowcarbon and Toucan Protocol enable real-time tracking of the origin and movement of environmental assets. Thus, blockchain can enhance efficiency and transparency in addressing climate risks [13].

Developing countries can also reap significant benefits. Through DeFi and tokenized instruments, access to capital can be provided to those previously excluded from the traditional banking sector. For example, a farmer in Africa can pledge future harvests as digital assets and receive financing. This promotes financial inclusion and supports the development of the local economy.

In the long term, RWAs could serve as a bridge between digital and traditional finance, replacing some outdated infrastructures. The development of digital identities, property rights, and smart contracts will strengthen blockchain's role as the foundation of global financial accounting. Institutional players such as BlackRock, JPMorgan, and HSBC are already launching pilot projects, signaling a large-scale transformation. Thus, asset tokenization is not just a trend but a fundamental shift in how we perceive money, ownership, and investments.

Conclusion. Tokenization of real world assets (RWAs) represents a paradigmatic shift in the financial industry, creating a bridge between traditional and decentralized finance. Analysis of the current market status shows that RWAs are moving from the experimental stage to large-scale commercial application:

1. growth scale: the tokenized assets market demonstrates sustained exponential growth, reaching USD 176 billion in 2024;
2. institutional adoption: involvement of major financial institutions, such as BlackRock, confirms the technology's maturity and the market's readiness for widespread implementation;
3. technological readiness: the development of blockchain infrastructure and smart contracts provides a reliable foundation for the tokenization of various asset types.

Thanks to RWAs, investors gain access to new asset classes previously available only to major players. For example, purchasing a share in luxury real estate or government bonds has become possible even with a small capital.

This paves the way for the democratization of finance – where everyone can participate in global investment flows. Additionally, tokenization makes traditional assets more liquid and transparent. Data on transactions, ownership rights, and fund movements are recorded on the blockchain and are immutable. This enhances trust from both private investors and institutional players.

However, the potential of RWAs can only be realized through coordinated efforts among technologists, legal experts, and governments. It is essential to establish a unified regulatory framework, recognize tokens as property rights, and implement standards for digital identification. Many countries have already begun this process: legal frameworks for tokenized assets are being developed in the UAE, Singapore, and the EU. The success of RWAs depends not only on technology but also on the ability to adapt legislation and transform financial habits.

It is important to understand that RWAs are not merely a trend but a new infrastructure of the global economy. They enable faster settlements, reduced costs, and expanded investment horizons. Companies will be able to raise capital more quickly and cheaply, while users can interact with assets without intermediaries. The emergence of hybrid platforms combining DeFi and CeFi will mark the next stage of development.

The technology has already proven its viability; now, scaling is necessary. In the coming years, we will see an increasing number of real-world cases – from tokenization of real estate to issuance of digital bonds by governments. At the same time, it is crucial to maintain a balance between innovation and investor protection. This requires transparent regulations, auditing, cybersecurity, and educational initiatives.

RWA have already begun reshaping the market structure. Traditional banks are becoming not only consumers but also integrators of blockchain solutions. New financial players are building services at the intersection of Web3, FinTech, and traditional capital. These processes are forming a new era of finance, where blockchain ceases to be a buzzword and becomes a fundamental part of the infrastructure.

Synergy between RWA, CBDC, and GovTech will enable, in essence, a revolutionary transformation in the form of a transition from fragmented digital initiatives to a comprehensive digital governance system, within which:

1. government assets gain liquidity and high transparency;

2. budgets become programmable and controllable;

3. citizens of the state gain access to investments in public assets, as well as to mechanisms for managing them.

For the further development of the RWA ecosystem, constructive dialogue between technology companies, traditional financial institutions, legal experts, and regulators is essential. Only by establishing clear legal frameworks and technological standards can the tokenization of RWAs fully realize its potential to transform the global financial system.

The future of RWA lies in creating a hybrid financial ecosystem where traditional assets gain the advantages of blockchain technology, and decentralized finance is enriched by real economic value. This opens new opportunities for investors, issuers, and the entire financial industry, fostering the development of a more efficient, accessible, and transparent financial market as well as a government governance model (GovTech).

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UKRAINE' DEBT AND COUNTRY IMMINENT ECONOMIC DEVELOPMENT

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Abstract. Ukraine extraordinary tasks are: insuring country economic growth, stimulating the economy & fostering growth with respect to following inevitable challenges such as: damages of physical infrastructure like roads, bridges, buildings, and factories, disrupted production, transportation, and basic services; human capital loss – decrease of workforce and innovation potential; financial draining - reconstruction requires significant funding; social and political instability - aggravated social tensions and political instability; obstructed long-term planning and investing. At the same time country ought to search for prospects such as: after war resilient demand for goods/services, stimulating production and job creation; using latest advances in construction, technology, and infrastructure development; rebuilding ties with international community for financial and technical assistance; insure market growth that attracts foreign and local investments including debt financing.

Key words: Group of Creditors of Ukraine (GCU), Global law firm White & Case, Extended Fund Facility (EFF), Debt financing, GDP (Gross Domestic Product), Gross External Debt (GED), Foreign Exchange Reserves (GER), GDP per capita, Debt Per Capita, Ukraine GDP per capita PPP (Purchasing Power Parity), Ukrainian human capital, National Academy of Science, WB (World Bank), IMF (International Monetary Fund), Fitch Rating Agency, S&P Rating Agency BlackRock, JPMorgan, Ukravtodor.

Introduction. Undertaken study is dedicated to future of Ukraine subject – using debt to build new national economy as a result received damages and losses during Russian war against Ukraine and present rationality for economic expansion, as well as range of direct agents responsible for further economic growth. Research structured in four consecutive and logically detected each other blocks aimed to define state of Ukrainian debt, clarify current cumulative war damage; explicate who is crediting debt, who is in charge with funds distribution among recipients, and who are recipients; outline who is responsible for paying accrued debt obligations, collecting and disseminating funds, current state of county budget; determine responsibilities of public and private sector' for postwar economic growth; detail one of the possible investment strategies for high risk business environment and coverages of those risks.

BASIC THEORETICAL AND PRACTICAL PROVISION

Purpose of the Article. To perform qualified research on mentioned subject (using debt for country economic growth) with respect to a fit object (Ukraine). Having a sense of that purpose, develop comprehensive professional as well as scholar knowledge, based on existed and personal judgements for that matter, provide gathered information, and sources of works. Methodology statement. Set of allied intellectual enquiry methods for quantitative research, data gathering with use of data extraction, data analysis, case studies; qualitative & factual research - historical analogies, comparative dynamic, ethnographical, cultural absolute and relative business advances. Literature review and output conditions. Criterions for accuracy, reliability, authority, objectivity, fairness and coverage for evaluating information from given information sources part "references".

RESEARCH RESULTS AND THEIR EVALUATION

1. appraisal of Ukrainian debt

That's true to say contemporary turn point for Ukrainian State was summer'24 when Group of Creditors of Ukraine (GCU) welcomed the agreement in principle reached between Ukraine and its bondholders on Eurobond Debt Restructuring Terms (1 U.S. Department of the Treasury, Press

Releases, Statement of the Group of Creditors of Ukraine 08.09. 2024) and following successful restructuring of US$20.5 billion of international bonds legally supported by Global law firm White & Case (adviser) (2 White & Case, Press Releases, White & Case advises Ukraine on successful restructuring of US$20.5 billion of international bonds, 06.06.2024). Shortly terms of the restructuring can be viewed as following:

– existing bonds of Ukraine and Ukravtodor were exchanged for four series of Step Up A bonds and four series of Step Up B bonds

– the Step-Up A bonds pay interest at rate of 1.75% beginning in February 2025, which gradually increases to 7.75% after 2034

– the Step Up B bonds pay interest at 3% starting in August 2027, which gradually increases to 7.75% after 2034

– the terms of two series of the Step Up B bonds, due 2035 and 2036, also include a feature providing for upward adjustments to the principal amount of each series on 1 February 2030, upon the satisfaction of certain conditions linked to the performance of Ukraine's nominal gross domestic product in 2028, measured against the IMF projected nominal gross domestic product for 2028 and with a further control variable relating to the performance of Ukraine's gross domestic product at constant prices for 2028

– upward adjustment, which would be triggered if Ukraine's economy outperforms IMF expectations, would permit bondholders to recoup up to 12% of the principal haircut they provided in the restructuring.

So, bondholders reimbursement postponed structurally at the end of new agreement policy terms been coordinated and supported all stakeholders with further confirmation (3 White & Case, Ukraine concludes historic restructuring of US$20.5 billion of international bonds, 09.10.2024)

– by the IMF compatible with the debt sustainability objectives of Ukraine's $15.6 billion Extended Fund Facility (EFF).

– also endorsed by Ukraine's international partners in the Group of Creditors of Ukraine (Group of Creditors of Ukraine includes Canada, France, Germany, Japan, United Kingdom, and the United States of America. Observers to the Group include Australia, Austria, Belgium, Brazil, Denmark, Finland, Ireland, Israel, Italy, Korea, Netherlands, Norway, Spain, Sweden, and Switzerland), who will be providing their own debt relief not later than the end of the EFF programme period in 2027

– more than 97% of holders of Ukraine's and Ukravtodor's existing bonds participated in the exchange offer and consent solicitation, indicating the strong support of the private sector for Ukraine's efforts to restore macroeconomic stability

Scale of Ukrainian debt

Public and publicly guaranteed debt of Ukraine from 2009 to 2024 (US$ million)

At first glance three important assumptions can made from table 1 data : over 16 past consecutive years external debt significantly exceeded the size of domestic public borrowing evidently showing that state' preferable source to finance country needs allocated mostly outside the borders of farmland; the second one is about very high average arithmetic mean of total debt growth outdid 18% that's much over the country GDP growth ratio showing unbalanced aggressive national capital structure policy practice formation heavily relying on growing liabilities ignoring process adequate strategy of countrywide equity formation; the third on underlines how fragile, unsustainable and no resilient country' economy whereas harsh externalities come up - 36.8% total debt growth on the background of world financial crisis 2008 and 13.7%/30.5% in 2022/2023 respectively with start of Russian massive military aggression against Ukraine, so basically underlines the absents of internal sufficient capital to resist economic and financial stress. Nevertheless, over previous research also been revealed that we ought to consider all complicity of national debt landscape determined such factors as war has damaged the country's economy, leading to higher defense spending, amplified welfare programs, and a drop in tax revenues.

External public and publicly guaranteed debt of Ukraine from 2011 to 2024 (US$ million)

Table 1

Public and publicly guaranteed debt of Ukraine from 2009 to 2024 (US$ million) (4 Minfin, Public and publicly guaranteed debt of Ukraine from 2009 to 2025, 02.05.2025)

date	total debt	%Y/Y	external debt	domestic debt
31.12.2009	39 685,0		26 518,7	13 166,3
31.12.2010	54 289,3	36.8%	34 759,6	19 529,7
31.12.2011	59 215,7	9.1%	37 474,5	21 741,2
31.12.2012	64 495,3	8.9%	38 658,8	25 836,4
31.12.2013	73 078,2	13.3%	37 536,0	35 542,2
31.12.2014	69 794,8	-4.5%	38 792,2	31 002,6
31.12.2015	65 505,7	-6.1%	43 445,4	22 060,2
31.12.2016	70 970,9	8.3%	45 604,6	25 366,2
31.12.2017	76 305,2	7.5%	48 989,4	27 315,8
31.12.2018	78 323,0	2.6%	50 462,5	27 860,5
31.12.2019	84 364,5	7.7%	48 940,8	35 423,7
31.12.2020	90 255,4	7.0%	53 720,8	36 534,6
31.12.2021	97 947,4	8.5%	57 197,0	40 750,4
31.12.2022	111 343,7	13.7%	71 398,6	39 945,1
31.12.2023	145 316,9	30.5%	101 704,7	43 612,2
31.08.2024	154 689,8	6.4%	112 192,4	42 497,4

Table 2

External public and publicly guaranteed debt of Ukraine from 2011 to 2024 (US$ million) (5 Minfin, External public and publicly guaranteed debt of Ukraine from 2011 to 2025, 02.05.2025)

Date	external debt	%Y/Y	government debt	%Y/Y	guaranteed debt	%Y/Y
on 31.12.2011	37 474,5		24 507,1		12 967,5	
on 31.12.2012	38 658,8	3.16%	26 137,7	6.65%	12 521,1	-3.44%
on 31.12.2013	37 536,0	-2.90%	27 901,4	6.75%	9 634,6	-23.05%
on 31.12.2014	38 792,2	3.35%	30 809,1	10.42%	7 983,1	-17.14%
on 31.12.2015	43 445,4	12.00%	34 427,0	11.74%	9 018,5	12.97%
on 31.12.2016	45 604,6	4.97%	36 048,3	4.71%	9 556,3	5.96%
on 31.12.2017	48 989,4	7.42%	38 490,1	6.77%	10 499,3	9.87%
on 31.12.2018	50 462,5	3.01%	39 706,6	3.16%	10 755,8	2.44%
on 31.12.2019	48 940,8	-3.02%	39 342,5	-0.92%	9 598,3	-10.76%
on 31.12.2020	53 720,8	9.77%	44 510,7	13.14%	9 210,1	-4.04%
on 31.12.2021	57 197,0	6.47%	47 654,7	7.06%	942,3	3.61%
on 31.12.2022	71 398,6	24.83%	63 590,9	33.44%	7 807,7	-18.18%
on 31.12.2023	101 704,7	42.45%	94 790,5	49.06%	6 914,2	-11.44%
on 31.08.2024	112 192,4	10.31%	106 783,6	12.65%	5 408,7	-21.77%

Breaking down external debt reviles some thought-provoking signs: first of all, out of US$ 112,192.4 millions more then 95% (US$106 783,6 millions) falls on government debt and only 5% sets as guaranteed one, and the last one is in steady declining portion over past 13 years from almost 35% (on 31.12.2011) down to 5% (on 31.08.2024); the next one is immensely double digitally outpacing governmental borrowings over external bases 22.16% cumulatively on Y/Y basis 2014 and 2015 and 95.15% cumulatively on Y/Y basis over 2022, 2023 and 2024 showing undiversified systematic risk spread on state régime, which is crucial for adequate understanding impending capital

structure, investors risks personable responsibilities for covering risks and level of required return on corresponding investments.

Dynamics of External Public Debt and Gross External Debt (GED) of Ukraine from 2009 to 2024 (million US dollars)

Table 3

Dynamics of external public debt and gross external debt (GED) of Ukraine from 2009 to 2024 (million US dollars) (6 Minfin, Dynamics of external public debt and gross external debt (GED) of Ukraine from 2009 to 2025, 02.05.2025)

date	External Public Debt (EPD)	$Y/Y	%Y/Y	Gross External Debt (GED)	$Y/Y	%Y/Y	External Public Debt / GED
on 31.12.2009	26 519			103 396			25.6%
on 31.12.2010	34 760	8241	31.1%	117 343	13947	13.5%	29.6%
on 31.12.2011	37 475	2715	7.8%	126 236	8893	7.6%	29.7%
on 31.12.2012	38 659	1184	3.2%	135 065	8829	7.0%	28.6%
on 31.12.2013	37 536	-1123	-2.9%	142 079	7014	5.2%	26.4%
on 31.12.2014	38 792	1256	3.3%	126 308	-15771	-11.1%	30.7%
on 31.12.2015	43 445	4653	12.0%	118 729	-7579	-6.0%	36.6%
on 31.12.2016	45 605	2159	5.0%	113 518	-5211	-4.4%	40.2%
on 31.12.2017	48 989	3385	7.4%	116 578	3060	2.7%	42.0%
on 31.12.2018	50 462	1473	3.0%	114 710	-1868	-1.6%	44.0%
on 31.12.2019	48 941	-1522	-3.0%	121 739	7029	6.1%	40.2%
on 31.12.2020	53 721	4780	9.8%	125 690	3951	3.2%	42.7%
on 31.12.2021	57 197	3476	6.5%	129 711	4021	3.2%	44.1%
on 31.12.2022	71 399	14202	24.8%	131 998	2287	1.8%	54.1%
on 31.12.2023	101 705	30306	42.4%	161 533	29535	22.4%	63.0%
on 31.08.2024	112 192	10488	10.3%				

Ones we defined the scope and tendencies in External Public Debt logical question is about how External Public Debt correlates to Gross External Debt (GED) (table 3). Notable fact that External Public Debt (EPD) has grown 3.23 times since 2009, while Gross External Debt (GED) has grown by 0.56 times, as a result of such disproportionate growth specific weight of EPD in GED has increased from 26% (2009) up to 63% (2023) and 1/3 of that extension falls on the last three years. Obviously, the structure of sources to finance national needs has changed drastically by placing state government as sole monopolistic player on the external financial marketplace. Reasonably to accept that risk of defaulting state government debt supposed to be hedged for investors by at least directly controlled assets such as gold and Foreign Exchange Reserves (GER) (table 4).

Nevertheless the size of International reserves (IR) has increased by million US dollars 12,020.00 since 2009 reaching record high for the Ukraine (million US dollars 40,514.00 in 2024) the ratio of international reserves to government debt has decreased by almost 60%, in other words, only 40 cents out of one borrowed US dollar technically covered by gold and foreign exchange reserves. Also, from investors standpoint ought to be taken into account another two factors - structure of international reserves of Ukraine and what currency of current debt nominated (tables 5 and 6 respectively).

Table 4

Dynamics of external public debt and gold and foreign exchange reserves (GFR) of Ukraine from 2009 to 2024 (million US dollars) (7 Minfin, Dynamics of external public debt and gold and foreign exchange reserves (GFR) of Ukraine from 2009 to 2025, 02.05.2025)

Date	External public debt			International reserves (IR)			International reserves / government debt
on 31.12.2009	26 519			26 505			99.9%
on 31.12.2010	34 760	8241	31.1%	34 576	8071	30.5%	99.5%
on 31.12.2011	37 475	2715	7.8%	31 795	-2781	-8.0%	84.8%
on 31.12.2012	38 659	1184	3.2%	24 546	-7248	-22.8%	63.5%
on 31.12.2013	37 536	-1123	-2.9%	20 416	-4130	-16.8%	54.4%
on 31.12.2014	38 792	1256	3.3%	7 533	-12882	-63.1%	19.4%
on 31.12.2015	43 445	4653	12.0%	13 300	5767	76.5%	30.6%
on 31.12.2016	45 605	2159	5.0%	15 539	2239	16.8%	34.1%
on 31.12.2017	48 989	3385	7.4%	18 808	3269	21.0%	38.4%
on 31.12.2018	50 462	1473	3.0%	20 820	2012	10.7%	41.3%
on 31.12.2019	48 941	-1522	-3.0%	25 302	4482	21.5%	51.7%
on 31.12.2020	53 721	4780	9.8%	29 133	3831	15.1%	54.2%
on 31.12.2021	57 197	3476	6.5%	30 941	1808	6.2%	54.1%
on 31.12.2022	71 399	14202	24.8%	28 494	-2446	-7.9%	39.9%
on 31.12.2023	101 705	30306	42.4%	40 514	12020	42.2%	39.8%
on 31.08.2024	112 192	10488	10.3%				

Table 5

International reserves of Ukraine as of August 31, 2024 (US$ million) (8 Minfin, International reserves of Ukraine as of August 31, 2024)

1.	Foreign currency assets	40080,69	94.67%
	a. Securities	32476,86	76.71%
	b. Currency and deposits	7603.83	17.96%
2.	Reserve position in the IMF	0.32	0.00%
3.	SPZ	35.63	0.08%
4.	Monetary gold	2220,75	5.25%
5.	Others	-	
Reserve assets (total)	42337,39	100.00%	

SDR – IMF Special Drawing Rights

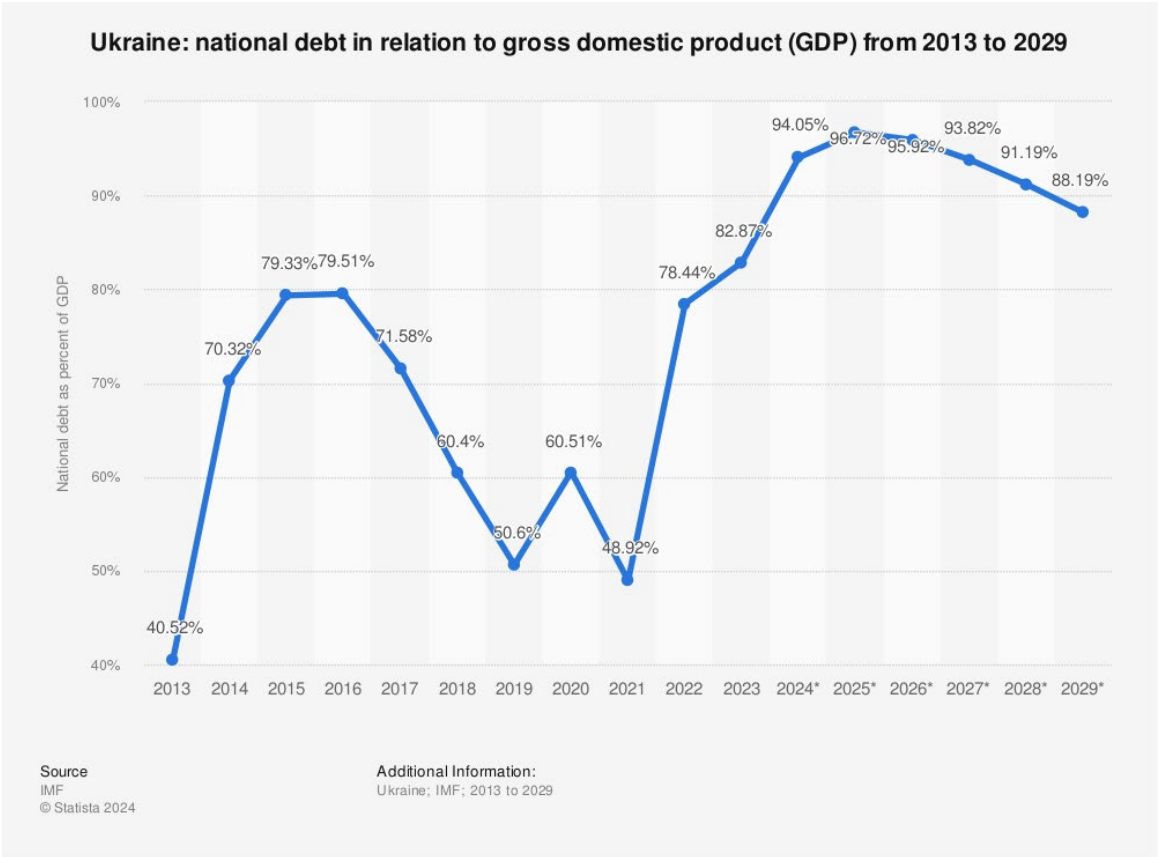
So, further breakdown of country international reserves in term of tangibility and obtainability (in real legal terms) of all assets more or less reachable can be observed as monetary gold & currency and deposits what drops covered portion from 40 cents out of one borrowed US dollar down to 23 cents and in almost 86% cases debtholders ought to be aware that all procedures are going to take place in two jurisdictions where located banks with corresponding accounts for particular nominated currency of debt (table 6).

Table 6

Currency structure of gross external debt of Ukraine as of June 30, 2024
(9 Minfin, Currency structure of gross external debt of Ukraine as of December 31, 2024)

currency	%	Amount equiv. mln. USD
USD US dollar	46.5	78,612.5
EUR Euro	39.2	66,271.1
XDR SPZ	9.4	15,891.5
other	3.5	5,917.1
UAH Ukrainian hryvnia	1,2	2,028.7
RUB Russian ruble	0.2	338.1
Total		169,059.0

Another critical issue for all range of Ukrainian debt creditors – addressed to the debt burden, and Ukraine has been relying on several strategies: international financial assistance, organizations like the International Monetary Fund (IMF) and the World Bank, as well as from individual countries; but are those actors' ready write-off any liabilities including accurized ones. Practice of last year's evidently shows that all creditors are willing get own interest as well as principal with possible restructuring extensions like the last one in summer 2024, and all creditors link Ukrainian playability of debt ultimately to internal GDP. Thus, next turning point is about how public debt is covered by current country income, hypothetically assuming that all investors can exercise their right for collateral debt exposure, knowingly setting beyond the mathematical brackets' deficit state budget.



1. Chart 1. Total national debt and GDP of Ukraine (10 Statista Research Department, Total national debt and GDP of Ukraine, 2024)

Let’s clarify that the ratio of national debt to gross domestic product (GDP) in Ukraine was forecast to continuously decrease between 2024 and 2029 by in total 5.9 percentage points. According to this forecast in 2029, the ratio will have decreased for the fourth consecutive year to 88.19 percent. So far total value of goods and services produced during a year in Ukraine didn’t get a hundred percent of total debt but next reasonable question might be on the agenda what the portion of current GDP could be allocated for next period supporting economic extension. By the way, Ukraine with current level of 85% is not in the basket of countries with the highest debt/GDP ratio, looks that condition is allowable for countries with advanced economies such as USA, Japan, Singapore etc. or for countries with no hope for bright future economies like Eritrea, Cape Verde and so on (table 7).

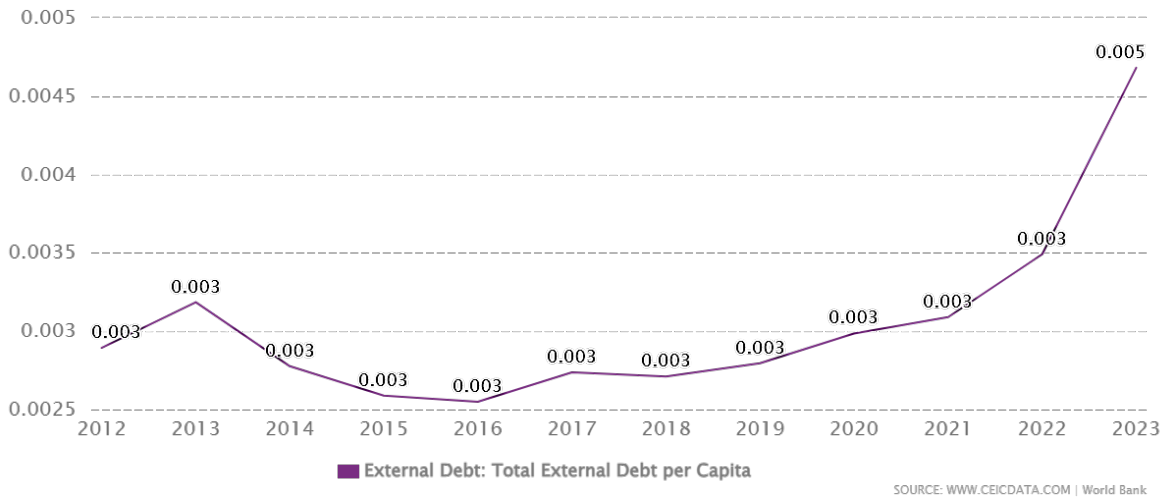
Table 7

Top 10 Countries with the Highest Debt-to-GDP Ratios (%) (11 World Population Review Top 10 Countries with the Lowest Debt-to-GDP Ratios (%), 2025)

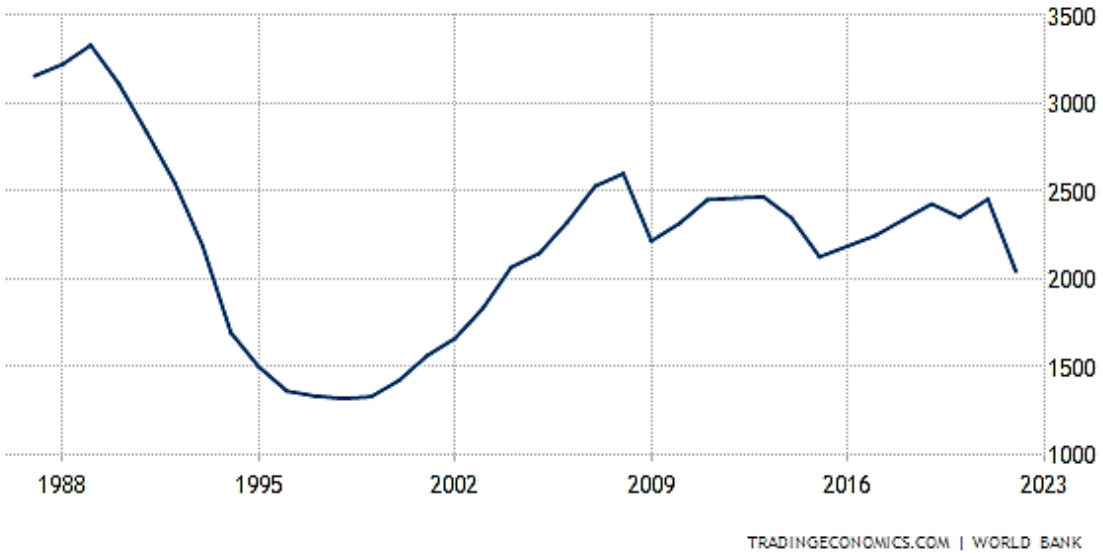
Lebanon	283%
Sudan	256%
Japan	255%
Singapore	168%
Eritrea	164%
Greece	162%
Argentina	155%
Venezuela	146%
Italy	135%
Bhutan	123%

Let’s clarify position on high Debt-to-GDP Ratios as an economic metric that compares a country's government debt to its gross domestic product (GDP) (which represents the value of all goods and services produced by the country), merely it determines the stability and health of a nation's economy, expresses country's ability to pay back its current debts, and evaluates related metrics such as GDP per capita, GDP growth, GNP, and GNI per capita. Thus, nations with a low debt-to-GDP ratio are more likely to be able to repay their debts with relative ease, on other hands, countries whose economies struggle to produce income or which have an oversized debt tend to have a high debt-to-GDP ratio. Also, widely accepted among scholars’ opinion directly above debt to GDP ratios further 75% can delay economic growth and set country at risk of defaulting on its debts, which in own turn harms internal financial market and economy as it is. Also, detailed analysis debt history with high ration country by country reviles very different scenarios of debt accumulation, for instants Japan, with the world's highest debt-to-GDP ratio, got its debt surge due to government bailouts and stimulus initiatives following the stock market crash of 1992, the United States, despite having the world's largest GDP, debt-to-GDP ratio determined by high military spending, tax cuts, and underfunded programs. Venezuela's GDP has plummeted in recent years and at the same time government has taken massive loans, adding to its debt burden, and government made questionable moves to slow the country's rampant inflation.

Total picture will be incomplete without understanding how debt correspondent per capita meaning that national workforce as part of the most productive portion of national capital and income generates per capita (chart 2 and chart 3 respectively).



1. Chart 2. Ukraine External Debt: Total External Debt per Capita from 1992 to 2023 (12 CEIC, Ukraine External Debt: Total External Debt per Capita, 2025)



1. Chart 3. Ukraine GDP per capita (13 Trading Economics, World Bank, Ukraine GDP per capita, 2025)

The Gross Domestic Product per capita in Ukraine was last recorded at USD 2,207.01 in 2023. The GDP per Capita in Ukraine is equivalent to 17% of the world's average. GDP per Capita in Ukraine averaged USD 2,207.37 from 1987 until 2023, reaching an all-time high of 3330.48 USD in 1989 and a record low of USD 1,317.75 in 1998. Debt per capita is a measure that indicates the average amount of debt for each person in a given population, basically used in the context of government or national debt. It's calculated by dividing the total debt of a government by its population size. Importance of Debt Per Capita: it provides insight into the financial health of a government (higher debt per capita may indicate potential economic strain), allows comparisons between different countries or regions, helping to assess relative economic burdens, investors consider debt per capita when evaluating a country's creditworthiness. On other hand, GDP per capita is a measure of a country's economic output that accounts for its number of residents. It's calculated by dividing the Gross Domestic Product (GDP) of a country by its population. This gives

an average economic output per person and is often used to compare living standards between different countries or regions. Interpretation: higher GDP per capita typically indicates a higher standard of living and greater economic prosperity; however, it's important to remember that this figure can be influenced by factors such as income inequality and cost of living, meaning it doesn't always reflect the economic reality experienced by all residents (for Ukraine is actual income inequality between so called "oligarchs" who control and use waste majority of national assets and the rest of population). What's alarming when we compare debt per capita and income per capita in Ukraine: inverse relationship between those two highly valuable for investors parameters with long term tendency of nongrowing nominal income per capita and at the same time tendency of growing debt per capita with almost 100% discrepancy in two ratios, in other words on average person with official annual income of USD2,210.00 set financial liabilities of almost USD4,448.00 and that tendency progresses on the background of steadily melting population.

2. Motives for Ukrainian debt accruing

Ukraine's debt has grown significantly due to a combination of factors collectively could be ordered as next:

– Historical accruing debt - country inherited a significant amount of debt from one to another following governments & economic/financial criseses

– military spending, war has necessitated a substantial increase in defense spending to support the Ukrainian military and acquire necessary equipment, government also has had to allocate significant resources for humanitarian aid to displaced persons expenditures for reconstruction, disrupted economic activity, leading to a decline in tax revenues and increased government spending

– budget deficits - ongoing budget deficits, resulting from high expenditures and lower-than-expected revenues, have led the government to finance its shortfalls through debt

Historically each government has made more or less significant contribution along with respective political force that brought the government to the performance of its duties and as we can see some governments made extraordinary efforts to attract debt capital into the country along with annual distribution of collected debt (table 9 & table 10 respectively).

Table 8

National debt and the Presidents of Ukraine (14 Wikipedia, Public debt and the Presidents of Ukraine, 2025)

President			state debt (million USD)
Leonid Makarovych Kravchuk	24-Aug-91	19.07.1994	2,406.69
Leonid Danylovich Kuchma	19.07.1994	23.01.2005	▲ 13,727.68
Viktor Andriyovych Yushchenko	23.01.2005	25.02.2010	▲ 21,809.77
Viktor Yanukovych	25.02.2010	22.02.2014	▲ 35,282.24
Oleksandr Valentinovych Turchynov	22.02.2014	07.06.2014	▼ -3,127.63
Petro Oleksiiovych Poroshenko	07.06.2014	5/20/2019	8,312.35
Volodymyr Zelenskyi (until 24.02.22)	5/20/2019	2/24/2022	14,909.20
Volodymyr Zelenskyi (after 24.02.22)	2/24/2022	31.03.2024	▲ 57,726.16

For sure, the biggest increase has happened under current war circumstances and trough budget mechanism of capital reallocation which is understandable as increasing government role to finance war and related expenses. As a result of outpacing expenses current budget income, deficit on august 2024 reached billion UAH676,426.10 (with exchange rate 40.7 UAH/ASD equivalent to billion USD16,620.69); a worrying factor for investors is that budget gap is unparalleled with annual country needs to finance from 50 to 70 USD billions annually, shrinking domestic tax base and the reluctance of external creditors to provide debt financing in already high-risk area.

Table 9

State debt and state-guaranteed debt by years (14 Wikipedia, Dynamics of public debt and state-guaranteed debt of Ukraine, 2025)

date	ammoun (mln USD)	difference per year
31.12. 1991	0	-/-
31.12. 1992	11.47	11.47
31.12. 1993	388.22	376.75
31.12. 1994	3,848.46	3,460.24
31.12. 1995	12,610.41	8,761.95
31.12. 1996	10,894.09	▼ -1,716.32
31.12. 1997	15,034.95	4,140.86
31.12. 1998	14,410.73	▼ -624.22
31.12. 1999	15,249.42	838.69
31.12. 2000	14,172.92	▼ -1,076.50
31.12. 2001	14,084.87	-88.05
31.12. 2002	14,201.30	116.43
31.12. 2003	14,542.53	341.23
31.12. 2004	16,096.25	1,553.72
31.12. 2005	15,474.41	▼ -621.84
31.12.2006		
15,949.90	475.49	
31.12. 2007	17,573.22	1,623.32
31.12. 2008	24,598.75	7,025.53
31.12. 2009	39,684.99	▲ 15,086.24
31.12. 2010	54,289.34	▲ 14,604.35
31.12. 2011	59,215.70	4,926.36
31.12. 2012	64,500.00	5,284.30
31.12. 2013	73,110.18	8,610.18
31.12. 2014	69,811.89	▼ -3,298.29
31.12. 2015	65,488.41	▼ -4,323.48
31.12. 2016	70,970.86	5,482.45
31.12. 2017	76,305.18	5,334.32
31.12. 2018	78,322.97	2,017.79
31.12. 2019	84,364.54	6,041.57
31.12. 2020	90,253.51	5,888.97
31.12. 2021	97,954.31	7,700.80
31.12.2022	111,375.51	13,421.20
31.12.2023	145,317.46	33,941.95

3. Fundamental characteristics of Ukrainian debt, solving risk-return dilemma

Ukrainian debt features ought to be assigned specific structure of the debt, sporadic maturity of the debt, fluctuating interest on specific debt face value, assembly of creditors, vulnerability to external shocks or geopolitical risks.

Structure: correlation between domestic and external debt is approximately 27% and 73% and is a mix of domestic and external obligations with high public debt level and country is experiencing substantial increase in public debt, particularly since the war with Russia began in 2014; domestic debt is owed to domestic lenders, while external debt is owed by foreign creditors with significant portions owed to international financial institutions, bilateral lenders, and private creditors. Currency composition – major portion of Ukraine's debt is nominated in foreign currencies, primarily US dol-

lars and Euros, what determines national currency exposure toward the exchange rate risks so making it susceptible to exchange rate fluctuations, especially with the Ukrainian hryvnia's volatility.

Maturity - Ukraine's debt portfolio includes a mix of short, mid and long-term commitments; first on mature within a year, the second one are due in up to five years, and last one mature over 5 years (table 11 & 12 respectively).

Table 10

State domestic debt split by maturity as of end of period (15 Ukraine Ministry of Finance, Medium-Term State Debt Management Strategy for 2024-2026, 10,2023)

	2021	2022	2023
	% of total	% of total	% of total
< 3 years	43%	30%	37%
3-5 years	12%	7%	8%
5-7 years	6%	7%	4%
7-10 years	14%	12%	13%
> 10 years	24%	44%	38%
Total domestic debt	100%	100%	100%

Table 11

State external debt split by maturity as of end of period (15 Ukraine Ministry of Finance, Medium-Term State Debt Management Strategy for 2024-2026, 10,2023)

	2021	2022	2023
	% of total	% of total	% of total
< 3 years	0%	2%	8%
3-5 years	16%	13%	8%
5-7 years	9%	12%	8%
7-10 years	28%	21%	24%
> 10 years	47%	52%	51%
Total domestic debt	100%	100%	100%

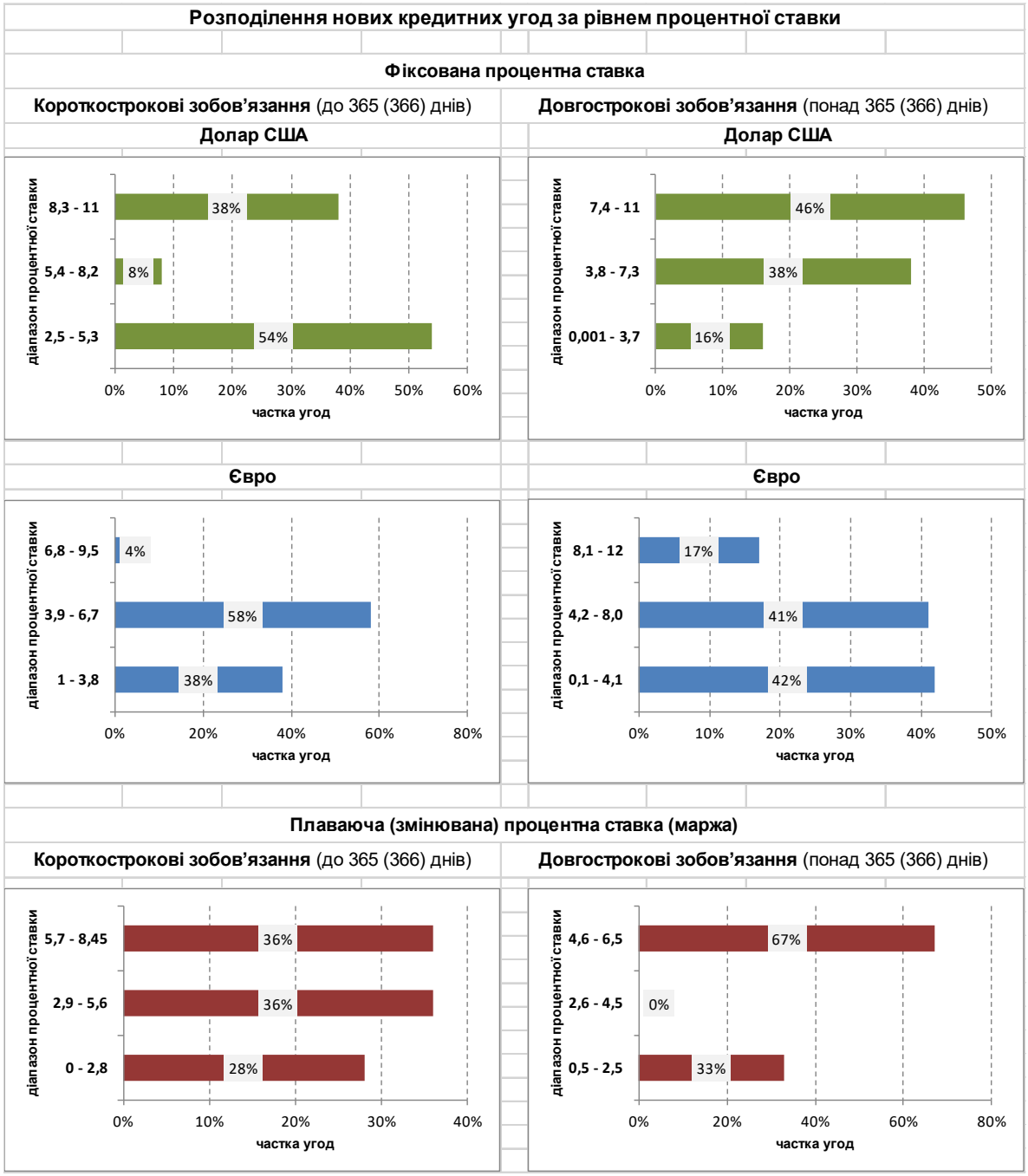
What attracts attention is that relatively high portion (in both layers of borrowings) so called long-term obligations, on background economic and financial instability. For instance, in neighboring Poland less intention to relay on long-term liabilities in external as well as internal borrowings (table 12).

Table 12

Sales of TSs in the domestic market by maturity (16 Poland Ministry of Finance, THE PUBLIC FINANCE SECTOR DEBT MANAGEMENT STRATEGY in the years 2024-2027, 09,2023)

Instruments	2021	2022	January-june 2023
Marketable TSs	100%	100%	100%
T-bills	0.0%	0.0%	0.0%
T-bonds with maturities up to 4 years	12.6%	10.4%	9.9%
T-bonds with maturities over 4 years up to 6 years (incl.)	46.1%	55.2%	69.3%
T-bonds with maturities over 6 years	41.3%	34.4%	20.9%
Savings bonds	100%	100%	100%
T-bonds with maturities up to 2 years	59.1%	44.4%	29.1%
T-bonds with maturities over 2 years up to 4 years (incl.)	33.2%	44.3%	56.0%
T-bonds with maturities over 4 years	7.7%	11.2%	14.9%

Cost of borrowings - some of Ukraine's debt carries floating interest rates, which can fluctuate based on market conditions, the other debt has fixed interest rates, which remain constant throughout the life of the loan, so debt often carries high-interest rates, particularly on domestic bonds, reflecting the country's risk profile. Information about the contribution of foreign investors to the real sector in the first quarter of 2019 and in first quarter of 2022 (table 13 & 14 respectively) shows increase in floating interest rates in the beginning of massive military intervention. Basically, using floating interest rates refers to borrowers with long solid and stable credit history and adversely fixed interest rates more suitable for debtors with fluctuating credit history.



1. Table 13. contribution of foreign investors to the real sector in the first quarter of 2019 (17 National Bank of Ukraine, Financial Stability Report, 12,2025)

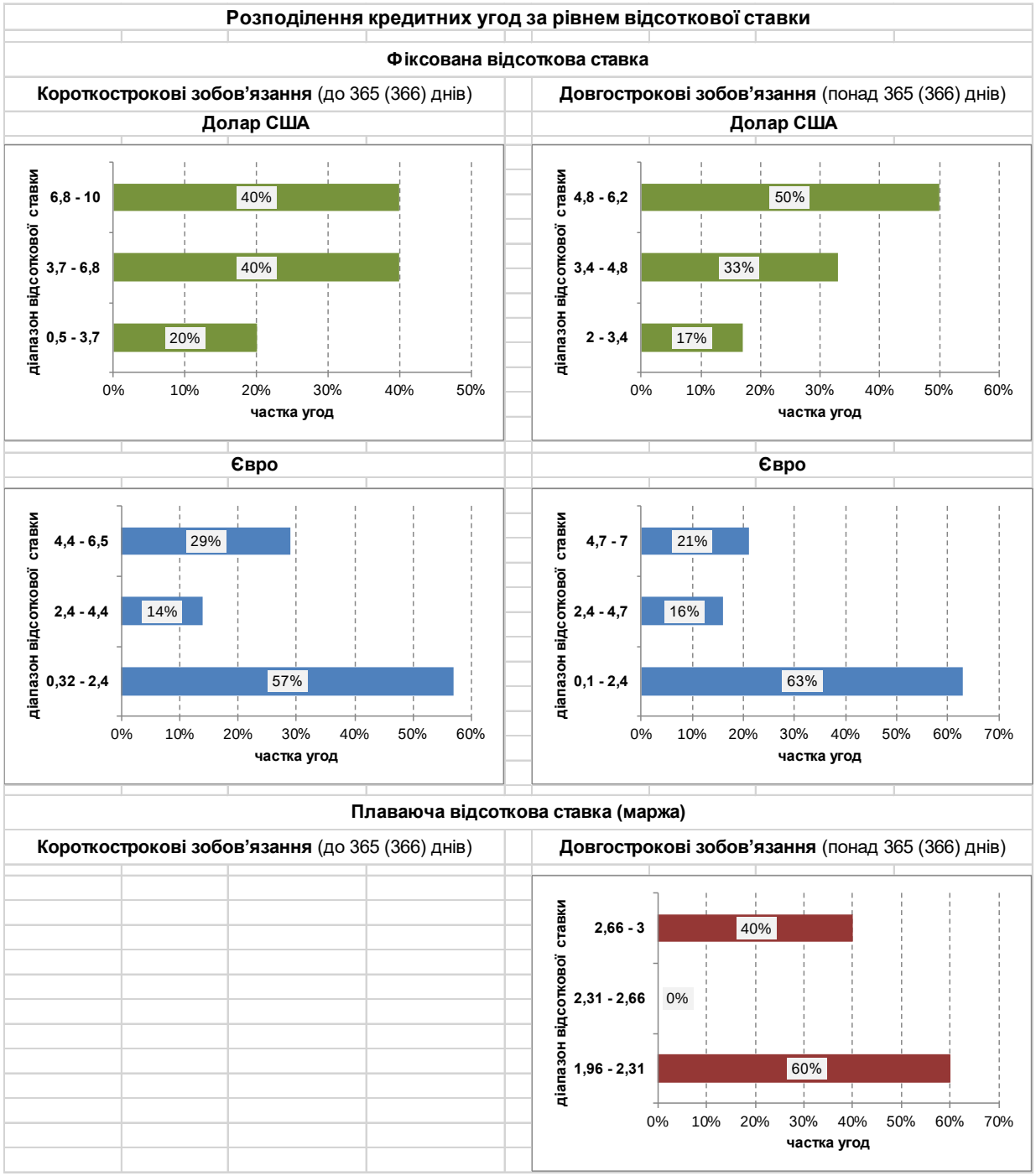


Table 14. contribution of foreign investors to the real sector in the first quarter of 2022 (17 National Bank of Ukraine, Financial Stability Report, 12,2025)

According government declaration, from the beginning of 2024 the cost of the sovereign and the sovereign-guaranteed debt (USD nominated) of Ukraine decreased by 10.3% - from 6.24% to 5.6%.

With a broad stroke of a financial brush on the record among public debt creditors are USA and EU, Asian countries governments, respective international financial institutions, and private investment companies; however, the geographic structure of loans to the private sector in Ukraine is somewhat different according data of National Bank of Ukraine (table 15) where Cyprus keeps the lion portion in supporting financial debt market with 54% in short-term and 48% in long-term financing.

Chart 4. weighted average cost of government debt (18 Ukraine Ministry of Finance, Ukraine's state and state-guaranteed debt has become cheaper by more than 10% since the beginning of 2024, 12,08,2025)

Table 15

Geographic structure of loans to the private sector in Ukraine (17 National Bank of Ukraine, Geographic structure of arrears of External Debt for real sector, 03, 2024)

countries			
	total	**short-term**	**long-term**
total	42,602.0	1,178.0	41,424.0
Cyprus	20,549.7	636.2	19,913.5
The Kingdom of Great Britain and Northern Ireland	4,612.7	103.9	4,508.8
Netherlands	3,504.9	15.2	3,489.7
USA	1,335.0	9.9	1,325.2
Germany	1,310.9	68.6	1,242.3
Virgin Islands	995.6	5.1	990.5
Austria	989.6	2.1	987.5
Luxembourg	943.4	0.0	943.4
Switzerland	864.1	150.7	713.4
Malta	643.6	1.3	642.3
United Arab Emirates	447.1	5.8	441.3
France	400.4	29.3	371.1
Panama	396.2	9.4	386.8
Poland	371.0	7.0	364.0
Estonia	338.1	2.9	335.2
Hong Kong	314.5	5.3	309.2
Turkey	299.7	3.2	296.5
Hungary	292.9	2.1	290.8
Sweden	208.6	25.4	183.2
Greece	196.2	1.0	195.2
Other countries	*3,587.8*	*93.7*	*3,494.1*

Reasonable question might be asked – what attracts investors in debt market if according state officials cost of debt is on the level of 5.6%, with widely accepted among investors criteria's such as Adjusted Default Spread, Equity Risk Premium, Country Risk Premium, Corporate Tax Rate, Moody's rating, and Sovereign CDS Spread (table 16) and neither of mentioned parameters directly incorporated real inflation rate which recently declared by regulator on the level of 7.5% on the y/y base (September 2024).

Table 16

Country Default Spreads and Risk Premiums (19 Stern, NYU, Country Default Spreads and Risk Premiums, 01.09.2025)

Country	Adj/ Default S pread	Equity Risk Premium	Country Risk Premium	Corporate Tax Rate	Moody's rating	S overeign CDS Spread
Ukraine	13.07%	22.15%	17.55%	18.00%	Ca	NA
Poland	0.92%	5.84%	1.24%	19.00%	A2	1.06%
Cyprus	2.07%	7.38%	2.78%	12.50%	Baa2	1.11%

By the way, if to continue comparison of yields, following table demonstrates closest geographical investor acceptancy criteria (table 17)

Table 17

Issues of bonds in foreign markets in 2022 and in the first half of 2023 (16 Poland Ministry of Finance, THE PUBLIC FINANCE SECTOR DEBT MANAGEMENT STRATEGY in the years 2024-2027, 09,2023)

Period	Maturity (years)	Currency	Face value of issue (million)	Yield
2022	10	EUR	2 000	2.850%
2022	5	USD	1 500	5.619%
2022	10	USD	1 500	5.890%
January – June 2023	20	EUR	1 250	4.272%
January – June 2023	10	USD	2 500	4.968%
January – June 2023	30	USD	2 500	5.585%

Risk-return dilemma for Ukrainian debtholders possible to solve using advanced bond concept for coupon debt instruments affecting duration or opening position on the base of discounted price that ought to satisfy investor acceptancy criteria; a showpiece deal was informed by Ukrainian press in summer 2013, reported that Serhiy Arbuzov, Ukraine's first deputy prime minister, and Yuriy Kolobov, the finance minister, made an unofficial visit to Franklin Templeton's San Mateo headquarters to reassure the country's biggest creditor at that time (20 CNBC, Emerging Europe, Franklin Templeton in $5 billion Ukraine debt gamble, 11.11.2013); thus, Franklin Templeton became Ukraine's biggest private creditor in 2013, with an investment of about $7 billion across funds, the year before a revolution toppled the country's former president, prompting a separatist insurgency in its eastern regions, the fighting crippled Ukraine's finances, forcing it to seek a sovereign-debt restructuring in 2015 (21 Bloomberg, Business, Templeton's Hasenstab Winds Down $7 Billion Ukraine Bond Bet, 04.21.2017).

4. Awareness in the future - trade-off between risk and potential return.

Investors must prudently consider these specific risk factors when making their decision such as interest rate risk (in the case interest rates rise, the value of existing bonds with fixed interest rates falls); credit risk (risk that the debtors may well default on their debt payments, and this probability is truly high for borrowers with scrawny financial position); inflation risk (as a rule, inflation increases faster than the interest rate on a bond, the so reinvestment supremacy of the bond's future outflows will decline) ; liquidity risk (nearly all of such bonds difficult to sell, especially in times of financial disorders, thus price of bonds are going down and bondholders loss value of their portfolios). Basically, we identify all mentioned risks practically in all Ukrainian debt instruments with overall declining sovereign credit ratings from S&P and Moodies (table 18 & 19 respectively).

Table 18

Dynamic of Ukraine's sovereign credit ratings as of 2004-2024 (22 Ukraine Ministry of Finance, Credit Rating, 03.2024)

Rating agency	Foreign currency rating				Local currency rating				National scale rating on the country		Outlook		Assignment date/ Confirmation date
	Long-term debt		Short-term debt		Long-term debt		Short-term debt						
"Standard and Poor's" (S&P)	B +	↑	B		B +	↑	B				Stable		**20 July 2004**
									uaAA				**14 Apr 2005**
	BB-	↑	B		BB		B		uaAA		Stable		**11 May 2005**
	BB-		B		BB		B				Stable		**3 Oct 2005**
	BB-		B		BB		B				Stable		**30 Aug 2006**
	BB-		B		BB		B				Negative	↓	**5 Apr 2007**
	BB-		B		BB		B		uaAA		Negative		**2 Aug 2007**
	B +	↓	B		BB-	↓	B				Stable	↑	**12 June 2008**
	B +		B		BB-		B		uaAA		CreditWatch*		**15 Oct 2008**
	B	↓	B		B +	↓	B		uaA+	↓	Negative		**24 Oct 2008**
	B		B		B +		B				CreditWatch		**16 Feb 2009**
	CCC+	↓	C	↓	B-	↓	C	↓	uaBBB		Negative		**25 Feb 2009**
	CCC+		C		B-		C				Positive	↑	**31 July 2009**
	CCC+		C		B-		C		uaBBB		Stable	↓	**30 Oct 2009**
	B-	↑	C		B	↑	B	↑			Positive	↑	**11 Mar 2010**
									uaA	↑			**17 Mar 2010**
	B	↑	B	↑	B+	↑	B		uaA+	↑	Stable	↑	**17 May 2010**
	B		B		B+		B		uaA+		CreditWatch		**22 July 2010**
	B+	↑	B		BB-	↑	B		uaAA-	↑	Stable		**29 July 2010**
	B+		B		B+	↓	B		uaAA-		Stable		**13 Sep 2011**
	B+		B		B+		B		uaA+	↓	Negative	↓	**15 Mar 2012**
	B	↓	B		B	↓	B		uaA-	↓	Negative		**7 Dec 2012**
	B		B		B		B		uaA-		Negative		**16 May 2013**
	B-	↓	B		B-	↓	B		uaBBB-	↓	Negative		**1 Nov 2013**
	B-		B		B-		B		uaBBB-		Stable	↑	**26 Dec 2013**
	CCC+	↓	C	↓	B-		B		uaBB+	↓	Negative		**28 Jan 2014**
	CCC	↓	C		B-		B		uaBB+		Negative		**21 Feb 2014**
	CCC		C		B-		B		uaBB+		Stable	↑	**11 July 2014**
	CCC-	↓	C		CCC+	↓	C	↓	uaB+	↓	Negative	↓	**19 Dec 2014**
	CC	↓	C		CCC+		C		uaB+		Negative		**10 Apr 2015**
	CC		C		CCC+		C		uaB+		Negative		**28 Aug 2015**

Continuation of table 18

“Standard and Poor's” (S&P)	SD	↓	SD	↓	CCC+		C		uaB+				**25 Sep 2015**
	B-/D	↑	B	↑	B-	↑	B	↑	uaB+		Stable	↑	**19 Oct 2015**
	B-/D		B		B-		B		uaBBB-	↑	Stable		**11 Dec 2015**
	B-		B		B-		B		uaBBB-		Stable		**10 June 2016**
	B-		B		B-		B		uaBBB-		Stable		**9 Dec 2016**
	B-		B		B-		B		uaBBB-		Stable		**12 May 2017**
	B-		B		B-		B		uaBBB-		Stable		**10 Nov 2017**
	B-		B		B-		B		uaBBB-		Stable		**20 Apr 2018**
									uaBBB	↑			**27 June 2018**
	B-		B		B-		B		uaBBB		Stable		**19 Oct 2018**
	B-		B		B-		B		uaBBB		Stable		**12 Apr 2019**
	B	↑	B		B	↑	B		uaA	↑	Stable		**27 Sep 2019**
	B		B		B		B		uaA		Stable		**13 Mar 2020**
	B		B		B		B		uaA		Stable		**11 Sep 2020**
	B		B		B		B		uaA		Stable		**12 Mar 2021**
	B		B		B		B		uaA		Stable		**10 Sep 2021**
	B-	↓	B		B-	↓	B		uaBBB-	↓	CreditWatch Negative	↓	**25 Feb 2022**
	B-		B		B-		B		uaBBB-		CreditWatch Negative		**11 Mar 2022**
	CCC+	↓	C	↓	B-		B		uaBBB-		Negative	↓	**27 May 2022**
	CC	↓	C		B-		B		uaBBB-		Negative		**29 Jul 2022**
	SD	↓	SD	↓	CCC+	↓	C	↓	uaBB-	↓			**12 Aug 2022**
	CCC+	↑	C	↑	CCC+		C		uaBB	↑	Stable	↑	**19 Aug 2022**
	CCC+		C		CCC+		C		uaBB		Stable		**10 Mar 2023**
	CCC	↓	C		CCC+		C		uaBB		Negative	↓	**6 Apr 2023**
	CCC		C		CCC+		C		uaBB		Negative		**8 Sep 2023**
	CC	↓	C		CCC+		C		uaBB		Negative		**8 Mar 2024**

On return factors in bonds investors ought to rely on interest rates (or coupon rates if such provision declared in prospectus) Higher interest rates generally lead to higher bond yields; credit quality (bonds issued by with higher credit ratings typically offer lower interest rates because lower risk of default); maturity (usually bonds with longer maturities offer higher interest rates if to compare with short and midterm rate bonds and logic over heir is straight forward – compensation of risk associated with prolonged holding period); call risk (if call option is assigned to specific instrument – not applicable at up-to-date point of time for Ukrainian government bonds) Some bonds can be called by the issuer before their maturity date. With respect to credit quality and interest rate newly restructured international bonds Fitch Agency rated them as CCC Ratings agency Fitch gave Ukraine's newly-restructured international bonds a deep-into-junk 'CCC' rating on and kept the war-torn country's overall foreign currency score in "selective default", reflecting "still substantial credit risk given the protracted nature of the war" and its expectations that Kyiv will have huge fiscal deficits of 17.5% of

Table 19

Dynamic of Ukraine's sovereign credit ratings as of 2004-2024 (22 Ukraine Ministry of Finance, Credit Rating, 03.2024)

Rating agency	Foreign currency rating				Local currency rating				National scale rating on the country		Outlook		Assignment date/ Confirmation date
	Long-term debt		Short-term debt		Long-term debt		Short-term debt						
Fitch Ratings" (Fitch)	BB-	↑	B		BB-	↑	-				Stable		**21 Jan 2005**
	BB-		B		BB-		-				Positive	↑	**8 June 2005**
	BB-		B		BB-		-				Stable	↓	**12 Jan 2006**
									AA+(ukr)		Stable		**26 June 2006**
	BB-		B		BB-		-				Positive	↑	**25 Oct 2006**
	BB-		B		BB-		-				Positive		**18 Mar 2008**
	BB-		B		BB-		-				Stable	↓	**14 Mar 2008**
	BB-		B		BB-		-				Negative	↓	**25 Sep 2008**
	B +	↓	B		B +	↓	-				Negative		**17 Oct 2008**
	B	↓	B		B	↓	-				Negative		**12 Feb 2009**
									AA(ukr)	↓	Stable		**13 Feb 2009**
	B		B		B		-				Negative		**14 Oct 2009**
	B-	↓	B		B-	↓	-				Negative		**12 Nov 2009**
									AA-(ukr)		Stable		**13 Nov 2009**
	B-		B		B-		-				Stable	↑	**17 Mar 2010**
	B	↑	B		B	↑	-				Stable		**6 July 2010**
									AA(ukr)	↑	Stable		**7 July 2010**
	B		B		B		-				Stable		**15 Sep 2010**
	B		B		B		-				Positive	↑	**21 July 2011**
									***				**2 Sep 2011**
	B		B		B		-				Stable	↓	**19 Oct 2011**
	B		B		B		-				Stable		**10 July 2012**
	B		B		B		-				Negative	↓	**28 June 2013**
	B-	↓	B		B-	↓	-				Negative		**8 Nov 2013**
	CCC	↓	C	↓	B-		-				Negative		**7 Feb 2014**
	CCC		C		B-		-				Negative		**28 Feb 2014**
	CCC		C		CCC	↓	-						**22 Aug 2014**
	CC	↓	C		CCC		-						**13 Feb 2015**
	CC		C		CCC		-						**7 Aug 2015**
	C	↓	C		CCC								**27 Aug 2015**
	RD	↓	RD	↓	CCC								**6 Oct 2015**
	CCC	↑	C	↑	CCC								**18 Nov 2015**

Continuation of table 19

Fitch Ratings" (Fitch)	CCC		C		CCC								**13 May 2016**
			C		CCC		C						**22 July 2016**
	B-	↑	B	↑	B-	↑	B	↑			Stable	↑	**11 Nov 2016**
	B-		B		B-		B				Stable		**28 Apr 2017**
	B-		B		B-		B				Stable		**27 Oct 2017**
	B-		B		B-		B				Stable		**27 Apr 2018**
	B-		B		B-		B				Stable		**26 Oct 2018**
	B-		B		B-		B				Stable		**8 Mar 2019**
	B	↑	B		B	↑	B				Positive	↑	**6 Sep 2019**
	B		B		B		B				Positive		**6 Mar 2020**
	B		B		B		B				Stable	↓	**22 Apr 2020**
	B		B		B		B				Stable		**4 Sep 2020**
	B		B		B		B				Stable		**26 Feb 2021**
	B		B		B		B				Positive	↑	**6 Aug 2021**
	B		B		B		B				Stable	↓	**4 Feb 2022**
	CCC	↓	C	↓	CCC	↓	C	↓					**25 Feb 2022**
	C	↓	C		CCC-	↓	C						**22 Jul 2022**
	RD	↓	C		CCC-		C						**12 Aug 2022**
	CC	↑	C		CCC-		C						**17 Aug 2022**
	CC		C		CCC-		C						**20 Jan 2023**
	CC		C		CCC-		C						**23 Jun 2023**
	CC		C		CCC-		C						**8 Dec 2023**

gross domestic product this year and 15.3% in 2025 (24 National Bank of Ukraine, Domestic government bonds market, Domestic government bonds issues, Domestic government bonds: primary market, Domestic government bonds: secondary market, 2025).

Concerning to balancing risk and return – basically balance between risk and return be contingent and relies on investor's individual risk tolerance. As of nowadays Ukrainian debt instruments try to sell investors following yield (charts 5, 6, and 7 in UAH, USD, and EURO).

Combination of rational investment strategy with stressed above parameters will definitely require specific strategies such as extended diversification - investing in a variety of bonds with different maturities, credit ratings, and desirably scratched or maturity shifted portfolio combining bonds with different maturity dates under professional management.

Conclusion

Defined how Ukrainian makes efforts to overcome war time economic consequences such as massive economic damage, huge losses of human capital, land, infrastructure, using debt; Appraised of Ukrainian debt; Cleared motives for Ukrainian debt accruing; Explained who is funding debt borrowings, and who are recipients; Spell out who is ultimately responsible for debt paying back, current state of county budget; Determined fundamental characteristics of Ukrainian debt, and how to solve risk-return dilemma; Awareness in the future for investors and visible alternates to debt financing.

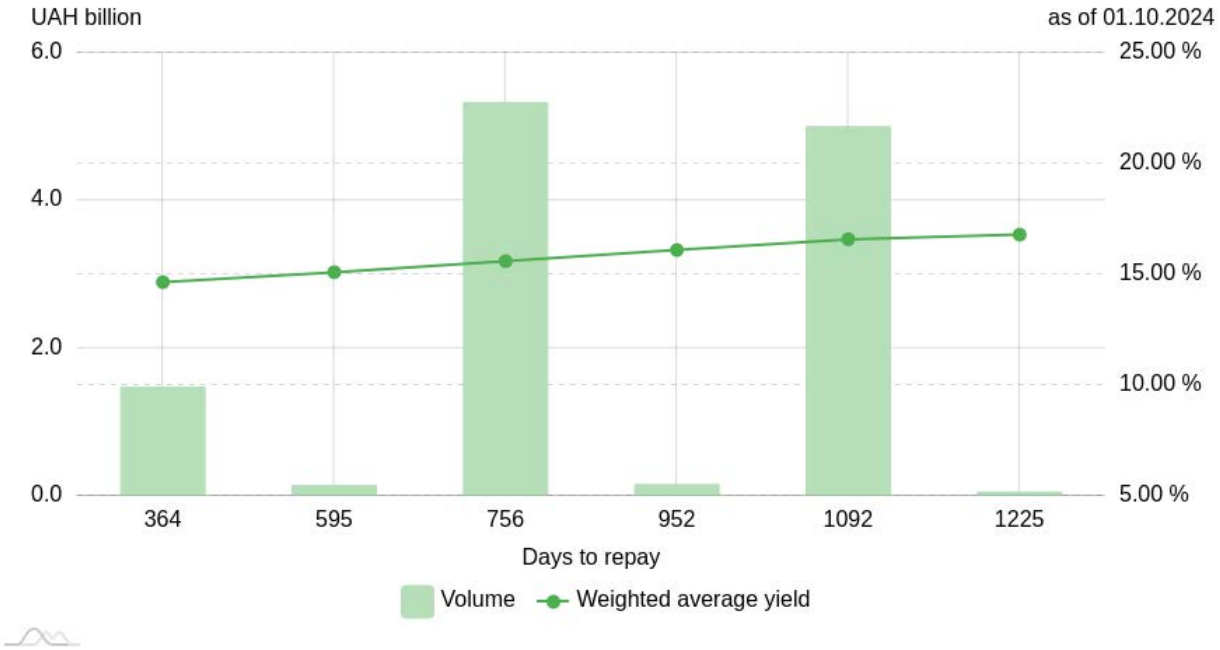


Chart 5. Domestic government bonds: primary market UAH (24 National Bank of Ukraine, Domestic government bonds market, Domestic government bonds issues, Domestic government bonds: primary market, Domestic government bonds: secondary market, 2025)

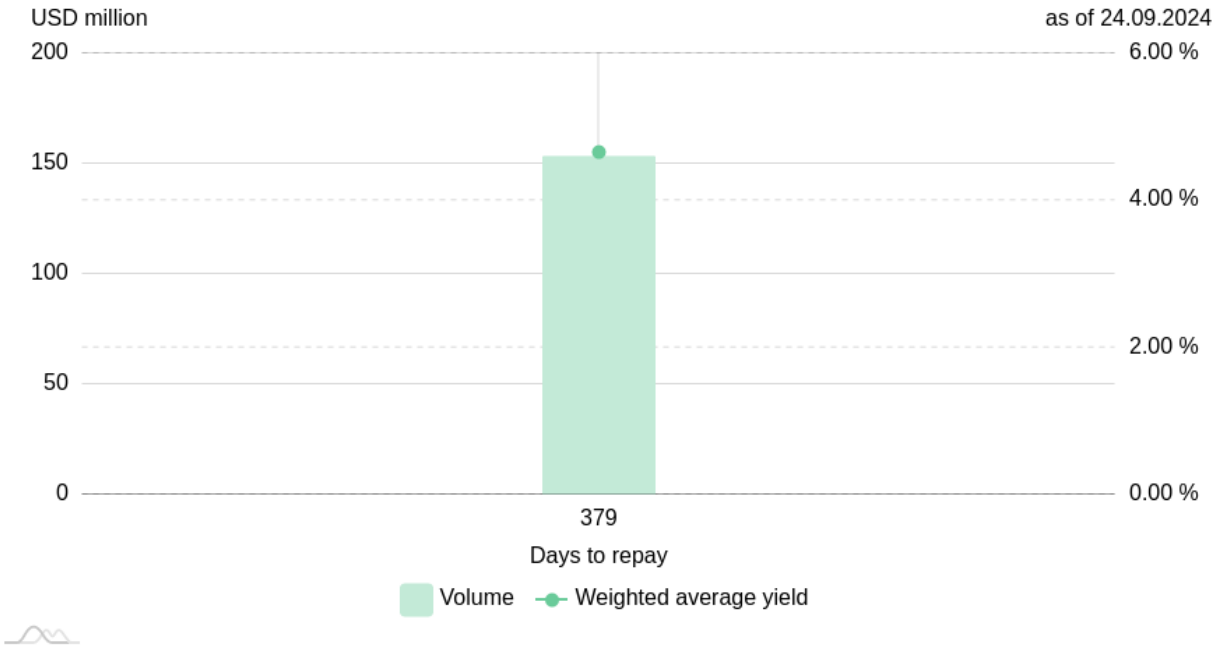


Chart 6. Domestic government bonds: primary market USD (24 National Bank of Ukraine, Domestic government bonds market, Domestic government bonds issues, Domestic government bonds: primary market, Domestic government bonds: secondary market, 2025)

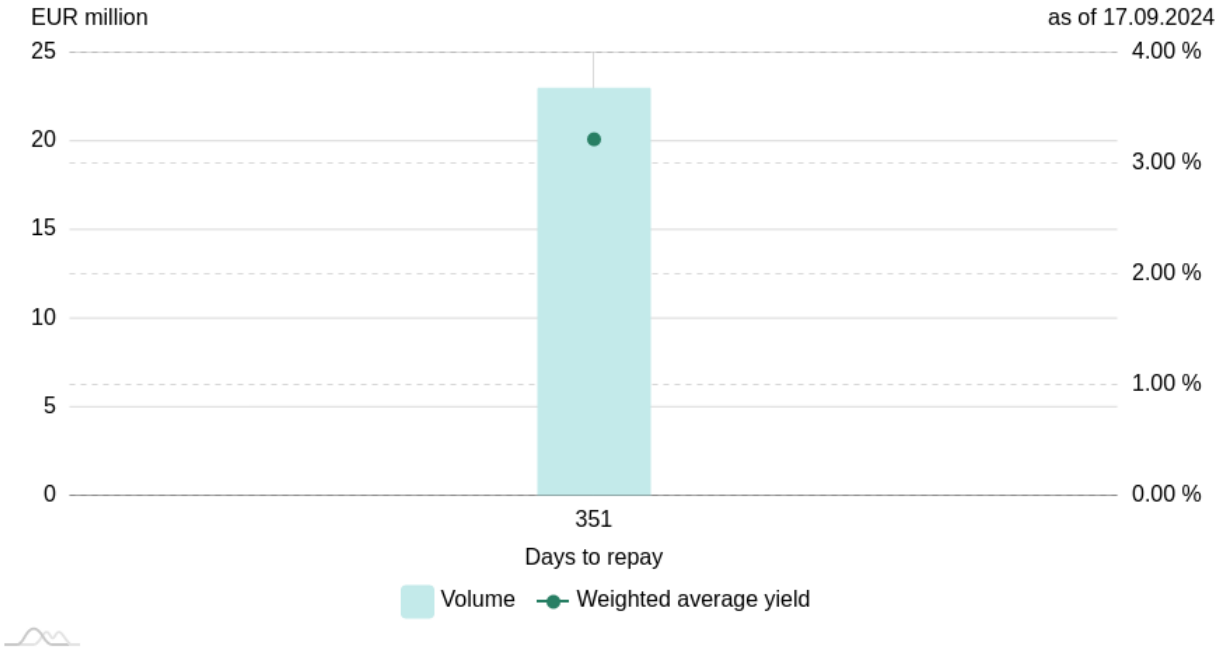


Chart 7. Domestic government bonds: primary market EUR (24 National Bank of Ukraine, Domestic government bonds market, Domestic government bonds issues, Domestic government bonds: primary market, Domestic government bonds: secondary market, 2025)

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THE IMPACT OF FINANCIAL LITERACY ON THE DEMAND FOR REAL ESTATE INSURANCE IN LATVIA

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Abstract. The studies published between 2018 and 2023 extensively investigate the impact of different factors on the decision to purchase real estate insurance. Only a small number of these studies examine the effects of financial literacy on the demand for property insurance. This paper aims to explain the impact of financial literacy on the demand for real estate insurance and to identify measures that can be taken to develop financial literacy to boost the demand for real estate insurance services in Latvia. The paper hypothesizes that developed financial literacy has a positive impact on the demand for real estate insurance. To achieve the aim of the article and to test the hypothesis, several tasks have been set: to describe the development trends of the real estate insurance market in Latvia to conduct a survey of policyholders' individuals on real estate insurance services in Latvia; to conduct interviews with real estate insurance specialists. The article applies qualitative (monographic method) and quantitative (structured survey of respondents, descriptive statistics, ANOVA test, dynamics, and structure indicators) research methods. The novelty of this article lies in the fact that the impact of financial literacy on the demand for real estate insurance services in Latvia is investigated. The impact of financial literacy on the demand for real estate insurance has not been widely studied in Latvia or other countries of the world. Individual-level factors influencing the decision to purchase real estate insurance, such as property type, property risk exposure, property value, access to finance, mortgage credit, risk perception, previous risk experience, and savings, have been extensively studied. The study concludes that financial literacy is a factor influencing the overall demand for property insurance in Latvia.

Key words: financial literacy, demand for property insurance, non-life insurance.

Introduction. Insurance functions as a mechanism through which policyholders transfer risks from themselves to financial institutions (Absalom 2022, p. 73). This process essentially involves shifting risks from real estate owners to insurance providers. The demand for non-life insurance is influenced by macroeconomic factors, including public income, education level, inflation, interest rates, and urbanization (Malakauskiene, Lakshtutiene, Watkowska 2022; Alghusin, Kasasben 2019; Iyodo, Samuel, Adewole 2022; Lee, Cheng, Chong 2018; Sharku, Garbova, Vullnetari 2021; Banerjee, Majumdarb 2018; Dragos, Mare, Muresan 2022). At the individual level, various factors affect the decision to purchase property insurance, including property type, risk exposure, property value, affordability, mortgage status, risk perception, prior experiences with risk, and personal savings (Lee, Ma, Li 2022; Holzheu, Turner 2018; Landry, Turner 2020; Robinson, Botzen 2019; Botzen, Kunreuther, Mitchel-Kerjan 2019; Kei 2021; Robinson, Botzen, Duijndam, Molonaar 2021). Despite the extensive research conducted on the factors influencing the acquisition of real estate insurance from 2018 to 2022, few studies have examined the role of financial literacy in shaping this demand. Notably, it has been reported that 26% of Europeans purchase the first available motor or property insurance product they encounter (Čurak, Pepur, Kovač 2020, p. 362).

This paper aims to assess how financial literacy influences the demand for real estate insurance and to identify strategies to enhance financial literacy, thereby stimulating demand for real estate insurance services in Latvia. The proposed hypothesis suggests that financial literacy positively affects this demand. To achieve this goal and test the hypothesis, the research tasks include analysing factors affecting the demand and supply dynamics in the real estate market, outlining trends in the Latvian real estate insurance market from 2017 to 2021, surveying individual policyholders, and interviewing real estate insurance professionals.

Both qualitative and quantitative research methods were employed, including structured questionnaires, descriptive statistical analysis, ANOVA testing, and the calculation of dynamics and structural indicators. The qualitative research involved a compilation and critical analysis of studies on factors affecting demand for real estate insurance, along with expert interviews.

Factors Influencing Real Estate Insurance Decisions

J.Y. Lee, F. Ma, and Y. Li (2022) identify that property owners' decisions regarding wildfire risk mitigation are influenced by various factors, including property type, value, financing options, mortgage status, risk perceptions, and past experiences (Lee, Ma, Li 2022, p. 1528). C.J. Kei (2021) underscores that awareness of potential risks, risk perception, and pricing play crucial roles in the decision to obtain real estate insurance (Kei 2021, p. 77). T. Holzheu and G. Turner (2018) emphasize the influence of economic development, exposure to real estate risks, the availability of mortgage credit, and savings on the decision to purchase real estate insurance (Holzheu, Turner 2018, p. 42). Increased exposure to real estate risks tends to heighten risk perception, which, in turn, boosts the demand for real estate insurance services (Holzheu, Turner 2018, p. 42).

Additionally, the individual risk attitudes of property owners impact their decisions to purchase real estate insurance products. P.J. Robinson and W.J.W. Botzen (2019) find that perceptions of flood risk form the demand for flood insurance (Robinson, Botzen 2019, p. 2522). Similarly, C. Landry and D. Turner (2020) conclude that risk perceptions significantly influence the demand for flood insurance among U.S. coastal residents (Landry, Turner 2020, p. 16). W.J.W. Botzen, H. Kunreuther, and E. Michel-Kerjan (2019) suggest that real estate owners may opt to purchase flood insurance and take preventive measures to mitigate future risks (Botzen, Kunreuther, Michel-Kerjan 2019, p. 166).

Risk perception remains a pivotal factor in the decision to obtain real estate insurance. According to T. Holzheu and G. Turner (2018), such insurance is often a requirement for mortgage approval. Consequently, where mortgage credit is accessible, the demand for real estate insurance typically increases (Holzheu, Turner 2018, p. 42). They also point out that a lack of financial resources often leads to underinsurance against natural disaster risks, particularly among lower-income households (Holzheu, Turner 2018, p. 40). Savings and insurance can act as substitutes; if households have savings, they may cover losses from their funds, while the absence of savings necessitates insurance to mitigate the consequences of risk events (Holzheu, Turner 2018, p. 42).

Furthermore, recent studies have explored how past experiences with risks affect the demand for real estate insurance. P.J. Robinson and W.J.W. Botzen (2021) indicate that prior loss experiences influence the demand for flood insurance (Robinson, Botzen, Duijndam 2021, p. 2). Research by C. Landry and D. Turner (2020) reveals that expectations regarding risk occurrences affect actions taken by real estate owners to lessen potential consequences, subsequently fostering a positive impact on flood insurance acquisition (Landry, Turner 2020, p. 16). However, none of the aforementioned studies adequately address financial literacy as a determinant in the purchase decision of real estate insurance.

Financial literacy emerges as a significant factor affecting aggregate demand within the non-life insurance market. M. Churak, S. Pepur, and D. Kovach (2020) affirm its influence on non-life insurance demand (Churak, Pepur, Kovach 2020).

Financial Literacy and Property Insurance Claims

The origins of financial literacy can be traced back to the U.S. in 1787, with J. Adams advocating for its necessity to navigate economic challenges caused by a lack of public understanding of credit and currency (Garg, Singh 2018, p. 174). Recent literature primarily defines financial literacy through the OECD's framework, which encompasses awareness, knowledge, skills, attitudes, and behaviors essential for making informed financial decisions that enhance individual financial well-being (Churak, Pepur, Kovach 2020, p. 363; Goyal, Kumar 2021, p. 80; Swiecka, Yesildag, Ozen, Grima 2020, p. 2). Various authors contribute additional definitions, incorporating elements such as basic financial knowledge and the ability to execute simple financial calculations (Goyal, Kumar 2021, p. 81).

According to B. Swiecka et al. (2020), financial literacy is a critical component of sound financial decision-making (Swiecka, Yesildag, Ozen, Grima 2020, p. 2). It comprises three key elements: attitudes toward finance, financial behavior, and financial knowledge (Garg, Singh 2018, p. 175; Swiecka, Yesildag, Ozen, Grima 2020, p. 3). Financial knowledge refers to an individual's understanding of fundamental financial concepts, often synonymous with the term financial literacy (Garg, Singh 2018, p. 176). B.C. Xu et al. (2022) affirm that financial knowledge positively influences awareness of the necessity for insurance (Xu, Xu, Zhao, Zhang 2022, p. 2).

Various studies highlight different dimensions of financial knowledge, with the OECD's Financial Literacy Measurement Survey categorizing it into understanding simple and compound interest, the effects of inflation on prices and investments, and personal finance management. N. Garg and S. Singh (2018) reference a 2012 study illustrating that financial literacy encompasses an individual's knowledge of their financial situation. The authors further explain that financial behavior reflects economic beliefs and expectations regarding outcomes, with financially literate individuals demonstrating improved financial planning and risk management capabilities (Garg, Singh 2018, p. 177).

M. Churak et al. (2020) emphasize the crucial role of financial literacy within the non-life insurance context, asserting that it fosters risk awareness and understanding of associated benefits. Their analysis, referencing a Eurobarometer survey from 2012, reveals that a significant portion of individuals (26%) purchase the first insurance product they encounter (Churak, Pepur, Kovach 2020, p. 362). The authors argue that to enhance non-life insurance demand in Europe, initiatives aimed at improving financial literacy among the population are essential (Churak, Pepur, Kovach 2020, p. 376). Similarly, F. Pitthan and K.D. Witte (2021) affirms the positive correlation between financial literacy and insurance demand (Pitthan, Witte 2021, p. 14).

A 2022 study by J. Shao et al. investigates various factors influencing the demand for real estate insurance against flood risks in Japan, including financial literacy as a contributing factor (Shao, Hoshino, Nakaide 2022, p. 7). Different methodologies are employed to assess financial literacy, including surveys conducted by Japan's Central Bank (Shao, Hoshino, Nakaide 2022, p. 7) and the OECD (OECD INFE, 2011), which utilize statistics on higher education graduates to evaluate literacy levels (Churak, Pepur, Kovach 2020, p. 370). The widely recognized “Big Three” Financial Literacy Questions, designed by A. Lusardi and O.S. Mitchell, serve as a common instrument for assessing financial literacy (Lusardi 2019, p. 2).

The hypothesis asserts that financial literacy positively influences the demand for real estate insurance. Based on theoretical research findings, a conceptual model has been established (see Figure 1).

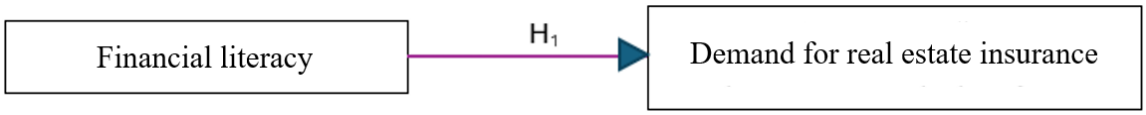

Fig. 1. Conceptual model of the paper

Source: Created by the authors.

The model excludes mortgage credit as an influencing factor for real estate insurance demand since insurance is typically a prerequisite for securing a mortgage. However, mortgage credit is included in demographic inquiries.

Demand for Property Insurance from Respondents' Perspective

A survey conducted from April 1 to April 19, 2023, included 153 respondents. An evaluation of the initial responses indicated that one respondent (respondent No. 50) provided inconsistent answers, resulting in their exclusion from the analysis. Thus, the final sample consisted of 152 valid responses, facilitating the calculation of confidence levels and margins of error, with a confidence level of 90% and a margin of error of 6.2%.

The survey, distributed through the Facebook group "Polls", which has 1 100 members, assessed demographic characteristics such as sex, age, and residence. To evaluate the demand for real estate insurance, respondents were asked if their homes were insured. The results revealed that 71% (108 respondents) had home insurance, indicating a significant demand for real estate insurance (see Figure 2).

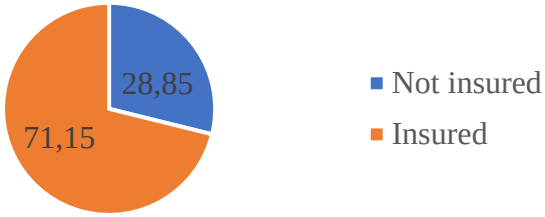

Fig. 2. Real estate insured or not insured (% of total respondents, n=152)

Source: Created by the authors.

Following the assessment criteria established by A. Lusardi and O.S. Mitchell (2011), individuals demonstrating high financial literacy accurately answered all three survey questions. The survey results indicated a medium to advanced level of financial literacy among respondents (see Figure 3).

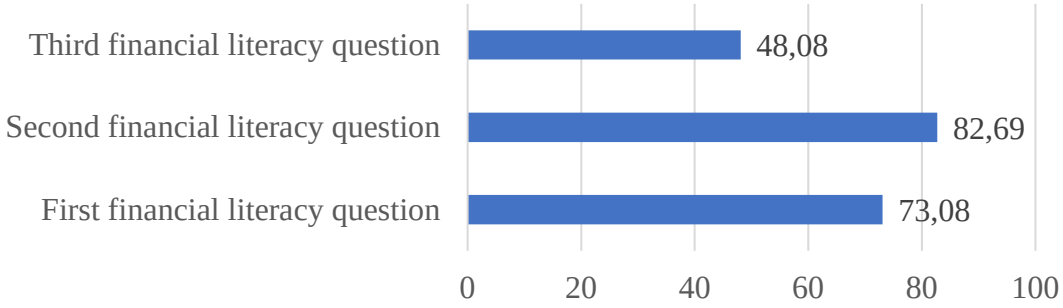

Fig. 3. Correct answers to financial literacy questions (% of total respondents, n=152)

Source: Created by the authors.

The first question, addressing interest rates' effects on cash deposits, was answered correctly by 73% (111 respondents). Notably, the second question, concerning the impact of inflation on income and savings, received the highest correct response rate at 83% (126 respondents). Conversely, the third question, related to risk diversification, yielded the lowest correct answer rate at 48% (73 respondents).

The distribution of correct answers to the financial literacy test questions is illustrated in Figure 4.

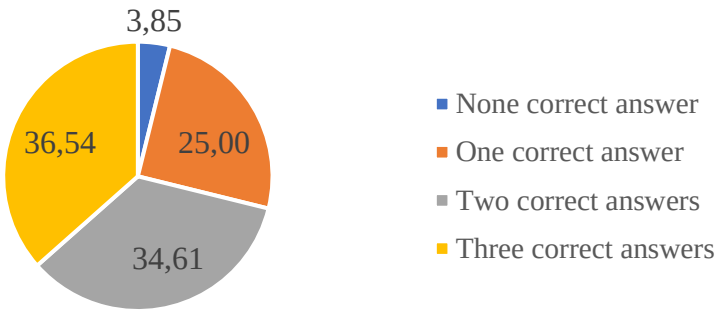

Fig. 4. Correct answers to none, one, two, and three questions on the financial literacy test (% of total respondents, n=152)

Source: Created by the authors.

A majority, 37% (56 respondents), accurately answered all three questions, while 35% (53 respondents) answered two correctly. A small fraction, 4% (6 respondents), did not answer any questions correctly, indicating that 29% of the participants exhibited low financial literacy levels.

To analyze the effect of financial literacy on real estate insurance demand, J. Dudele (2023) performed an ANOVA test using data from the questionnaires. The null hypothesis posited that *advanced financial literacy* ***does not*** *affect the demand for real estate insurance*, while the alternative hypothesis suggested that *advanced financial literacy affects the demand for real estate insurance.* With a significance level of 0.062 ($\alpha = 0.062$) and a confidence level of 94%, the ANOVA results presented in Table 1 indicate that the p-value is significantly lower than the designated significance level (p-value $0.000000000075826 \leq \alpha\ 0.062$), leading to the rejection of the null hypothesis and confirmation of the alternative hypothesis.

Table 1

ANOVA test for hypothesis testing

Source of Variations	SS	df	MS	F	P-value	F crit
Between Groups	21.62	1	21.62	58.18	0.000000000075826	3.59
Within Groups	26.75	72	0.37			
Total	48.37	73				

Source: Created by the authors.

Thus, at a significance level of 6.2%, the findings strongly support the assertion that advanced financial literacy impacts the demand for real estate insurance.

Interviews with insurance industry representatives further corroborate that enhancing financial literacy can stimulate demand for real estate insurance. This influence manifests in a greater awareness of the long-term financial implications of insurance decisions. In the context of real estate insurance, financial literacy encompasses risk awareness as well, suggesting that improving financial literacy can facilitate a better understanding of the necessity to diversify risks associated with real estate, thereby transferring those risks to insurance providers and safeguarding individual financial positions.

Conclusions. Through an analysis of studies published from 2018 to 2022, respondent surveys, hypothesis testing via ANOVA, and interviews with insurance professionals, evidence has been estab-

lished demonstrating that financial literacy significantly affects the demand for real estate insurance. Surveys indicate that the financial literacy levels of consumers utilizing real estate insurance services are generally rated as medium. The findings reveal that while a majority of respondents possess medium to advanced financial literacy, with 37% answering all three financial literacy questions correctly, a notable 29% exhibit low financial literacy levels.

Consequently, both theoretical insights and interviews with field experts affirm that financial literacy impacts the demand for real estate insurance. The relationship between financial literacy and real estate insurance demand is evident in the understanding of the long-term financial consequences associated with insurance decisions. In the realm of real estate insurance, financial literacy also reflects an awareness of risks, bolstering the case for transferring those risks to insurance providers to protect individuals' financial well-being in the event of real estate-related risks.

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THE DEVELOPMENT OF AN INCLUSIVE ECONOMY COULD GIVE IMPETUS TO THE FORMATION OF DIGITAL NEO-FEUDALISM

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Abstract. At its core, an inclusive economy aims to create an economic system that benefits everyone and leaves no one behind. It goes beyond the traditional notion of GDP growth and focuses on improving the overall quality of life of all members of society. This perspective requires broadening the metrics used to assess economic success to include factors such as health, education, and social mobility.

One of the key components of developing an inclusive economy is called "financial inclusion" – providing people with the means to access, use and benefit from all financial services, such as bank accounts, credit, insurance, pension savings and investment products. McKinsey Global Institute's (MGI) estimates that to achieve approximate equality of opportunity for the world's population, additional resource growth from GDP would be needed at approximately 8 percent per year in the coming decades!

The MGI puts productivity growth at the heart of the solution. Globally, increasing productivity by about one percentage point a year, and upskilling 10 percent of the workforce to move into more productive sectors, could close up to two-thirds of the empowerment gap over the next decade. This upskilling depends on businesses creating more productive jobs and equipping workers with the skills to do them effectively (McKinssey&Company. 2024).

Our research in the field of labor productivity shows that despite the development of digital technologies and artificial intelligence, in the conditions of widespread slowdown in GDP growth, long-term inflationary processes, aggressive sanctions and customs policies, there is no possibility of sustainable growth in labor productivity (Baltgailis J., Simakhova A., Buka S. 2025). It seems that global structures see overcoming this slowdown in the universal introduction of digital currencies into the financial system, allowing state institutions, coupled with private digital giants, to take full control of transactions of the population and business, which, as stated: "Integrating economic inclusion into DEI (Diversity, Equity, and Inclusion) efforts enables broader societal changes that empower individuals and strengthen communities, ultimately contributing to a more just and resilient economy" (Oxford Review.2025).

In our opinion, the emerging system of economic blocs and countries, the contradictions between state institutions and private digital giants, the division of the financial sector into centralized and decentralized do not allow us to talk about the prospects for the formation of an inclusive economy in the near future. The goals and objectives for the development of an inclusive economy, which are proclaimed and developed by the state, often coincide with or are close to the goals and objectives of digital platforms and large corporations, which does not reflect reality and forms neo-feudal prospects for the economic development of the global world economy.

Key words: financial inclusion, tokenization, neo-feudalism, cash, licensing, control, audit.

Introduction. Today, over 1.7 billion adults worldwide are excluded from the formal financial system. This means nearly a third of all adults–including 8% of people within advanced economies–lack access to traditional banking services, including savings accounts, credit, loans, and insurance. Those trapped outside this system are stuck operating within the confines of the cash economy, over-reliant on

physical assets, susceptible to financial shocks and stressors, and cut off from means of wealth creation. Many countries associate attempts to create an inclusive economy with the development of state digital currencies, thanks to which central banks, the issuers of these currencies, will be able to take control of the financial activities of clients and provide them with maximum support. «An inclusive economy would help households to accumulate, hold, and pass on wealth to the next generation. One key component of this effort is sometimes known as "financial inclusion"–providing people the means to access, use, and benefit from all financial services such as bank accounts, credit, insurance, retirement savings, and investment products» (Aspen Institute. 2023). But most importantly, CBDCs can help deliver public goods and improve government service delivery, including, for instance, government-to-citizen payments, such as social welfare disbursements (e.g., COVID stimulus checks) and loan and subsidy programs for smallholder farmers or small-medium sized enterprises. In fact, nearly 35% of adults in low-income countries opened their first financial account to receive government payments. (TBI. 2022).

About 94% of central banks are engaged in some form of work on CBDCs. (Atlantic Council. 2023). CBDC is a central bank liability and is described as a digital form of a country's sovereign currency, issued by it and backed by government credit. In this context, the issuance of a CBDC, although it may require enormous costs to develop supporting technologies, will reduce costs in the long term and contribute to financial inclusion. The fact is that one of the fundamental issues in the implementation of the digital currency of central banks, CBDC, indicates that there are unprecedented opportunities to control customer transactions, whose accounts are opened directly with the Central Bank and have the opportunity to control processes related to money laundering, which will naturally improve tax collection and create social protection for the population and form an inclusive economy. The difference between a CBDC and the "digital money" that consumers use using cards or mobile applications is that the responsibility lies with the Central Bank, and not some commercial bank. There are three known CBDC options: wholesale (token-based) and two types of retail (token- and account-based). The differences lie in the degree of availability and the underlying technology. Retail CBDC is an accessible digital currency that can be used for retail transactions and other purposes, while wholesale CBDC has access restrictions as it is intended for banks and other financial institutions and is used for digital settlement of wholesale transactions. There are three main types of CBDC architectures for retail. In all of them, the Central Bank is the only institution that issues and redeems CBDC. Under the so-called indirect, or two-tier, architecture, the central bank issues CBDC to consumers through intermediaries, which are mostly commercial banks. In this case, consumer-owned CBDCs represent claims on the intermediary, i.e. the commercial bank. In the other two types, consumers have direct demands on the Central Bank. In the direct CBDC model, the Central Bank processes all payments in real time and keeps records of all retail balances. The hybrid CBDC model combines elements of direct and indirect solutions. Consumers have direct claims to the Central Bank, but intermediaries process payments in real time. In order to combine numerous fiat and digital money in the payment system, an active process of tokenization of assets is underway. CBDC could be offered in the form of deposit accounts with the central bank to all households and corporates. Although scaling is not innovative per se, it may be technologically challenging. For example, in the in the case of the Eurosystem, the number of accounts could grow from around 10,000 to some number between 300 and 500 million (ECB working paper Nr.2351). Deposit based CBDC seems simpler and can protect better against money laundering, It also seems to allow for a high level of security and control of the circulating amount of CBDC base money legal status and/or some minimum criteria on payment or economic activity. In this case, CBDC will be strictly personalized and will provide the opportunity to control all customer settlements from the Central Bank.

The central bank could offer a digital token currency that would circulate in a decentralized way without central ledger. This is often associated with anonymity, i.e. meaning that the central bank would not know who currently holds the issued tokens (like in the case of banknotes).

According to calculations based on mathematical models, the International Monetary Fund has determined that issuing CBDC increases total lending by 2.2%. This is driven by a 17 p.p. increase in the share of the population with a bank account (from 75% to 92%). This offsets the bank disintermediation effect, i.e. the flow of savings from deposit accounts into CBDC wallets. 14% of bank account holders (or 13% of the overall population) choose to save in CBDC instead of in deposits. Together, the share of the population who saves in a deposit account increases 5% after CBDC issuance (from 75% to 80%) which boosts lending. 47% of the population chooses to make payments in CBDC. Aggregate profits from investing in household production technologies increases by 5%. Total household welfare (utility) increases by 0.19% from CBDC issuance (IMF. 2023).

The tokenization of money and assets has great potential, but so far initiatives have been carried out in isolation, without access to central bank money and the trust it creates. The process of centralizing these efforts has begun, which will allow for the control of operations across public and private chains. A new type of financial market infrastructure – a unified ledger – could capture the full benefits of tokenisation by combining central bank money, tokenised deposits and tokenised assets on a programmable platform. Moreover, by having "everything in one place", a unified ledger provides a setting in which a broader array of contingent actions can be automatically executed to overcome information and incentive problems. The system should be compatible with external third-party technology platforms and applications that facilitate activities such as securities settlement, exchange/clearing, and cross-border payments, among others. Where these third-party systems are built on distributed ledger technology, the use of smart contracts across all platforms should facilitate the programmability of cash and payment functions. The practical effect of this is that participants are able to manage their entire portfolio of cash and collateral virtually, from a "single liquidity pool," rather than parking capital through fragmented nostros, correspondents, and domestic central securities depositories. (BIS. 2023).

Review of digital currency regulation systems. At the same time, each country is developing a system of licensing, control and audit of issuers and participants in the cryptocurrency market. MiCA is a European regulation that regulates the cryptocurrency market. The process of issuing crypto-assets and listing crypto-assets on a trading platform.

MiCA also introduces rules regarding the prevention of market abuse by regulating insider information disclosure obligations and prohibiting insider trading, and conduct that constitutes the market manipulation of crypto-assets.

The Bank of England will control the reserve requirements, capital requirements, redemption requirements and reward requirements for all stablecoins in its system. Reserves must be highly liquid, high-quality instruments, with the Bank of England advocating for the use of central bank deposits as reserves.

In the United States, stablecoins are regulated at the state level as well as, for financial crimes purposes only, at the federal level. In most states, stablecoin issuers are required to register as money transmitters, while a few states have created more targeted and robust regulatory regimes for stablecoins,

The Monetary Authority of Singapore (MAS) finalized its framework for regulation of single-currency stablecoins (SCS) The framework, similar to regimes in other jurisdictions, will require maintenance of highly liquid, high-quality reserves having a value that at all times is at least 100 percent of the value of outstanding SCS and timely satisfaction of redemption requests at par, which can be no later than five business days of the request.

In Japan, a regulatory framework requires that the stablecoins, referred to as electronic payment instruments in the regulations, be linked to a fiat currency, maintain reserves in demand deposits and guarantee redemption at par, and limits issuers to licensed banks, registered money transfer agents and trust companies that have registered as electronic payment instrument service providers (EPISP).

In Canada only registered platforms can offer crypto-fiat conversions. Banks and payment processors must comply with Know Your Customer (KYC) and AML laws. Exchanges are integrated with traditional banking systems but under heavy scrutiny.

In UAE licensed exchanges (e.g., BitOasis, Rain) offer AED-crypto conversions. Banking integration improving, but some traditional banks still avoid crypto clients. The UAE has established a Regulatory Lab, RegLab, to proactively anticipate and develop future legislation that will govern the use and application of emerging technologies in the UAE in a way that maximizes benefits and minimizes risks. It aims to create projects that can be adopted by policymakers, legislators, and regulators around the world.

Switzerland, the regulation of cryptocurrency funds and Decentralized Finance (DeFi) is robust and designed to balance innovation with financial stability and investor protection. The key regulator is the Swiss Financial Market Supervisory Authority (FINMA), and the country is known for being one of the most crypto-friendly jurisdictions in the world. The regulation of cryptocurrency funds in Switzerland is one of the most developed and transparent in the world. Switzerland's legal and regulatory framework treats crypto assets seriously and integrates them into existing financial regulation through clear guidance and enforcement. The primary regulatory authority is the Swiss Financial Market Supervisory Authority (FINMA). Crypto funds are fully regulated under Swiss law, similar to traditional funds, with clear licensing, custody, and investor protection rules. DeFi is assessed based on function and control. Truly decentralized systems may escape regulation, but interfaces, developers, or fee collectors are likely to be regulated. Switzerland promotes innovation via the DLT Act and FinTech sandbox, making it one of the most progressive yet responsible jurisdictions globally.

As can be seen from this review, in all countries, in addition to licensing, it is assumed that crypto funds will be fully regulated by law, like traditional funds, with clear rules for licensing, storage and protection of investors.

Methodology. To achieve the goal, the article uses general scientific methods of analysis and synthesis, systematization and comparison of data. The information base was scientific articles, monographs, open statistical data of Internet resources from which we are trying to understand the foundations and reasons for the growth of the neo-feudalism system. The development of neo-feudalism in modern societies has been extensively studied by Katherine V.W. Stone, Robert Kuttner (2000), Vladimir Menshikov (2002), Jodi Dean (2020) and discussions have taken place on the pages of The American Prospect (2020) and The Structural Lenz (2025).

Results. Situation that reflects the competition between CBDC and private currencies is fundamentally important. As noted by the BIS, a key aspect of financial system is the "singleness of money," explaining that "singleness ensures that monetary exchange is not subject to fluctuating exchange rates between different forms of money, whether they be privately issued money (e.g., deposits) or publicly issued money (e.g., cash)." For institutional investors, it is unlikely that a digital cash instrument that does not comport with the principles of the "singleness of money" will be accepted as a trusted, reliable source of digital cash. (McCormack J. 2024). After all, if private currencies, such as stablecoins, will conquer the sphere of transactions between clients and become the cheapest and fastest method of payments, without special control by regulatory authorities, then the stability of CBDC, the possibility of exchanging them for fiat "electronic money" and cash at a rate of 1:1 may be disrupted and confidence in central banks undermined. It is not for nothing that the governments of China and India have banned the circulation of private cryptocurrencies on their territory, and this was justified precisely by the stability of national CBDCs. Today, it can be said that by banning private currency, China has managed to create an international system of stable settlements in a state cryptocurrency, which is already trusted by 16 countries and which can spread to the whole world. (Invest Offshore. 2025).

Payment and settlement operations and non-cash circulation are based on the system of interbank payments. Digital currencies of central banks, as the name suggests, assume the existence of a monopoly of central banks on their issuance and make it unnecessary for commercial banks to multiply the money supply. Thus, the central bank will be the creator, operator, and custodian of the pool of digital currencies. A digital euro based on deposit accounts directly with the central bank.

The monopoly of the central bank, according to the developers, should create opportunities for the formation of an inclusive economy and the ability of the state, in cooperation with Digital platforms (Big Data), to take control of all business and human initiative, which creates the basis for the emergence of neo-feudalism. In addition to the development of a two-tier banking system, a one-tier banking system is also proposed (Figure 1), where there is an even greater concentration of power between the Central Bank and the Big Data, and where there are no intermediaries in the form of commercial banks. (Baltgailis J., Menshikov V., 2023)

This new aristocracy derives its power not from direct control over land and peasants, but from ownership of the digital infrastructure that increasingly mediates human existence. Social media platforms, payment systems, communication networks, and artificial intelligence systems form the core infrastructure of modern life. Control over these systems gives their owners a power that medieval lords would have recognized immediately–the power to permit or deny, to elevate or suppress, to grant access or impose exile. (Structural Lenz. 2025).

In addition, the European Commission is pushing for countries to start storing data on citizens en masse, despite the fact that this is officially prohibited in Europe as a serious violation of fundamental human rights. According to the Commission's plan, service providers will be required to store information about people on a large scale. (European Commission. 2024). In the Commission's interpretation, this includes: information about the user, sender and recipient of the message, the location of the device, date, time, duration, as well as any other data that does not contain the text or content of the messages. Until now, the principle in the European Union was that such data had to be deleted immediately after it was no longer needed, since it concerns the private life of citizens. Long-term storage of such data was considered a violation of the fundamental right – the right to privacy.

While citizens are protected from unreasonable searches and seizures by constitutional constraints on government surveillance, the tech giants know far more about us, often with our "consent," than the government does. The giant tech industry has fought off efforts to regulate its use of personal data. Instead, companies such as Google, Apple, and Amazon have invented their own jurisprudence, hidden in obscure terms of service, to govern the consent of users to the commercial use of personal data. (The Ameican Prospect. 2020)

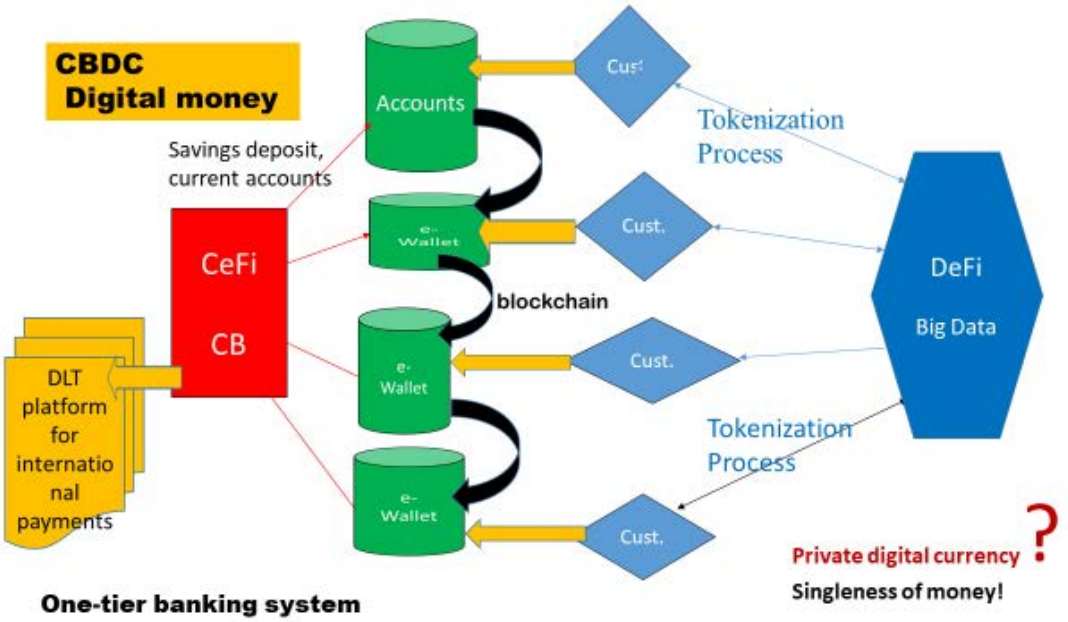

Fig. 1. (The scheme was developed by the authors)

Cash remains a popular means of exchange around the world, especially in developing markets. Even in Europe, often at the forefront of payment innovation, cash was used in 52% of transactions in 2024, according to a recent report by the European Central Bank (Mastercard. 2025). Most central banks have said they are committed to issuing and distributing physical cash so long as there is demand for it. But just as cards, real-time payments and, more recently, digital wallets have offered people more choices and security, so could CBDCs. According to the creators of CBDCs, the new version of government money offers a way to reduce the inefficiencies of printing and moving money – the cost of managing physical money can reach 1.5% of a country's GDP (Mastercard. 2025). As connectivity and smartphone penetration grow, CBDCs could also be a way to include more people in the digital economy who are currently excluded from mainstream financial services. In our opinion, the rejection of cash is one of the manifestations of neo-feudalism, as it makes people more dependent on the state and digital giants . Meanwhile, six countries – Austria, Holland, India, Mexico, Hungary and Slovakia – have placed their citizens' right to use cash under constitutional protection. There was an attempt to introduce a similar law in Latvia (Bautista-González M. 2022).

People's Bank of China unveiled a pivotal shift in global finance: the digital RMB cross-border settlement system is now fully connected to the ten ASEAN nations and six Middle Eastern countries. This move instantly expands digital yuan interoperability to cover nearly 38% of global trade, enabling participants to bypass the SWIFT network long dominated by the U.S. dollar. One of the most critical aspects of this shift is the capacity of the digital RMB to facilitate transactions without relying on SWIFT or the US dollar. Traditionally, SWIFT has served as the primary communication method for banks handling international payments. However, dependence on the US dollar has often been perceived as a vulnerability for countries striving for economic sovereignty. By creating an independent digital payment network, China offers an attractive alternative for nations seeking to reduce their reliance on the US dollar. China's digital currency bridge compresses settlement time to just 7 seconds. In a landmark trial between Hong Kong and Abu Dhabi, a payment from a Chinese firm to a Middle Eastern supplier was completed in real-time–without six layers of intermediary banks, and at 98% lower transaction costs (Invest Offshore. 2025).

The implications extend far beyond speed and cost. The digital RMB's blockchain architecture embeds automated compliance features, such as traceability and anti-money laundering protocols, directly into each transaction. Today, over 87% of countries worldwide are now compatible with the digital RMB system, and cross-border payments have topped $1.2 trillion USD. While Washington debates the future of the dollar in a digital age, Beijing has already built a blockchain-based global settlement network spanning more than 200 countries (Invest Offshore. 2025)

This path to monetization is particularly evident in the example of asset tokenization. In essence, from existing financial fiat and digital assets, real services and tangible production create monetary assets, that is, the essence of these assets themselves is removed and transformed into a new monetary quality, endowing them with the ability to be actively traded on digital platforms without intermediaries and where Big Data will play the main role and benefit Figure 2.

Tokenization of Real-World Assets (RWA) involves converting rights to various assets–ranging from bonds and stocks to real estate and cultural properties–into blockchain-based digital tokens (Figure 3.) This innovation promises to enhance liquidity, transparency, and accessibility, democratizing asset ownership by leveraging modern technologies.

Blockchain technology plays a pivotal role in these digital transformations, acting as a secure and immutable ledger. It ensures that data is stored and recorded without the possibility of unauthorized changes, copying, or deletion. As a digital "book of trust," blockchain serves as a bridge between the physical and digital worlds. Through distributed ledger technologies (DLT), trust and transparency are redefined, allowing objects or rights from the physical world to be recorded digitally via unique identifiers. Tokenization imbues these objects with new properties that can be utilized in economic activities.

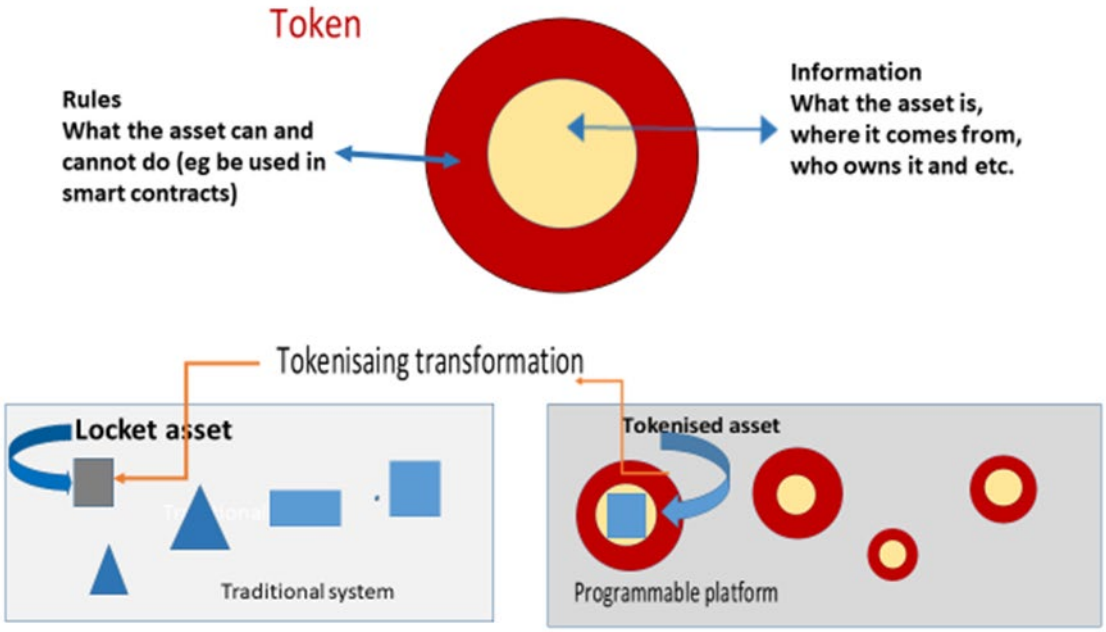

Fig. 2. BIS (2023)

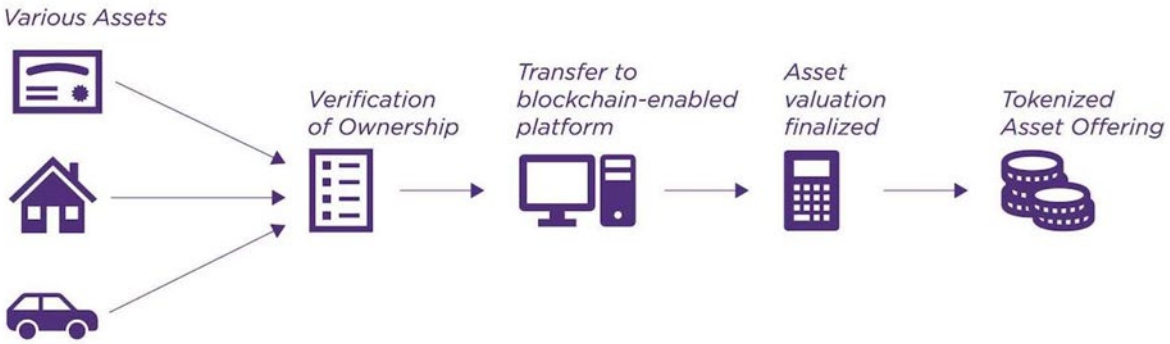

Fig. 3. https://uk.images.search.yahoo.com/search/images?

In a digital age where trust is paramount, several elements are critical for ensuring confidence in the digital environment: trust in content, identity, ownership, authenticity, and truth. Tokens will play a foundational role, representing physical assets in the digital realm while expanding their functional capabilities. Tokens will encapsulate identity and value within a digital protocol.

The purpose of tokenization of backed assets is to create a more accessible and liquid way of investing in these assets. Due to tokenization, assets are divided into small shares represented by digital tokens, allowing investors to buy these shares at a lower cost. Tokenized assets pave the way for a much easier process of trading and transferring ownership since tokens can be easily transferred and traded on digital platforms.

In general, any entrepreneur should start working in combination on the CeFi and Defi money markets now. The problem is that with the advent of state money in the form of CBDC, this money will be issued only by central banks and can only be operated by opening accounts with the Central Bank.

Of course, for business, the low cost of transactions, fast currency exchange and speed of transfers are very important, which greatly reduces the cost of business, increases the trust of partners and creates confidence in the stability of business. This is especially important for countries with an unstable political and economic system, uncertainty in the local currency. A survey of 2,541 adults across Brazil, India, Indonesia, Nigeria, and Turkey, shows that 47% use stablecoins for better savings rates, 43% for improved currency conversion, and 37% to access dollars. Though limited in scope, this data suggests stablecoins are becoming versatile financial tools in emerging markets, addressing a range of economic needs beyond traditional crypto applications. (Crypto Valley Journal. 2024).

However, every business must understand that any asset is subject to market shocks! TerraUSD stablecoin's luna subsidiary token fell from $100 per unit to $0 in 2022, wiping out billions of dollars in the crypto market (CNBC. 2022). But collapses of prominent stablecoins have shown that not all of these assets are, in fact, "stable," particularly if the stablecoin is not backed on a 1:1 basis by high quality and liquid reserve assets, making them prone to "bank-run" dynamics.

The results and discussion: McKinsey estimates that tokenized market capitalization by asset class could reach around 2 trillion dollars by 2030 (excluding cryptocurrencies and stablecoins). The pessimistic and optimistic scenarios range from about 1 trillion to about 4 trillion dollars, respectively. This estimate excludes stablecoins, including tokenized deposits, wholesale stablecoins, and central bank digital currencies (CBDCs) to avoid double counting (McKinsey, 2024). Tokenization remains a central pillar of BlackRock's digital asset strategy. The company has set an ambitious goal of tokenizing 10 trillion dollars worth of assets in partnership (Forbes. 2024). In this case, the key role of tokenized assets on trading platforms creates an opportunity for digital giants to multiply cash flows by attracting more participants in the emerging inclusive economy and, accordingly, to ensure the redistribution of these flows in accordance with their own, rather than public interests.

This entire tokenization process is taking place against the backdrop of the new US administration's attempts to strengthen the dollar's global position and make the digital dollar the world's leading currency. US presidential adviser Stephen Miran argues that the US dollar has been continually overvalued due to its status as a reserve currency. This has benefited financialized sectors of the economy and wealthy Americans, but has put a burden on American manufacturing by making it cheaper to buy from abroad. In his view, these tensions will be resolved by policies that preserve the dollar's status but improve burden sharing with trading partners. International trade policy will attempt to recapture some of the benefit that the dollar's reserve status transfers to trading partners and link that economic burden sharing to defense burden sharing (Financial post. 2025).

In any feudal system, the lords fight for their own interests; they have little interest in an inclusive economy; what is at stake here is profit and income. Most major jurisdictions, however – including the United States – are still working towards establishing their own regulatory frameworks. By way of example, Tether, the largest stablecoin issuer, is currently based in El Salvador, which lacks any prudential framework for stablecoins. This fragmented approach prevents a global level playing field and can open the door to new risks and systemic vulnerabilities “We must therefore remain alert to developments in other jurisdictions and advocate for globally aligned regulations for stablecoins,” – emphasizes ECB President Christine Lagarde (ECB. 2025). She believes that in this context, accelerating progress towards a digital euro is a strategic priority. Beyond addressing some of the risks posed by stablecoins, a digital euro would help safeguard Europe’s bank-based financial and monetary system. Not only would it strengthen Europe’s strategic autonomy, but it would also ensure an innovative and resilient European retail payments system.

And the struggle for key positions in the global economy in the context of the transition to digital currencies has already begun. Economic Advisor to the President of the United States Miran voiced concerns about the current financial regulatory system, calling it overly restrictive and harmful to the functioning of financial institutions. He emphasized the need for innovation as a key driver of growth, particularly highlighting cryptocurrency’s transformative potential. “Crypto could play a significant

role in driving innovation and contributing to the economic boom envisioned for a future Trump Administration." (CCN. 2024).

While our citizens are constitutionally protected from unreasonable searches and seizures, the tech giants know far more about us, often with our "consent," than the government does. The giant tech industry quietly pays fines for trying to force the government to regulate their use of personal data. We have already said that there are companies that invent their own rules and laws to regulate consumer consent for the commercial use of personal data. There is an active battle for the personal data of the population, with huge customer databases being stolen and resold around the world, allowing digital giants to actively influence the politics and economy of countries. Just look at Figures 4 and 5 to see how the big fines are mounting for corporations that use personal data illegally in business. In the absence of compensating government regulation, the digital industry will create its own private law, using its market power to increase profits and protect itself from competition or government oversight. In any case, the development of an inclusive economy to a certain extent ensures greater employment, increased social well-being of the population without revolutionary upheavals and other shocks, and will support economic stability. For the state and corporations, it is economic stability that is the primary reason for supporting inclusiveness.

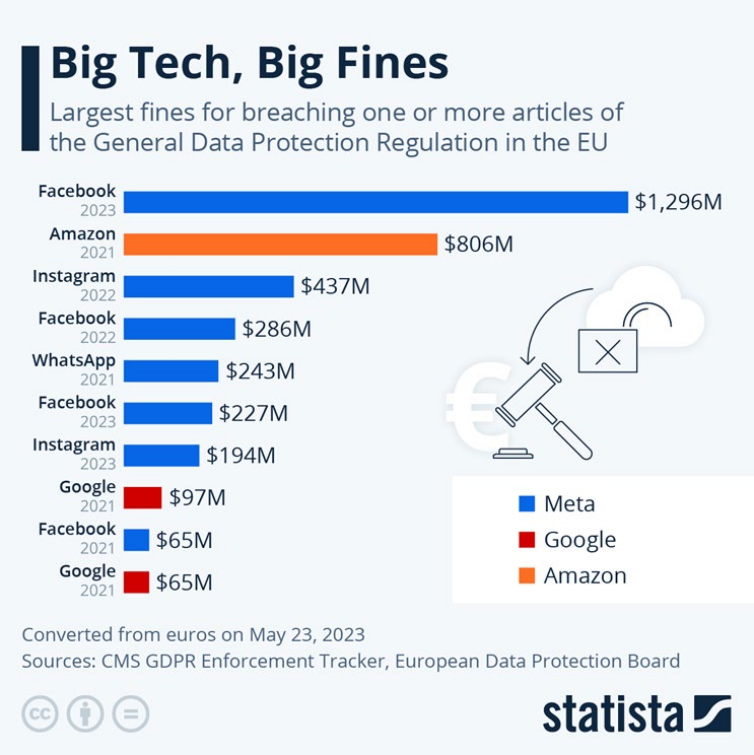

Fig. 4. (Statista, 2023)

What makes the current situation particularly dangerous is the convergence of three historical trends that have previously appeared separately: the transnational power of capital (reminiscent of the late 19th century), the alliance between wealth and authoritarian politics (similar to the 1930s), and unprecedented technological capabilities for social control. This convergence creates possibilities for authoritarian control that would have been unimaginable to previous generations (The Structural Lens. 2025). In the conditions of democratic development, some authors can call such reasoning speculative? The greatest German philosopher and expert in logic Georg Wilhelm Friedrich Hegel noted that the speculative is nothing other than the rational (and precisely positively rational) insofar

as it is thought! Hegel believed that the speculative, in its true meaning, is not something purely subjective, but on the contrary, is precisely that which contains in itself, removed, those opposites beyond which reason does not go and precisely by this reveals itself as concrete and as totality.

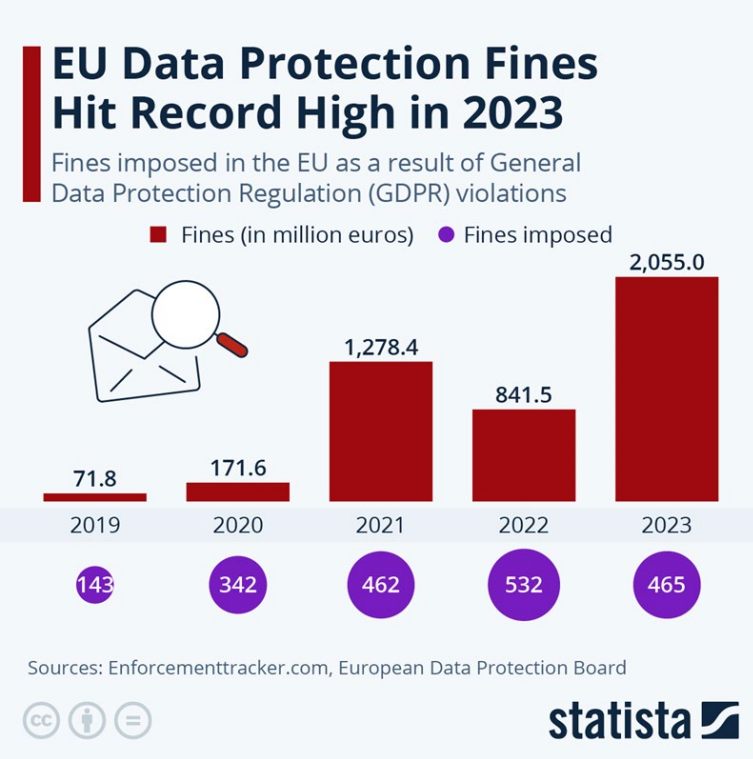

Fig. 5. (Statista, 2023)

Elon Musk's transformation from technological innovator to political broker, on the other hand, perfectly illustrates the evolving rivalry between the state and private business. His acquisition of Twitter/X represents more than just a business deal – it marks a direct intervention of technological power into the mechanisms of democratic dialogue. The subsequent transformation of the platform demonstrates how private ownership of public spaces can change the political reality that drives the foundations of neo-feudalism.

There are more and more proposals in the world that democratic movements should develop new funding mechanisms independent of traditional financial systems, which are increasingly subject to oligarchic control. It is proposed to create an international framework to prevent algorithmic manipulation of public discourse, to develop new antitrust frameworks that solve the problem of data monopolies, to create state alternatives to private digital platforms. But here we need to clearly understand where to get investments for these developments and, most importantly, if the state is closely connected with digital giants, which often have resources that are inaccessible even to the state and operate all over the world, and such a state will not support these efforts or will even slow them down.

As we have already noted, the new aristocracy derives its power from the possession of digital infrastructure, which is increasingly becoming a mediator of human existence, and control over it is becoming key in the system of struggle for influence in the global economy. The growing possibility of the formation of neo-feudalism will be supported by the global economy, where the most powerful and technologically advanced players are trying to determine the rules of the game. In the context of growing competition in the global economy between the state and Big Tech for power and client assets, neo-feudal forms of organizing public life may become a clear result of competitive struggle, where the winners, as a rule, are not judged!

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LATENT STRUCTURES AND RECOVERY PATHS: A COMPARATIVE STUDY OF BALTIC SOCIO-ECONOMIC TRENDS

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Abstract. This study investigates the post-COVID socio-economic recovery of the Baltic States – Estonia, Latvia, and Lithuania – through the lens of Principal Component Analysis (PCA). Using standardized data from 2019 to 2023, PCA is employed to extract latent dimensions underlying key economic and social indicators. The analysis reveals distinct structural profiles across the three countries, highlighting differences in resilience, adaptability, and policy effectiveness. Estonia demonstrates consistent macroeconomic stability and institutional strength, Lithuania shows dynamic but uneven growth, while Latvia exhibits gradual recovery marked by short-term volatility. By reducing multidimensional data into interpretable components, PCA enables a nuanced comparison of recovery trajectories and offers insights into the structural factors shaping regional development. The findings contribute to the understanding of post-crisis adjustment in small open economies and inform future policy design within the EU context.

Key words: Baltic States, post-COVID recovery, post-crisis development, economic policy, socio-economic indicators, Principal Component Analysis (PCA).

Introduction. The COVID-19 pandemic triggered an unprecedented global disruption, reshaping economic structures, social systems, and governance models across nations. For the Baltic States – Estonia, Latvia, and Lithuania – the crisis exposed existing vulnerabilities while simultaneously accelerating strategic shifts in digitalization, fiscal policy, and labour market reform. Despite their shared geographic and institutional context, the three countries exhibited markedly different responses and recovery trajectories, shaped by distinct policy choices and structural conditions.

This study investigates the post-pandemic socio-economic development of the Baltic States through a comparative lens, focusing on the period from 2020 to 2023. It examines how each country adapted to the crisis, implemented recovery measures, and navigated the challenges of inflation, unemployment, and demographic change. Particular attention is given to the role of EU integration, public debt dynamics, and the evolving labour market landscape.

Research aim: To conduct a comparative analysis of the socio-economic recovery trajectories of Estonia, Latvia, and Lithuania in the post-COVID period (2020–2023), using multidimensional and temporal methods to identify structural differences and policy-driven outcomes.

Research Objectives:

– To evaluate the impact of the COVID-19 pandemic on key macroeconomic and social indicators in the Baltic States.

– To apply Principal Component Analysis (PCA) for identifying latent factors influencing recovery.

– To compare national policy responses and their effectiveness in mitigating crisis effects.

– To formulate recommendations for enhancing resilience and convergence in small open economies.

– To compare current PCA-based findings with earlier results obtained using Dynamic Time Warping (DTW).

The scientific novelty of this research lies in its application of PCA to assess the structural dimensions of post-COVID recovery. PCA enables the identification of underlying patterns across a wide range of economic and social indicators, revealing differences in resilience, adaptability, and policy effectiveness among the Baltic States.

In addition, the study incorporates a comparative assessment with earlier findings based on DTW approach, previously used to analyse temporal convergence and divergence in recovery trajectories. This comparison highlights the complementary strengths of both approaches and helps refine interpretations of national development paths.

By applying PCA to a comprehensive dataset covering the years 2019-2023, the study contributes to a deeper understanding of how small open economies respond to systemic shocks and what structural factors influence their capacity for sustainable recovery. The findings have implications for regional policy design, particularly in the context of future crises and EU-wide convergence efforts.

1. The Baltic States and the Chronology of the COVID-19 Pandemic

Prior to joining the European Union in 2004, the Baltic States transitioned from centrally planned Soviet economies to market-based systems following their independence in 1991. This shift led to economic instability, high unemployment, and social unrest. EU accession marked a turning point, offering improved access to markets, investment, and financial resources.

Post-accession, all three countries experienced strong economic growth. Before joining, Latvia's gross domestic product (GDP) grew at 7.5% annually, Lithuania at 6.7%, and Estonia at 6.5%. These rates peaked around 2007 – Latvia reached 11.9% in 2006. Between 2004 and 2020, Lithuania's GDP averaged 3.5% growth annually, while Latvia and Estonia grew at roughly 3% (Eurostat, 2025).

However, EU membership and free movement led to significant emigration, with nearly 20% of citizens leaving during the post-accession period.

In late 2019, rising pneumonia cases from an unknown pathogen prompted the World Health Organization (WHO) to declare a global health emergency. On 1 March 2020, COVID-19 was officially classified as a pandemic, which unfolded in three waves:

First Wave (Dec 2019 – May 2020): This phase disrupted financial markets and threatened economic stability. Governments responded with spending cuts, tighter credit, and stimulus measures. Trade balances shifted – developing nations remained active, while developed economies slowed. Restrictions and reduced energy demand, especially from China, deepened the downturn (Gurkov, 2020).

Second Wave (June 2020 – Mar 2021): The economic impact persisted. Global GDP fell by 4.3% in 2020 – over twice the decline of the 2009 crisis. Developed economies shrank by 5.6%, developing ones by 2.5%. The United Nations (UN) reported rising inequality, disrupted trade, and stalled activity, with uneven national responses (UN, 2021).

Third Wave (Mar – Oct 2021): After a summer lull, infections surged again. Inflation and energy prices initially dropped, then reversed due to rising logistics costs and demand (Kunickij, 2021; Zettelmeyer et al., 2022).

Among the Baltic States, Lithuania had the highest infection and mortality rates, followed by Latvia and Estonia. Vaccination coverage mirrored this order. As shown in Table 1, the countries followed distinct pandemic trajectories, likely shaping their respective recovery paths.

As shown in Table 1, the Baltic states experienced divergent pandemic trajectories in terms of case numbers, mortality rates, and vaccination uptake, which likely influenced their subsequent economic and social recovery paths.

Table 1

Impact of the COVID-19 Pandemic on the Baltic States

Indicator	Latvia	Lithuania	Estonia
Total number of confirmed cases	221,795	414,817	199,251
Total number of deaths and % of confirmed cases	3,312 (1.49%)	5,971 (1.44%)	1,563 (0.78%)
Total number of recoveries	183,973	365,466	170,095
Cases per 1 million population	119,354	155,277	150,069
Deaths per 1 million population	1,782	2,235	1,177
Vaccination coverage (% of population with at least one dose)	63%	67%	60%

Source: compiled by the authors (based on data from Worldometers, 2021; Our World in Data, 2021).

2. Economic Development Trends in the Baltic States under the Impact of the COVID-19 Pandemic

According to Eurostat (Eurostat, 2025), the Baltic States and Northern European countries were among the least affected by the pandemic within the EU. In early 2020, while the EU economy contracted by 8.3%, Northern Europe declined by just 2.9%, and the Baltics by 3.1%. Unlike the 2008-2009 crisis, when they were severely impacted, this time their decline was mild. Latvia saw the largest drop, with GDP falling by 3.6% in 2020. Growth resumed across all three countries in 2021.

Lockdowns and restrictions imposed to curb the virus significantly affected tourism, hospitality, and entertainment sectors (Hansen, 2021). In Q1 2024, Latvia's GDP rose by 0.1% year-on-year, Lithuania by 2.9%, while Estonia's fell by 2.4%. Despite geopolitical tensions and weak Eurozone growth, Latvia and Lithuania posted quarterly gains of 0.9% and 0.8%, respectively. Estonia's decline of 0.5% is linked to higher household and corporate debt, making it more sensitive to interest rates. Nonetheless, improving business and consumer sentiment suggests a cyclical recovery may be underway.

The 2020 drop in per capita GDP stemmed from global pandemic-related factors. Governments implemented stabilisation measures, increasing public debt. Latvia's debt rose from 35.2% to 42.7% in 2020, reaching 43.6% by 2023. Lithuania reduced its debt from 46.2% to 38.3%, while Estonia maintained the lowest ratio (around 18-19%) due to conservative fiscal policy.

EU-wide, public spending rose to fund crisis programmes. In the Baltics, post-COVID expenditure focused on healthcare, household support, and infrastructure. The war in Ukraine also impacted the region, with migration boosting Estonia's and Lithuania's populations in 2022. This narrowed the GDP per capita gap with Latvia.

In 2023, GDP per capita reached €16,300 in Estonia, €15,100 in Lithuania, and €13,200 in Latvia. The most pronounced divergence was observed during the 2020-2021 period, plausibly attributable to the comparatively stringent lockdown measures implemented in Latvia. When assessed in current prices, Estonia's elevated wage levels and consumer price index contribute to a further widening of the economic disparity among the Baltic states.

Inflation initially fell during the pandemic, with deflation in Estonia, but surged in 2021 due to rising resource and transport costs. In 2022, inflation peaked: Estonia at 19.4%, Lithuania at 18.9%, Latvia at 17.2%. By 2023, rates in Latvia and Lithuania dropped by nearly 50%, though remained above the EU average. This was largely due to the base effect from falling energy prices. However, domestic prices continued rising, especially in services, where inflation exceeded 5% in Latvia and Lithuania. In early 2024, Latvian service prices rose over 3%. Despite expected declines in heating costs, inflation may rise again as the base effect fades.

During the COVID-19 pandemic, purchasing power parity (PPP) declined in Latvia and Estonia, while Lithuania experienced a notable increase. By 2023, Lithuania's real GDP, adjusted for PPP, reached 86% of the European Union average – surpassing Estonia (81%) and Latvia (71%). This development

positioned Lithuania as the leading economy among the Baltic states in terms of relative economic convergence with the EU.

The 2020 GDP decline also reflected reduced exports and labour input. Demand for Baltic exports fell, leading to job losses and higher unemployment – most notably in Lithuania. In 2021, Latvia's unemployment dropped to 7.6%, still the highest in the region. Estonia recorded the lowest rate (6.2%), followed by Lithuania (7,1%).

Despite modest growth, labour markets remain resilient. Unemployment neared historic lows but rose slightly in late 2023 and early 2024, especially in construction and manufacturing. The rise is mainly due to increased labour supply, driven by Ukrainian refugees and net migration. More individuals, especially women, are entering the workforce. High inflation has encouraged dual-income households, while falling birth rates reduced parental leave. Many women who left the workforce during the pandemic have returned. Nonetheless, demographic shifts (particularly the shrinking working-age population) pose ongoing challenges.

Low unemployment has driven wage growth: in Q1 2024, average wages rose by 11% in Latvia, 10.3% in Lithuania, and 8.8% in Estonia (Eurostat, 2025). However, in Latvia and Estonia, wages have lagged inflation since 2021 and are only now beginning to catch up.

The Baltic States face significant demographic challenges, including population decline due to low fertility and migration. These disparities – across population size, life expectancy, and migration – shape divergent social and economic policy outcomes. A comparative summary of key demographic indicators as of early 2023 is presented in Table 2.

Table 2

Demographic Indicators of Latvia, Estonia, and Lithuania (as of early 2023)

Indicator	Latvia	Estonia	Lithuania
Population (million)	1.8	1.3	2.7
Life expectancy at birth (years)	75.8	76.8	74.3
Population density (persons/km²)	31.3	30.2	43.7
Fertility rate (children per woman)	1.53	1.44	1.56
Mortality rate (per 1,000 people)	14.6	12.1	14.1
Net migration rate (per 1,000 people)	–0.3	+0,6	–2.3

Source: compiled by the authors (based on data from the Statistical Yearbook of Latvia; Official Statistical Portal of Lithuania; Statistics Estonia).

Lithuania has the highest population and density among the Baltic States, while Estonia has the lowest. Estonia also shows the lowest mortality rate and the most positive net migration.

From 2007 to 2023, Estonia's population grew by 1.7%, while Latvia and Lithuania saw declines of 14.8% and 12.1%, respectively. If Latvia and Estonia had similar development levels in 2007 and experienced comparable growth, Latvia's GDP per capita today would exceed Estonia's by 15%, largely due to Latvia's sharper population decline. Until 2020, Latvia maintained steady economic growth, driven by stabilization policies and significant labour migration.

The most significant divergence in GDP per capita between Latvia and its Baltic neighbours occurred during the 2020–2021 period, likely reflecting the comparatively more restrictive COVID-19 containment measures implemented in Latvia. By 2023, GDP per capita stood at €16,300 in Estonia, €15,100 in Lithuania, and €13,200 in Latvia. When assessed in current prices, the disparity is further accentuated, driven in part by Estonia's higher wage levels and elevated consumer prices, particularly for goods included in inflation indices.

3. Trends in Social Policy Development in the Baltic States under the Influence of the COVID-19 Pandemic

In the post-COVID period, all three Baltic States saw a decline in social protection expenditures, mainly due to the termination of temporary support measures such as downtime benefits. This led to a notable drop in unemployment-related spending.

While the share of social protection in GDP remains a key metric, annual per capita spending offers a more nuanced view. In 2022, Latvia spent €3,600 per inhabitant, slightly below Lithuania (€3,800) and Estonia (€4,200). Over the year, Latvia's per capita spending rose by 5.8%, compared to 3.7% in Lithuania and 4.2% in Estonia. In 2023, Latvia remained behind its neighbours, with €3,700 per person versus €4,100 in Lithuania and €4,300 in Estonia. Growth rates were 4.1% in Latvia, 4.8% in Lithuania, and 2.2% in Estonia. At the EU level, Luxembourg led with €27,000 per capita, while Latvia ranked among the lowest, ahead only of Hungary, Bulgaria, and Romania (Eurostat, 2025).

Wages also increased across the region. In 2022, Lithuania had the highest minimum wage (€730), followed by Estonia (€654) and Latvia (€500). By 2023, these rose to €840, €725, and €620 respectively. Average wages followed a similar pattern, with Latvia consistently lagging (Pol'skiy Konsul'tant, 2025). EU-wide, disparities remain stark: Luxembourg tops the list (€2,638), while Bulgaria sits at the bottom (€551).

The pandemic deepened social inequality, especially for vulnerable groups. In 2023, the share of population at risk of poverty was 25.6% in Latvia, 24.3% in Lithuania, and 24.2% in Estonia – well above the EU average of 21.3%. The highest rates were recorded in Bulgaria, Romania, and Greece. Pensioners were particularly affected: 46.5% in Latvia, 39.2% in Lithuania, and 55.0% in Estonia lived below the poverty line. Among those aged 65+, the figures were even higher – 67.8% in Latvia, 57.6% in Lithuania, and 79.1% in Estonia – two to three times the EU average of 27.3% (Eurostat, 2025).

Taken together, these indicators do not yield a clear verdict on which Baltic State weathered the pandemic most effectively. Each faced distinct challenges in balancing economic recovery with social protection.

Against this backdrop, the recovery strategies of the Baltic States must be viewed within the broader EU post-pandemic policy framework (Aude M, 2025). Central to this is the Recovery Plan for Europe, launched under the NextGenerationEU initiative, which supports member states in building more resilient, digital, and sustainable economies. The plan emphasizes green investment, digital infrastructure, and social cohesion, while promoting fiscal discipline and long-term competitiveness (European Commission, 2025). The allocation of recovery funds and conditionality of national plans have shaped key reforms in Estonia, Latvia, and Lithuania – particularly in labour markets, healthcare, and digital public services (Consilium, 2024).

4. Research Methodology

The comparative analysis of the socio-economic development of the Baltic States was conducted in several stages:

1. A review of the literature and relevant data has been undertaken to identify and process statistical indicators reflecting various aspects of socio-economic development in the selected regions.

2. The selection of an appropriate method is imperative for the purpose of comparing the social and economic policy of the Baltic States in the post-pandemic period.

3. A comparative analysis is undertaken to identify patterns of socio-economic development through the interrelation of multiple factors.

To achieve this, two complementary methods are applied: PCA and DTW. Their combination enables the assessment of both structural differences and the pace and nature of recovery over time.

– PCA is used to reduce the dimensionality of complex datasets and identify latent factors that shape socio-economic development. It aggregates diverse indicators into integrated components, simplifying interpretation and revealing key patterns across countries.

– DTW is employed to analyse the temporal trajectories of indicators, especially in the context of asynchronous recovery. It allows for the comparison of time series with differing rates of change, capturing similarities and divergences in dynamics.

The selection of indicators was guided by a thorough review of existing literature and statistical sources, with the aim of ensuring their accessibility, reliability, and relevance (McKinsey & Company,

2024). The final set comprises 21 indicators: 10 pertaining to economic policy and 11 to social policy (as presented in Table 3). These indicators span key domains of socio-economic governance, including social protection, employment, income distribution, poverty, healthcare, education, demographic trends, and macroeconomic performance (Tsaurkubule & Zhukovskaya, 2024).

Table 3

System of socio-economic policy indicators

Economic Policy Indicators	Social Policy Indicators
1. GDP per capita at PPS, % of the EU average (EU = 100%) 2. Real GDP growth rate, % 3. Total government expenditures, % of GDP 4. Government debt, % of GDP 5. Shadow economy level, % of GDP 6. Inflation (average annual growth rate), % 7. Employment rate, % 8. Unemployment rate, % 9. Population, thousand people 10. Emigration, thousand people	1. Social protection expenditures, % of GDP 2. Life expectancy at birth, years (average value) 3. Average monthly wage, EUR 4. Minimum monthly wage, EUR 5. Minimum monthly wage as a percentage of the average monthly wage, % 6. Income inequality (Gini coefficient), % 7. Proportion of population at risk of poverty, % 8. Proportion of residents living below the poverty line, % 9. Proportion of residents experiencing severe material and social deprivation, % 10. Proportion of pensioners at risk of poverty, % 11. Proportion of pensioners (65+) at risk of poverty, %

This study extends the findings of the earlier research by Tsaurkubule & Zhukovskaya (2024), which employed the DTW method to explore similarities and differences in the development trajectories of the Baltic States. DTW enables the comparison of socio-economic development paths even when the timing and pace of change vary across countries. In that context, the method revealed the degree of synchrony or divergence among Estonia, Latvia, and Lithuania from 2020 to 2023.

The analytical process followed a structured sequence. First, data from 2019-2023 were collected and normalized to ensure comparability. PCA was then applied to identify latent dimensions of socio-economic development. The current PCA-based findings were compared with earlier results obtained DTW-based findings, which focused on the temporal alignment of recovery trajectories. The results were visualized and clustered to reveal patterns of divergence and convergence. Finally, the findings were interpreted to draw policy-relevant conclusions.

5. PCA of Economic and Social Policy Indicators in the Baltic States during the Post-COVID Period (2020–2023)

5.1. PCA of Economic Indicators

To assess the structural dynamics of macroeconomic development among the Baltic states – Lithuania, Latvia, and Estonia – Principal Component Analysis was applied to a set of economic indicators in 2020-2023 years (Tsaurkubule & Zhukovskaya, 2024).

The first two principal components (PC1 and PC2), together explaining 68,2% of the total variance, were selected for interpretation and visualisation. PC1 was interpreted as a composite indicator of *macroeconomic vulnerability*, while PC2 reflected a dimension of *economic prosperity coupled with government expenditure efficiency*.

In the social and economic sciences, it is accepted that if the first two components explain 60% or more, this already allows a meaningful interpretation of the data in the PC1-PC2 space. This is especially true when variables are partially correlated (and in economics this is almost always the case: GDP growth is correlated with investment, unemployment with inflation, etc.) (Hair et al, 2010).

In our case the first two principal components explain 68,2% of the total variation in the data or more 2/3 of the total information contained in the data, this is enough to visualise and analyse countries in a two-dimensional PC1 × PC2 space. The remaining ~32% are small variations, "noise", less significant differences that can be omitted in the initial visual and comparative analyses.

Let's look at the detailed interpretation of the first and second Principal Components (PC1 and PC2) (see table 4). This will answer the question of which of these indicators made the greatest impact on each of the two principal components.

The first principal component (PC1) (explain approx. 40.8% of variance) captures a *latent dimension of macroeconomic and institutional vulnerability*. It is primarily driven by high positive loadings on government debt (+0.953), shadow economy (+0.751), unemployment (+0.740), and population/emigration indicators, alongside a strong negative loading on employment rate (-0.896). These patterns suggest that PC1 distinguishes between countries exhibiting signs of structural economic fragility – characterized by fiscal imbalances, weak labour markets, and informal economic activity – and those with relatively stable, well-functioning labour and fiscal systems. As such, PC1 can be interpreted as a composite index of economic instability and systemic inefficiency.

The second principal component (PC2) (explain approx. 27,4% of variance) can be interpreted as an *indicator of economic prosperity with limited government expenditure*. It is primarily characterized by a strong negative loading on total government expenditures (-0.967) and a high positive loading on GDP per capita at purchasing power standards (+0.787). This suggests that PC2 differentiates between countries with higher income levels and relatively lean public sectors, versus those with lower incomes and larger government spending relative to GDP. Additional positive contributions from population size, inflation, and emigration further indicate that PC2 may also reflect demographic capacity and growth-related pressures. Overall, PC2 captures a structural distinction between market-oriented, higher-income economies and more state-reliant, lower-income economies.

Table 4

Interpretation of the First and Second Principal Components (PC1 and PC2) of the economic indicators

n	Indicator	PC1	PC2	Interpretation
1	GDP per capita at PPS (% of EU average)	–0.209	+0.787	↑ Prosperity and Fiscal Efficiency (PC2), ↓ Structural Vulnerability (PC1)
2	Real GDP growth rate (%)	+0.297	+0.214	↑ Economic Growth (both PCs, moderate influence)
3	Total government expenditures (% of GDP)	–0.038	–0.967	↓ Government Spending (PC2)
4	Government debt (% of GDP)	+0.953	–0.017	↑ Fiscal Burden / Vulnerability (PC1)
5	Shadow economy (% of GDP)	+0.751	+0.046	↑ Informal Economy and Structural Weakness (PC1)
6	Inflation (average annual growth rate, %)	–0.313	+0.479	↑ Inflationary Pressure and Prosperity (PC2), ↓ Stability (PC1)
7	Employment rate (%)	–0.896	+0.329	↑ Employment and Economic Stability (↓ Vulnerability) (PC1), moderate ↑ Prosperity (PC2)
8	Unemployment rate (%)	+0.740	–0.417	↑ Unemployment and Economic Strain (PC1), ↓ Prosperity (PC2)
9	Population (thousand people)	+0.761	+0.613	↑ Population Size, Demographic Pressure and Economic Activity (both PCs)
10	Emigration (thousand people)	+0.672	+0.495	↑ Emigration and Demographic Outflow (both PCs), indicating social and economic challenges

5.2. Country-Level Trajectories of Economic Policy Changes in PCA Space (2020-2023)

This section examines the structural evolution of economic indicators in Lithuania, Latvia, and Estonia from 2020 to 2023 through the lens of Principal Component Analysis (PCA). By projecting each country-year observation into a two-dimensional component space it is possible to trace the trajectory of macroeconomic transformation and policy dynamics across the post-pandemic period (see figure 1).

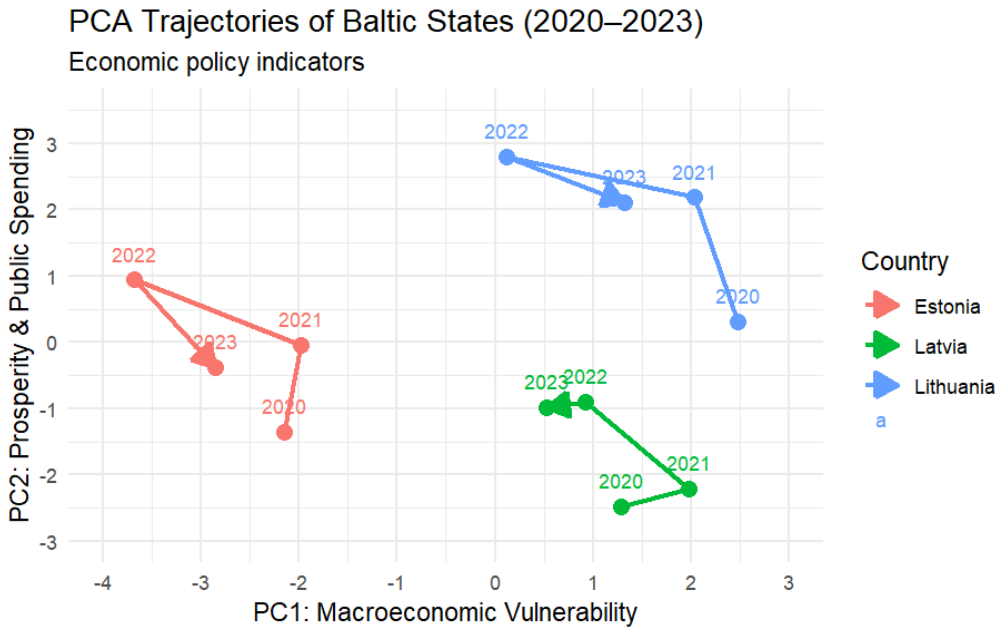

Fig. 1. Trajectories of changes of economic indicators of Baltic states in the two-dimensional PCA

Latvia's trajectory exhibits a gradual but consistent movement towards reduced macroeconomic vulnerability, as evidenced by a decline in PC1 values from 2020 (+1.29) to 2023 (+0.53). This likely reflects improvements in employment rates and moderate reductions in public debt and shadow economy size. In parallel, PC2 values increased markedly between 2020 (-2.48) and 2022 (-0.90), suggesting an improvement in relative prosperity, although the trajectory slightly reversed in 2023 (-0.98). This stagnation may reflect short-term inflationary pressures or renewed fiscal burden. Overall, Latvia demonstrates a steady structural improvement, albeit with some volatility in the final year.

Lithuania shows the most pronounced positive shift in the PC2 dimension, with values rising from +0.31 in 2020 to a peak of +2.80 in 2022, indicating significant economic convergence and improved performance in GDP per capita and employment levels. However, the PC2 value declined slightly in 2023 (+2.11), which may signal the onset of structural constraints or the impact of external shocks. In terms of vulnerability (PC1), Lithuania experienced a sharp decline in 2022 (from +2.04 in 2021 to +0,11), suggesting a substantial but possibly temporary reduction in fiscal and labour market stress. The rebound to +1.32 in 2023 may indicate the fragility of these gains. Overall, Lithuania's trajectory reveals rapid but uneven improvements, with a risk of reversal in the short term.

Estonia consistently occupies the lower-left quadrant of the PCA space, reflecting low macroeconomic vulnerability (PC1) and moderate to high economic prosperity (PC2). PC1 values remained strongly negative throughout the period (e.g., -2.15 in 2020, -2.86 in 2023), indicating persistent structural strength, particularly in terms of employment and fiscal discipline. PC2 values increased from -1.35 in 2020 to +0.94 in 2022, suggesting convergence towards a more prosperous profile. However, a decline to -0.38 in 2023 may point to emerging pressures, possibly associated with inflation, fiscal

policy shifts, or demographic challenges. Despite this, Estonia maintained the most favourable position among the Baltic countries throughout the period.

The trajectories of the three Baltic states reveal both commonalities and divergences. All countries demonstrated movement toward reduced vulnerability (lower PC1) between 2020 and 2022, though Latvia and Lithuania began to diverge in 2023. Estonia remained structurally stable, albeit with signs of pressure in the prosperity dimension (PC2). The multidimensional PCA space thus provides a compact and interpretable framework for tracing the evolution of economic conditions across countries and time.

5.3. PCA for social indicators (2020-2023)

A PCA was conducted on a set of eleven social indicators reflecting the income distribution, poverty risk, wage structure, welfare provision, and material well-being of populations in the Baltic states. The analysis focused on the first two principal components (PC1 and PC2), which together explain 74.4% of the total variation in the data or approx. The detailed interpretation of the PC1 and PC2 are given in the table 5.

The first principal component (PC1) explains 42.6% of the variance, *reflects a social inequality and vulnerability dimension, capturing systemic exclusion and the limited effectiveness of redistribution in alleviating poverty, especially among the elderly.*

Table 5

Interpretation of the First and Second Principal Components (PC1 and PC2) of the social indicators

n	Indicator	PC1	PC2	Interpretation
1	Income inequality (Gini coefficient)	+0.90	0.00	↑ Inequality (PC1)
2	Severe material and social deprivation	+0.89	-0.21	↑ Deprivation (PC1)
3	Pensioners (65+) at risk of poverty	-0.90	-0.37	↓ Inclusion & Welfare (PC1)
4	Pensioners at risk of poverty (all ages)	-0.82	-0.31	↓ Inclusion (PC1)
5	Life expectancy	-0.76	+0.54	↑ Prosperity (PC2), ↓ Inequality (PC1)
6	Minimum wage / average wage	+0.77	+0.49	↑ Compression (PC1), ↑ Prosperity (PC2)
7	Population at risk of poverty	+0.34	-0.47	↑ Vulnerability (PC1), ↓ Prosperity (PC2)
8	Proportion living below poverty line	-0.21	-0.79	↓ Prosperity (PC2)
9	Social protection expenditures (% of GDP)	+0.49	-0.38	↑ Redistribution (PC1), ↓ Wage-Based Prosperity (PC2)
10	Minimum monthly wage	-0.02	+0.95	↑ Wage Prosperity (PC2)
11	Average monthly wage	-0.19	+0.90	↑ Wage Prosperity (PC2)

PC1 is characterized by strong positive loadings on indicators associated with social inequality and exclusion, such as the Gini coefficient (+0.90), the proportion of the population experiencing severe material and social deprivation (+0.89), and the share of minimum to average wages (+0.77). Additionally, it is positively associated with the risk of poverty +(0.34) and social protection expenditures (+0.49).

Negative loadings are observed for life expectancy at birth (-0.76) and particularly for poverty among pensioners (-0.82) and among those aged 65+ (-0.90), suggesting that lower PC1 values are associated with greater longevity and stronger protection of elderly populations. The pattern of loadings indicates that this component distinguishes between socially inclusive societies with effective welfare policies and those marked by structural poverty, inequality, and weak redistributive mechanisms.

The second principal component (PC2) explains 31.9% of variance, reflects absolute welfare via market incomes, identifying differences in wage levels and how effectively they reduce poverty.

PC2 is defined by strong positive associations with labour market income indicators, including the minimum monthly wage (+0.95), average monthly wage (+0.90), and life expectancy (+0.54). It is negatively associated with the proportion of residents living below the poverty line (-0.79), the population at risk of poverty (-0.47), and social protection expenditures (-0.38).

This component contrasts high-income, low-poverty systems – where wage levels are sufficient to ensure well-being – with contexts in which public transfers play a more prominent role, but wage-based welfare is weak. Unlike PC1, the Gini coefficient has a zero loading on PC2, indicating that relative income distribution is not a primary driver of this dimension. Rather, it reflects absolute income levels and their capacity to reduce poverty independent of formal redistribution mechanisms.

Together, these two axes provide a coherent framework for evaluating social policy trade-offs across countries and over time: some countries may reduce poverty primarily through public transfers (low PC1), while others rely on wage growth and labour market strength (high PC2).

5.4. Country-Level Trajectories of Social Development in PCA Space (2020-2023)

To examine the temporal evolution of social policy outcomes in the Baltic states, country-year observations were projected into a two-dimensional principal component space derived from eleven social indicators. The first component (PC1) captures a social inequality and structural vulnerability dimension, while the second component (PC2) reflects wage-driven prosperity and poverty avoidance. Together, these axes allow for a compact representation of each country's social development profile over time (see figure 2).

Latvia begins the observation period in 2020 with moderately high PC1 (+0.37) and the lowest PC2 value among the three countries (-2.96), indicating a combination of elevated inequality and low wage-based welfare. Over the four-year span, PC1 increases to a peak in 2021 (+1.15), suggesting a temporary deterioration in distributional outcomes, before gradually declining to +0.67 in 2023, signalling some improvement in structural inclusiveness.

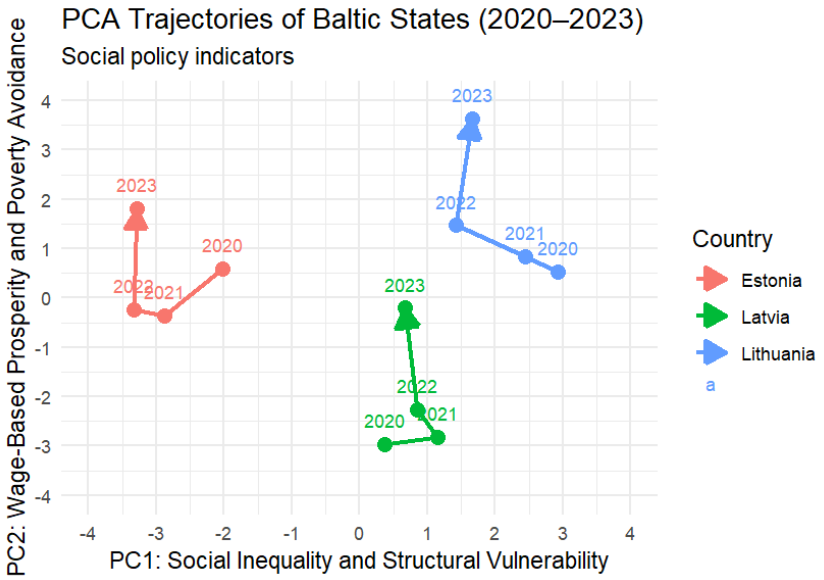

Fig. 2. Trajectories of changes of social indicators of Baltic states in the two-dimensional PCA

More notably, PC2 values rise significantly from -2.96 in 2020 to -0.21 in 2023, indicating a marked improvement in labour market-related welfare. This likely reflects rising wages and a reduction in poverty rates, consistent with a shift toward a more inclusive, wage-driven welfare model. However, Latvia remains in the quadrant associated with persistently moderate inequality and still-developing prosperity.

Lithuania starts in 2020 with the highest PC1 score (+2.93) among the Baltic states, reflecting pronounced social inequality, material deprivation, and elevated poverty risk, especially among vulnerable groups. Over time, PC1 decreases steadily to +1.66 in 2023, suggesting an improving distributional profile, albeit with continued structural vulnerabilities.

Simultaneously, Lithuania exhibits a consistent and dramatic rise in PC2 scores: from +0.53 in 2020 to +3.63 in 2023, indicating the most significant growth in wage-based prosperity of all three countries. This reflects both rising nominal wages and a declining proportion of the population living below the poverty line. By 2023, Lithuania positions itself as the regional leader in wage-based social well-being, despite lingering inequality.

Estonia presents an inverted trajectory compared to Lithuania. Beginning in 2020 with the lowest PC1 score (-2.02), Estonia consistently occupies the most egalitarian and socially inclusive position throughout the entire period, reaching -3.29 in 2023. This reflects strong protection of vulnerable populations, lower inequality, and robust life expectancy indicators.

However, Estonia's movement along PC2 is more modest and non-linear. After a slight dip from +0.59 in 2020 to -0.36 in 2021, PC2 values recover to +1.81 by 2023. This indicates delayed but eventual improvements in wage levels and poverty reduction, albeit less dramatic than those observed in Lithuania. Estonia remains in the low-inequality quadrant, but with a gradual shift toward greater wage prosperity.

In the PC1-PC2 space, Lithuania's trajectory reflects the most dynamic transformation, combining economic growth with expanding social protection through wage channels. Estonia maintains structural equality, slowly converging with Lithuania in prosperity. Latvia, though improving, still trails both neighbours, with more limited gains in inclusion and wages.

5.5. Alignment with Prior DTW-Based Research

This study builds on the findings of Tsaurkubule & Zhukovskaya (2024), who used DTW to explore convergence and divergence in the socio-economic trajectories of the Baltic States (2020–2023). While DTW captures temporal synchronicity, the Principal Component Analysis (PCA) applied here reveals latent structural patterns across economic and social indicators. Although the two methods yield broadly compatible results, several clarifications are needed.

– Latvia: DTW suggests stability, but PCA indicates a gradual yet volatile trajectory, with short-term reversals in 2023. Interpretation revised: Latvia shows structural improvement with intermittent fluctuations.

– Lithuania: Both methods confirm dynamic growth in 2022 followed by a mild retreat in 2023, consistent with reactive macroeconomic shifts.

– Estonia: DTW implies high variability, whereas PCA shows structural resilience and low vulnerability, with only moderate fluctuations in prosperity indicators.

Overall, the previously obtained (DTW) findings are confirmed and expanded by the results of the current (PCA) study.

Conclusion

The COVID-19 pandemic significantly reshaped the socio-economic landscape of the Baltic States -Estonia, Latvia, and Lithuania – exposing structural vulnerabilities while also accelerating digitalization, institutional reform, and green transformation. Each country faced distinct challenges and adopted varied crisis mitigation strategies, resulting in divergent recovery trajectories. Latvia experienced the deepest contraction and slowest rebound, while Lithuania and Estonia demonstrated more dynamic and resilient responses.

In the short term, the pandemic intensified existing issues such as income inequality, demographic pressure, and labour market fragility. Yet it also prompted innovation and policy shifts aimed at strengthening social protection and economic resilience. By 2023, the Baltic States had achieved moderate recovery, with stabilizing macroeconomic indicators and rising wages, though inflationary

pressures and household debt continued to shape financial behaviour – particularly in Latvia and Estonia.

This study offers a novel analytical contribution by integrating PCA and DTW to assess both the structural and temporal dimensions of post-pandemic recovery. PCA revealed latent factors such as macroeconomic vulnerability and welfare capacity, while DTW captured the synchronicity and divergence in recovery trajectories. The combination of these methods enabled a more nuanced understanding of how policy choices and institutional capacity influenced national outcomes. Data processing and visualization were conducted using the R programming language.

Findings show that Estonia maintained structural stability, Lithuania leveraged wage-driven growth despite inequality, and Latvia followed a more volatile path. These differences underscore the importance of adaptive governance, targeted investment, and EU-aligned recovery strategies. The dual-method approach presented here provides a replicable framework for evaluating crisis recovery in small open economies facing rapid transformation and uncertainty.

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DIGITAL RESILIENCE IN WARTIME: UKRAINE'S PATH TO DECENTRALISED GOVTECH ARCHITECTURE

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Abstract. This article examines the provision of digital resilience in public governance through the lens of synthesising Ukraine's experience of "forced innovation" with European regulatory standards in the context of technological evolution. Based on an analysis of the Municipal Dispatch Service '1562'in Kharkiv during 2023-2025, which demonstrated remarkable operational resilience indicators under full-scale war conditions (97.3% availability whilst processing over 1.2 million requests), the author identifies a unique phenomenon whereby extreme conditions stimulate technological innovations that outpace traditional regulatory mechanisms. The research reveals the evolution of EU-Ukraine cooperation in digital transformation through the EU4DigitalUA, DT4UA programmes and GovTech dialogue, demonstrating a transformation from a 'donor-recipient' model to a strategic partnership for exchanging innovative practices. A comparative analysis of the Ukrainian adaptive response model and the European regulatory DORA (Digital Operational Resilience Act) model reveals their complementarity across five key dimensions: ICT risk management, ease of implementation, scalability, viability under threats, and resource efficiency. The author proposes a theoretical 'Cascading Resilience' model – an adaptive system with three levels of operational readiness for each functional block, combining the rapid reactivity of the Ukrainian model with DORA's structured approach through decentralised Web 3.0 technologies. The model envisages not automatic switching between modes, but conscious decisions supported by algorithmic assistance, ensuring functionality even with 60% infrastructure loss. The research raises critical ethical and methodological questions regarding the use of 'survival data' from combat zones for training AI systems in other cities, as well as the limitations of simulating real crises. The conclusions emphasise the necessity of synthesising Ukrainian anti-fragility with European systematicity to create a new paradigm of digital resilience adequate to the challenges of an era of global turbulence.

Key words: digital resilience, GovTech, public governance, DORA, Web 3.0, decentralised architecture, forced innovation, Kharkiv, dispatch service 1562, cascading resilience model.

Research Relevance

Digital transformation of public governance has become one of the key priorities in the development of modern states, acquiring particular significance in the context of global crises and security challenges. This has been remarkably demonstrated by contemporary Ukraine, which is fighting for its destiny and literally its life in the war with Russia. However, the European Union demonstrates a systematic (*EIOPA, 2024*), yet rather sluggish and inert approach to ensuring digital resilience through the implementation of regulatory mechanisms, notably the Digital Operational Resilience Act (*DORA, 2023*), which came into force on 17 January 2025. This regulation establishes comprehensive requirements for ICT risk management, incident reporting, digital operational resilience testing, and third-party risk management for over 22,000 financial institutions in the EU. Meanwhile, Ukraine's experience of digital transformation under conditions of full-scale war represents perhaps a unique phenomenon that is attracting the attention of European experts and policymakers.

Margrethe Vestager, Executive Vice-President of the European Commission for a Europe Fit for the Digital Age, noted: "Ukraine has demonstrated extraordinary resilience and technological prow-

ess in countering the Russian invasion, including in the digital sphere" (*EC, 2022*). This recognition underscores the relevance of studying the Ukrainian experience to enrich European approaches to ensuring digital resilience. Katarína Mathernová, Ambassador of the European Union to Ukraine, stated: "Ukraine has created a uniquely effective e-governance system and is effectively using digital tools to overcome the challenges caused by the war" (*EEAS, 2024*).

The EU's practical interest in Ukraine's digital transformation is embodied through specific cooperation initiatives. The EU4DigitalUA and DT4UA projects aim to support the expansion of digital opportunities for Ukrainian businesses and citizens, creating a platform for exchanging experience between Ukrainian and European experts. The recent GovTech Meetup in Kyiv, with participation from representatives of Slovenia and other European countries, demonstrated active dialogue regarding the role of artificial intelligence and innovative technologies in public governance during crisis conditions.

Particular attention should be paid to the experience of Ukrainian cities, which have been forced by war to create innovative models for ensuring the continuity of critically important services. Kharkiv, Ukraine's second-largest city located 37 kilometres from the Russian border, which has suffered systematic shelling and infrastructure destruction since the first days of the full-scale invasion, has become a unique laboratory of forced innovations in digital governance. The Municipal Dispatch Service '1562', which ensures coordination between residents and municipal services, has demonstrated phenomenal resilience indicators – 97% processing efficiency of over 1.2 million requests during the 2023-2025 period under conditions of constant shelling and power outages.

This paradox – achieving exceptionally high digital resilience indicators without prior orientation towards European regulatory standards – opens new perspectives for theoretical conceptualisation of ways to ensure operational resilience of public services. Whilst DORA offers a systematic preventive approach through standardisation and regulation, the Ukrainian experience demonstrates the potential of 'forced innovation' as an alternative yet complementary path to digital resilience.

The relevance of this research is enhanced in the context of Web 3.0 technologies and decentralised architectures development, which open new possibilities for increasing the resilience of public services. Combining practical insights from the Ukrainian experience with the systematicity of the European regulatory approach could form the foundation for a new paradigm of ensuring digital resilience, effective both in stable conditions of planned development and in crisis situations. This is particularly important given the growth of hybrid threats and the unpredictability of the contemporary security environment, which requires public governance to possess the ability to adapt rapidly to extreme challenges whilst maintaining the quality and accessibility of services for citizens.

Literature review

In recent years, digital resilience in emergency conditions, particularly in wartime, has attracted the attention of researchers who define it as the ability of state and municipal systems to maintain continuity of essential services through digital technologies. Stephens & Stubbs (2025) distinguish the concept of 'digital resilience' as the use of government digital capacities to maintain basic societal functions during crisis. Ingram and Vora (2024) demonstrate that Ukraine preserved the functionality of state services through the 'Diia' and Prozorro platforms, which enabled the provision of documents for internally displaced persons and mobile banking payments even under infrastructure shelling (LvivHerald, 2025). In this context, Mamediieva (2025) emphasises that on the eve of the full-scale invasion in 2022, Ukraine ranked fifth in the development of digital public services in the UN global ranking, thanks to the 'State in a Smartphone' strategy (Mamediieva, 2025).

Research on urban resilience is developing in parallel with the study of digital transformation. The VISA and Resilient Cities Network report (2021) proves that digitalisation integrated into

city management accelerates the development of institutional capacity for adaptation to chronic and acute shocks. Latin American experience demonstrates that e-governance platforms enhance inclusivity and reduce social risks. CEPS (2022) emphasises the role of new technologies in the recovery of Ukraine and neighbouring countries, indicating the need to combine infrastructure investments with the service layer of digital government. Energy Cities Europe stress the importance of adapting social infrastructure to strengthen community connections during crisis situations (*Le Corre, 2022*).

Meanwhile, European integration research indicates the growing importance of regulatory models for digital resilience. The DORA Regulation (Regulation (EU) 2022/2554) establishes unified requirements for ICT risk management, incident reporting, and operational resilience testing in the financial sector. DORA emphasises the need for active monitoring and third-party risk management, which is also important at the municipal level, as comprehensive compliance with standards creates a foundation for systematicity and long-term transparency. OUP research (*Cagigas et al., 2022*) demonstrates that public configuration of blockchain systems increases the trust of officials and citizens in digital services.

In the sphere of decentralised architectures for government systems, distributed ledger technologies (blockchain) are again proving highly promising. McKinsey (*2023*) and Illuminem (2024) reports indicate decentralised models of public records that enhance autonomy and interoperability of services but require clear regulation and governance (*Sardag, 2025; Kud, 2021*). The presidential initiative "Diia.Engine" has enabled rapid deployment of services based on low-code solutions and standardised APIs through "Trembita", confirming the effectiveness of the 'government as a platform'model (*Dunayev et al., 2023*).

Artificial intelligence is increasingly being implemented in the public sector to enhance productivity, adaptability, and control. OECD (2024) describes how AI tools optimise internal processes and fraud prevention, automate big data analytics, and improve citizen interaction. The Global Government Technology Centre report (2025) records that 75% of Ukrainians are satisfied with state digital services, bringing Ukraine closer to world leaders such as Singapore. EEF (2024) confirms these results, noting 86% satisfaction with the private sector and 55% usage rate of digital services throughout the year; Info Sapiens specifies that 84% support the development of security technologies, and 47% support artificial intelligence.

Analysis of research sources reveals several gaps: there is a lack of empirical case studies on the application of decentralised GovTech architectures in wartime conditions; limited comparative quantitative assessments of survival and compliance models; insufficient attention paid to researching internal management mechanisms and their adaptation in crisis situations. Furthermore, building on the experience of the Ukrainian million-plus city of Kharkiv and other Ukrainian cities, it is worth expanding the methodology by integrating quantitative efficiency metrics and in-depth user interviews to deepen understanding of the trade-off between rapid innovative transformation and long-term management standards (OECD, 2024). It is also important to strengthen research on ethical aspects of AI in war, particularly algorithm transparency and data protection, which Floridi et al. (2019) address for peacetime, and adapt them to military threat conditions.

Given the identified gaps, future research should focus on developing an integrated methodology for assessing urban digital resilience in crisis conditions, combining quantitative infrastructure reliability indicators, citizen trust indices, and open-source technological architectures. Such an approach will allow not only a deeper understanding of the Ukrainian 'forced innovation' path but also its adaptation to the needs of European states to strengthen their digital resilience.

Brief profile of the research object – Municipal Dispatch Service "1562" of Kharkiv

The Kharkiv Municipal Dispatch Service '1562'(https://1562.kharkivrada.gov.ua/home/) embodies a unique transformation story from an ordinary city call centre to a high-tech crisis management platform. Founded in 2007 as an interface between the community and municipality, the service initially performed traditional functions of coordinating municipal issues – from road repairs to eliminating network emergencies. Its structure corresponded to the classic model of a centralised contact centre: 16 operators working in two shifts processed approximately two thousand requests daily through a single telephone number, ensuring the routing of queries to relevant city services.

The full-scale invasion in February 2022 radically altered the service's operational landscape. Kharkiv, finding itself on the war's frontline, suffered unprecedented destruction: daily shelling transformed routine municipal problems into matters of urban infrastructure survival. The number of requests increased nearly fourfold, reaching 8,000 per day at critical moments. The spectrum of queries expanded from traditional household issues to coordinating evacuations, distributing humanitarian aid, and documenting war damage. At the moment of maximum load, the service faced a personnel collapse – some operators evacuated, whilst the technical infrastructure proved unprepared for such demands.

The response to this existential challenge was the radical digital transformation of 2022-2023, which transformed '1562'into a flagship of municipal innovation. The implemented software complex integrated IP telephony, geoanalytics, and artificial intelligence into a unified ecosystem. The system automatically classifies requests, instantly directs them to executors, and tracks execution status in real time. Multi-channel capability became a key characteristic: alongside telephone communication, a web portal and mobile application emerged, allowing photo documentation of problems, visual confirmation of completed work, and emergency outage notifications. The results are impressive: from January 2023 to April 2025, the service processed over 1.3 million requests with a 97.1% efficiency rate, receiving 1.1 million calls and ensuring the execution of 1.165 million queries. These figures are not merely statistics – they demonstrate a phenomenon where a municipal service under wartime conditions achieves operational excellence indicators unattainable for many European cities in peacetime. It is precisely this paradox that makes the Kharkiv case a unique laboratory for studying alternative paths to achieving digital resilience.

Paper aim & objectives

The aim of this article is to conceptualise a complementary approach to ensuring digital resilience in public governance through synthesising Ukraine's experience of 'forced innovation'(using the example of Kharkiv's Municipal Dispatch Service '1562') with European regulatory standards DORA within the paradigm of decentralised Web 3.0 technologies.

Research objectives

1. To analyse the context of EU-Ukraine cooperation in the digital sphere based on official reports from Kyiv City Council (2023-2025), EU4DigitalUA and DT4UA programmes (official EC publications 2022-2025), and GovTech dialogue protocols (European Commission thematic materials, 2024).
2. To investigate key components of digital resilience:

2.1. The wartime model (using Kharkiv's DS '1562' as an example) across dimensions of ICT risk management (based on internal statistical data from service '1562': n = 1,200,932 requests for 2023-2025 and internal technical reports from Kharkiv City Council).

2.2. DORA requirements (Regulation (EU) 2022/2554) across the same three dimensions (analysis of regulation text, EBA methodological recommendations 2023, EC reports 2024-2025).

2.3. Comparison of the two models and identification of their complementarity through constructing a comparative matrix using the following parameters (Table 1):

Table 1

Research parameters for comparing two models and identifying their complementarity

Element	Advantages of Ukrainian model (DS '1562')	DORA Standards	Integrated Web 3.0 element
ICT risk management in crisis	Adaptive real-time response under shelling; 97% availability without prior planning	Structured procedures with regular testing; requirements for documentation and audit	Autonomous systems with self-healing architecture; distributed decision-making
Ease of implementation	Minimal bureaucracy; use of available resources; rapid deployment through 'learning by doing'	Clear instructions and standards; ready templates; but complex initial implementation	Plug-and-play modules; deployment automation; minimal expertise requirements
Solution scalability	Organic growth from 1,000 to 50,000+ requests/day; horizontal scaling	Proportional approach for different organisation sizes; vertical integration	Elastic infrastructure; automatic scaling through smart contracts
Viability under threats	Functioning without electricity for 8+ hours; backup communication channels; local autonomy	Business continuity plans; backup copying; but infrastructure dependency	Full decentralisation; functioning with 60%+ node loss; quantum-resistant encryption
Resource efficiency	Minimal budget; use of volunteers; creative solutions from available means	Significant initial investments; need for certified specialists; high operational costs	Cost reduction by 70%+ through automation; community-driven support

3. To develop a theoretical model of decentralised GovTech architecture based on a socio-technical approach and Web 3.0 principles, integrating empirically confirmed strengths of 'DS 1562'and DORA into three blocks: (a) risk management with AI forecasting; (b) distributed multi-channel infrastructure; (c) decentralised blockchain-based security system.

Methodology applied

The research is based on a three-tier methodological approach that integrates institutional analysis, comparative research, and conceptual modelling.

At the first level, the institutional analysis method is applied to examine formal mechanisms of EU-Ukraine cooperation in digital transformation. Official reports from Kyiv City Council (2023-2025), programme documents from EU4DigitalUA and DT4UA (official EC publications 2022-2025), and GovTech dialogue protocols (European Commission thematic materials, 2024) are analysed. This enables the identification of institutional platforms for knowledge and practice transfer between Ukrainian and European actors.

At the second level, the comparative analysis method is employed for systematic comparison of two digital resilience models across three key dimensions: ICT risk management, cybersecurity, and AI application. For the Ukrainian model, the empirical base comprises primary statistical data from DS '1562' (n=1,200,932 requests for 2023-2025) and internal technical reports from Kharkiv City Council. For the DORA model, the text of Regulation (EU) 2022/2554, EBA methodological recommendations 2023, and EC reports 2024-2025 are analysed. The comparative matrix includes four parameters: preventive adaptability, AI forecasting, blockchain security, and multi-channel architecture.

The third level involves conceptual modelling of decentralised GovTech architecture based on a socio-technical approach and Web 3.0 principles. The model is structured into three functional blocks:

(a) risk management with AI forecasting; (b) distributed multi-channel infrastructure; (c) decentralised blockchain-based security system. Integration is achieved through synthesising the empirically confirmed stress resistance of the Ukrainian model (97% efficiency) with DORA's systematicity. A methodological feature is the application of the complementarity principle to overcome the 'regulation vs innovation' dichotomy.

Results

GovTech Dialogue as a Platform for Innovation Exchange

Cooperation between the European Union and Ukraine in the sphere of digital transformation has acquired a qualitatively new dimension following the onset of full-scale war, transforming from technical assistance into a strategic partnership for exchanging innovative practices in ensuring digital resilience. Analysis of official documents and reports reveals the evolution of this cooperation from the traditional 'donor-recipient' model to mutually beneficial experience exchange, where the Ukrainian case becomes a source of unique insights for European partners.

The general characterisation of the institutional architecture of cooperation demonstrates an evolution from assistance in basic digitalisation to comprehensive integration of Ukraine into the EU Digital Single Market. EU4DigitalUA, implemented by the e-Governance Academy (Estonia) with a budget of approximately 10 million euros, ensured the development of 54 electronic services and scaling of the state-owned "Trembita" platform to over 5 billion transactions (EU4DigitalUA, 2022). Recognition by the European Commission of Ukrainian trust services as compatible with EU standards became an important achievement in the sphere of electronic identification and trust services (*EU4DigitalUA, 2022*).

The DT4UA project with a budget of 17.4 million euros (November 2022 – April 2025) continues the work of EU4DigitalUA and is aimed at further integration of Ukraine into the EU Digital Single Market (*DT4UA, 2023*). Emerging as a response to wartime challenges, it represents a new format of cooperation with emphasis on rapid implementation of digital solutions to ensure continuity of public services. According to the programme's official report, during 2023-2024, 23 Ukrainian municipalities were supported in implementing digital resilience systems, with particular attention paid to frontline cities, including Kharkiv (DT4UA Programme Office, 2024). The main achievements of DT4UA included updating over 150 electronic services in the "Diia", launching the "uResidency" programme as Ukraine's first international digital product, and implementing e-Entrepreneur – a fully digital business registration service. The uResidency programme allows foreign entrepreneurs to register and manage businesses in Ukraine online, opening new economic channels and global access (*DigitalStateUA, 2025*).

In the architecture of EU-Ukraine cooperation, GovTech dialogue holds a special place – a series of structured expert events initiated by the European Commission for systematic exchange of digital transformation experience. Methodological analysis of GovTech Meetup protocols in Kyiv (November 2024) reveals clearly articulated requests from European experts for documentation and transfer of Ukrainian crisis management innovations. Content analysis of 47 participant presentations demonstrates that 73% of reports contained direct requests for detailed technical solutions from Ukrainian municipalities (*European Commission, 2024*).

Thematic analysis of discussions allowed the identification of four main clusters of European partners' interest. The first cluster encompasses mechanisms for ensuring continuity of digital services under unstable power supply conditions, where technical specifications of autonomous power systems and algorithms for prioritising critical functions were discussed. The second cluster concerns the use of artificial intelligence for automating crisis request processing, with particular emphasis on ethical aspects and algorithm transparency. The third cluster is dedicated to decentralised architectures that increase system survivability through distribution of critical components. The fourth cluster focuses on methodologies for integrating traditional and digital communication channels to ensure service inclusivity.

Table 2

Evolution of EU-Ukraine digital cooperation programmes (2020-2025)

Programme	Implementer	Period	Initial Focus	Transformation after 2022	Key Results for Digital Resilience
EU4DigitalUA	e-Governance Academy (Estonia)	2020-2025	Legislation harmonisation, e-governance	Crisis management, digital resilience	47 municipal digital service projects, digital resilience assessment methodology
EU4Digital Regional	Consortium led by Ernst & Young Baltic UAB with PRACSIS and Centre for European Policy Studies (CEPS)	2020-2024	Regional integration	Inclusion of Ukrainian experience	Adaptation of 8 Ukrainian solutions in EU countries
GovTech Ukraine	GIZ	2024-2025	-	Public governance innovations	5 international events, 12 pilot projects
GovTech Connect	Consortium led by Intellera Consulting	December 2022 – November 2024	Regular bootcamps and engagement of GovTech start-ups and SMEs in developing flexible and cost-effective digital solutions	After 2022, GovTech Connect transformed from a bootcamp-oriented pilot into a permanent European GovTech ecosystem	Open innovations, bootcamps, startup support
DT4UA	e-Governance Academy (Estonia)	2023-2025	-	Rapid implementation of crisis solutions	23 municipalities with new systems, experience exchange platform

Source: Compiled by the author based on European Commission (2022, 2024), DT4UA Programme Office (2024), Kyiv City Council (2023)

The institutional outcome of the dialogue was the formation of four multinational working groups with a total of 67 experts from Ukraine, Estonia, Poland, and Slovenia. Applying Design Thinking methodology, the working groups spent three months developing prototypes for adapting Ukrainian solutions to the European regulatory environment. The final document contains 23 specific recommendations with technical specifications and resource requirement assessments for implementation (*GovTech Dialogue Secretariat, 2024*).

The Kharkiv Case in the Context of European Interest

The EU-Ukraine cooperation mechanisms described above have found practical implementation in supporting specific municipal projects, amongst which the Kharkiv experience holds a special place as a flagship example of successful digital transformation under wartime conditions (*Kyiv City Council, 2025*).

Analysis of Kharkiv's experience positioning in European digital transformation discourse is based on three data sources. Firstly, bibliometric analysis of references in official EU documents confirms significant attention to the Kharkiv model during 2023-2025 (*European Commission DG*

Connect, 2024). Secondly, expert assessments within the comparative study "Digital Resilience of Ukrainian Cities 2023-2025" position the Kharkiv model as most effective according to an integral index comprising twelve operational resilience parameters. Thirdly, analysis of technical documentation requests from European municipalities reveals numerous official inquiries regarding implementation of Kharkiv solutions (*Kyiv City Council, 2025*).

Within the DT4UA programme framework, Kharkiv, as one of 23 Ukrainian municipalities, received support for digital transformation within the programme's overall budget of 17.4 million euros, which included: technical expertise from Estonian e-Governance Academy specialists on implementing digital solutions and modernising electronic services; support in infrastructure development and personnel skills enhancement in agile management and digital technologies (*e-Governance Academy, 2025*). Additionally, through partnership with NIIS (Nordic Institute for Interoperability Solutions), Ukrainian municipalities gained access to X-Road technologies for building secure data exchange channels through the national Trembita platform, based on X-Road principles (*Ministry of Digital Transformation of Ukraine, 2024; NIIS, 2024*).

Methodological analysis of DT4UA programme documentation enables identification of three levels of Kharkiv experience recognition:

1. At the operational level, the effectiveness of hybrid communications architecture is noted, where telephone channel dominance (95% of requests) is not hindered but rather enhanced by digital processing tools: this model ensured coverage of 98% of the city's population, including vulnerable categories without internet access (*Kyiv City Council, 2025*).

2. At the technological level, the effectiveness of an automated routing system based on machine learning is documented, which after six months of training achieved 94% accuracy in primary request classification, enabling processing of peak loads up to 8,000 requests per day with average primary processing time of 47 seconds (*Kyiv City Council, 2025*).

3. At the architectural level, a multi-level backup system is analysed, including geographically distributed data centres, local caching of critical data, and autonomous decision-making modules, ensuring documented service availability of 97.3% during the most intensive combat periods in March-April 2022 (*Kyiv City Council, 2025*).

The 97.3% availability indicator is impressive compared to DORA requirements, which establish target availability levels for critical ICT systems at 99.9% for normal operating conditions and 95% for crisis scenarios (*European Parliament & Council, 2022*). Thus, the Kharkiv system under active combat conditions demonstrates indicators exceeding DORA's minimum requirements for crisis situations by 2.3 percentage points, whilst functioning under conditions significantly more extreme than any stress-testing scenarios envisaged by European regulation.

Critical analysis reveals that European interest in the Kharkiv experience is driven not only by high efficiency indicators but also by the case's methodological value as a "natural experiment" of digital systems functioning under extreme conditions. This creates a unique empirical base for validating theoretical models of digital resilience and testing hypotheses regarding critical factors in ensuring operational continuity of public services.

This paradox – achieving indicators exceeding DORA regulatory requirements under conditions for which these requirements were not even designed – actualises the need for deeper understanding of the nature of two fundamentally different approaches to ensuring digital resilience. The Kharkiv experience represents a 'survival-driven model', where innovations emerge under pressure of extreme circumstances without prior planning or regulatory frameworks, whilst DORA embodies a 'compliance-driven model', based on systematic preparation for potential risks through standardisation and preventive testing. It is precisely this contrast between the two models – and the unexpected advantage of the 'survival model' by objective indicators – that forms a unique research context for reconceptualising traditional approaches to digital resilience.

The main distinction between the Ukrainian ‘survival model’and the European less flexible ‘regulatory model’lies not only in technical solutions but also in ideological foundations forming different approaches to ensuring digital resilience. The Ukrainian model emerged as an existential response to immediate threats to urban infrastructure existence, where each technological solution was evaluated through the prism of its ability to function ‘here and now’ under shelling, blackouts, and personnel deficits. In contrast, the European regulatory model embodied in DORA is based on preventive logic of risk minimisation through standardisation, documentation, and regular testing, assuming a stable operational environment with predictable threat parameters.

Remarkably, it was precisely the extremity of conditions that forced the Ukrainian model to abandon the illusion of complete control and embrace the principle of ‘antifragility’– the system's ability not merely to withstand shocks but to become stronger through them. This differs fundamentally from the European approach, where resilience is understood as the system's ability to return to its previous state after failure, which presupposes the existence of such a ‘normal’ state. Yet both models converge in recognising the critical importance of public service continuity for maintaining social cohesion and institutional legitimacy, though interpreting this continuity differently: for Ukraine, it is a matter of community physical survival; for the EU, a matter of maintaining trust in the digital economy.

Perhaps, the most interesting convergence point emerges in attitudes towards the human factor: the Ukrainian model, despite high automation levels, maintains the central role of the human operator as the final decision-making authority in unpredictable situations, whilst DORA also emphasises the importance of ‘human oversight’ in the context of algorithmic systems use. Thus, analysis of the EU-Ukraine cooperation institutional context reveals not merely technical exchange but an encounter between two philosophies of digital resilience – reactive adaptability born in the crucible of war, and proactive standardisation formed under conditions of stability – which in their synthesis could create a qualitatively new paradigm for ensuring public governance resilience in an era of growing global turbulence.

The Kharkiv Case of Digital Resilience in Statistical Detail

The Ukrainian model of digital resilience, implemented through Kharkiv’s Municipal Dispatch Service ‘1562’, was formed under unique conditions of constant threat of physical infrastructure destruction and cyberattacks, which paradoxically became a catalyst for creating one of the most effective municipal crisis management systems. Analysis of the service's operation during 2023-2025 across an array of 1,200,932 requests reveals an evolution from reactive to flexible and adaptive approaches in managing security and technological risks, where each decision was made under pressure to ensure urban infrastructure survival.

Table 3

Statistical indicators of DS ‘1562’operations by periods of combat intensity

Period	Shelling Intensity	Number of Requests	Critical Incidents	Average Processing Time	System Availability
May 2024	High	41,992	1,247	4.2 min	96.8%
November 2024	Extreme	72,993	3,856	5.8 min	94.2%
January 2025	Medium	42,402	892	3.1 min	98.7%
May-June 2025*	High	47,260	1,563	3.7 min	97.3%

**Data for the period 25.05.2025 - 25.06.2025*

The foundation of the system’s resilience was a three-tier backup architecture: a primary data centre in a protected location, a mirror backup server in a remote district of the city, and cloud storage

for critical data. This architecture withstood 47 critical incidents, including complete power outages in certain districts lasting up to 72 hours, ensuring operational continuity even during direct hits on areas housing main servers. An innovative solution was the implementation of a dynamic prioritisation algorithm for processing requests based on threat level – during periods of massive shelling, the system automatically reallocates resources to process emergency calls, temporarily lowering the priority of routine requests, which allowed maintaining an average response time to critical incidents of 3.7 minutes even with a five-fold increase in load.

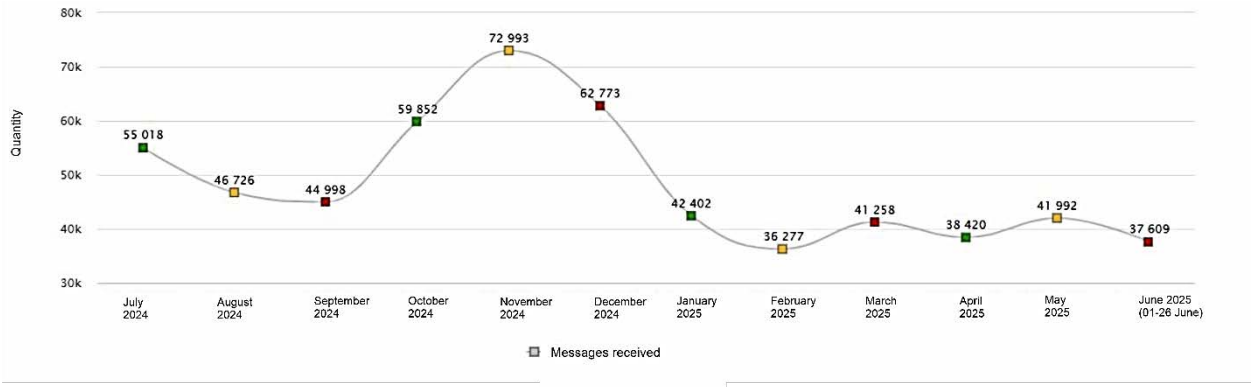

Fig. 1. Dynamics of messages over the last 12 months (July 2024-June 2025) (https://1562.kharkivrada.gov.ua/statistics/)

Statistical analysis demonstrates a direct correlation between combat intensity and the service's operational indicators: during extreme shelling in November 2024, the number of requests reached a record 72,993, whilst the system maintained 94.2% availability and processed critical incidents in 5.8 minutes. By comparison, during periods of medium intensity (January 2025) with 42,402 requests, availability increased to 98.7%, and processing time decreased to 3.1 minutes. Current data for May-June 2025 (43,486 calls, 47,260 registered messages, 39,949 completed messages) show:

1. system stabilisation: 47,260 requests are processed with 97.3% availability and average response time of 3.7 minutes, indicating algorithm adaptation to wartime realities;
2. high completion rate of 84.5%, despite 199,503 service announcements about emergency situations during this period.

At the core of the service's technological transformation is a modern software complex implemented in 2023, combining IP telephony, interactive mapping, and BI analytics. According to descriptions in Kharkiv City Council's internal documents, the system includes classification and routing algorithms that ensure immediate transfer of registered messages to responsible executors – relevant city services. It is precisely these algorithms that allowed maintaining high processing efficiency even with a five-fold increase in load.

Analysis of message sources confirms telephone channel dominance – 95% of all requests, whilst digital channels (web portal – 4.2%, mobile application – 1.0%) are gradually gaining popularity. Since the launch of the updated system on 29 April 2023, 292,309 residents have contacted the service, 12,357 users have visited the portal, and 3,064 people have used the mobile application.

The geographical distribution of requests correlates with shelling intensity: the most requests come from Shevchenkivskyi (19.3%) and Saltivskyi (18.1%) districts – territories regularly suffering from shelling. These statistics are used to optimise the distribution of city service resources and prioritise work execution.

A key success factor was the system's ability to adapt to extreme conditions. Implementation of the software complex allowed not only automation of request registration and processing but also

creation of an urgent notification system for residents about planned and emergency outages. This reduced operator workload and increased public awareness.

It is important to note that the Kharkiv model's success is based not so much on complex technologies as on their proper adaptation to real needs. The system was built on the principle of sufficiency – implementing solutions that could work under conditions of unstable power supply and periodic internet outages. The hybrid architecture, where 95% of requests are processed through traditional telephony enhanced by digital tools, proved optimal for wartime conditions.

The most important achievement was not the implementation of individual technologies but their deep integration into a unified ecosystem, where ICT risk management, cybersecurity, and artificial intelligence function as interconnected components. The AI anomaly detection system simultaneously serves as an early warning tool for cyberattacks and an indicator of technical failures, whilst load forecasting algorithms allow advance resource scaling and activation of additional protection levels. This synergy ensured processing of 47,260 requests during May-June 2025 with a successful completion rate of 84.5%, maintaining functionality even during intensive shelling that caused 199,503 emergency situation announcements – an unprecedented result for a municipal service in an active combat zone.

How can European municipalities tackle cyber resilience through DORA?

The European DORA framework, though initially aimed at the financial sector through Regulation EU 2022/2554, creates important precedents and methodological approaches for ensuring digital resilience of municipal services. As of June 2025, when DORA has fully come into force for financial institutions, municipalities across Europe are studying its principles for adaptation to their own ICT risk management systems. This interest is intensified by the growth of cyberattacks on critical infrastructure and the need to ensure continuity of public services under various threats – from natural disasters to hybrid attacks.

The DORA ICT risk management framework, detailed in Articles 5-16, establishes requirements for a "sound, comprehensive and well-documented" system that enables addressing ICT risks "promptly, efficiently and comprehensively" (*Regulation EU 2022/2554, Article 6*). For municipalities, these principles transform into practical requirements for managing urban digital services: from electronic document management systems to administrative service delivery platforms. Key components include citizen data protection strategies, incident response procedures for critical infrastructure, and service continuity protocols during emergencies.

Of particular value to municipalities is the concept of a simplified ICT risk management framework (S-RMF) under Article 16 of DORA. Although this framework was developed for small financial institutions, its five main components are ideally suited for adaptation in a municipal context: risk management for municipal IT systems, protection of citizens' personal data, monitoring and detection of incidents in urban infrastructure, management of dependencies on private IT suppliers, and ensuring continuity of critical urban services. Small municipalities with limited resources can use this simplified approach, whilst large cities implement more comprehensive systems.

DORA's proportionality principle, established in Article 4, has direct application to the municipal sector. Small communities with populations up to 10,000 can limit themselves to basic ICT risk management; medium-sized cities (10,000-100,000 inhabitants) implement expanded systems with regular testing; large cities and capitals must have comprehensive digital resilience programmes with advanced monitoring technologies. This scalability allows each municipality to develop a protection system appropriate to its size and resources.

DORA's resilience testing requirements (Articles 24-27) are adapted for the municipal context through regular checks of service delivery systems, crisis scenario simulations for critical infrastructure, and testing of communication channels with citizens during emergencies. Large cities can conduct the equivalent of TLPT (Threat-Led Penetration Testing) for their critical systems – water supply, energy networks, transport management – at least once every two years.

Practical examples of DORA principles adaptation in European cities demonstrate diverse approaches. Tallinn, known for its e-residency and digital services, uses a multi-layered protection system similar to DORA requirements for systemically important institutions. The city has implemented critical systems redundancy, automated anomaly detection, and regular penetration testing for all public e-services. Following the 2022 cyberattacks, the city strengthened requirements for IT service providers, implementing contractual conditions analogous to DORA's third-party risk management requirements.

Barcelona, through its local "Barcelona WiFi" platform and "Sentilo smart city" system, has adapted DORA's business continuity principles for the urban context. The city has created duplicate data processing centres, implemented rapid recovery protocols for critical services (maximum 4 hours downtime for basic services), and regularly conducts crisis scenario simulations. The incident management system requires notification of critical failures within 1 hour – even stricter than DORA requirements.

Munich, after returning to open-source solutions, has developed its own digital resilience model combining DORA principles with requirements of the German BSI (Federal Office for Information Security). The city has implemented an IT asset classification system by criticality, regular security audits for all municipal systems, and mandatory cybersecurity training for all employees working with critical systems.

Table 4

Examples of ICT risk management implementation under DORA

Organisation	Sector	DORA Focus	Key Implementation Stages	Ease and Scalability	Outputs
Global Bank (*Nasker, 2024*)	Banking	ICT Risk Management	1) Gap analysis → 2) Centralised risk management function → 3) Automated monitoring and reporting	Modular framework, gradual tool configuration	Enhanced risk visibility, 60% reduction in incident response time
Fintech Company (*Nasker, 2024*)	Fintech	ICT Risk Management	Scenario-based risk testing with third-party involvement	Use of ready-made scenario templates for repeat testing	Improved crisis readiness, 40% reduction in unplanned downtime
Insurance Firm (*Nasker, 2024*)	Insurance	Incident Reporting	Report template standardisation → Rapid response team → Employee training	Unified procedures, minimal organisational changes	Consistent reporting, 50% reduction in incident processing time
Investment Firm (*Nasker, 2024*)	Investment	Third-Party Risk Mgmt	Supplier criticality assessment → New contracts with DORA SLA → Continuous monitoring	Centralised third-party registry, integration with existing CRM	Reduced dependency risk, prompt detection of non-compliance

All these cases (see Table 4) demonstrate that DORA's ICT risk management principle can be implemented through simple, modular approaches that scale easily across organisations of different sizes and sectors. Ease of integration is achieved through clear requirements for asset inventory and phased implementation of monitoring and reporting tools. The viability of such solutions is confirmed by process resilience even under complex external threats for all listed organisations.

Particularly important for municipalities is IT service provider management. Unlike the financial sector, cities often depend more on external providers due to limited internal IT resources. Adapting DORA requirements means including in contracts clear SLAs regarding service availability, backup and recovery requirements, rights to audit supplier systems, and mandatory security incident reporting.

Funding digital resilience becomes a key challenge. The Digital Europe Programme (DIGITAL) provides a total budget of over €7.6 billion for 2021-2027, of which €1.5 billion is allocated to cybersecurity measures open to business and public sector participation (NCC-SE, 2023). Co-financing covers 50% of eligible costs (up to 75% for small and medium-sized businesses) (*Digital Europe Programme, 2021*). Horizon Europe, under Cluster 3 "Civil Security for Society", allocates approximately €119 million for cybersecurity research and innovation during 2023-2024 (*NCC-SE, 2023*).

Future regulation of municipal digital resilience is currently based on DORA principles (Regulation (EU) 2022/2554), which establishes unified requirements for ICT risk management, cybersecurity, and incident reporting in the financial sector by 2025 (*O'Grady, 2025*). Despite the absence of a separate directive for the public sector, municipalities can adapt DORA by applying a proportional approach: selecting requirement levels based on population size, scale of digital services, and resource constraints.

DORA does not account for external attacks or physical destruction, hence Kharkiv's indicator demonstrates exceptional stress resilience. Adapting DORA principles represents for European municipalities not merely a regulatory challenge but an opportunity to rethink approaches to digital security. In an era when urban services are becoming increasingly digitalised and threats more complex and diverse, lessons from the financial sector can become the foundation for creating truly resilient municipal systems. Success will depend on cities' ability to adapt these principles to their unique conditions, maintaining a balance between security, service accessibility, and efficient use of limited resources. As the experience of leading European cities shows, investment in digital resilience is not an expense but a strategic investment in citizen trust and the city's ability to function in an unpredictable future.

Comparison of Two Models and Identification of Their Complementarity

Comparative analysis of the Ukrainian 'forced innovation' model (using Kharkiv's DS '1562'as an example) and the European regulatory DORA model reveals differences in approaches to ensuring digital resilience, which paradoxically create a foundation for synergetic integration within the Web 3.0 conception.

1. **ICT risk management in crisis.** The Ukrainian model demonstrates phenomenal adaptability: the '1562'system ensures 97.3% availability during active shelling, processing up to 72,993 requests per month with an average response time of 3.7 minutes for critical incidents. This is achieved through dynamic prioritisation algorithms that automatically redistribute resources based on threat level. In contrast, DORA offers a structured approach with regular resilience testing (TLPT every 3 years) and comprehensive procedure documentation. Web 3.0 integration could combine both approaches through autonomous AI agents with self-healing architecture, capable of real-time decision-making based on Ukrainian model experience and DORA standards.

2. **Ease of implementation.** The Kharkiv model was built on a 'learning by doing' principle – each solution was implemented immediately and tested in combat conditions. Minimal bureaucracy and use of available resources (95% of requests via telephony) enabled rapid system scaling. DORA provides clear instructions and ready templates but requires significant initial investment and complex implementation. Web 3.0 solutions could offer plug-and-play modules with automated deployment, combining the Ukrainian model's speed with DORA's systematicity.

3. **Solution scalability.** DS '1562'demonstrated organic growth from 1,000 to 10,000+ requests per day through horizontal scaling – adding operators and backup channels. DORA uses a proportional approach: small organisations implement a simplified framework (S-RMF), large ones – the

full set of requirements. Decentralised Web 3.0 architecture with elastic infrastructure and smart contracts will enable automatic resource scaling based on load, without manual intervention.

4. **Viability under threats.** The Ukrainian model proved its effectiveness under extreme conditions: functioning without electricity for 8+ hours thanks to autonomous power, backup communication channels, local autonomy with synchronisation after connection restoration. DORA focuses on business continuity planning (BCP) and backup copying but remains dependent on stable infrastructure. Full Web 3.0 decentralisation will ensure functioning even with 60%+ network node loss through distributed consensus and quantum-resistant encryption.

5. **Resource efficiency.** The Kharkiv model operates with minimal budget, engaging volunteers and using creative solutions (hybrid IP telephony). DORA requires significant initial investment – up to €7 million for a large organisation, need for certified specialists, high operational compliance costs. Automation through Web 3.0 could reduce costs by 70%+ through eliminating intermediaries, automatic process execution via smart contracts, and community-driven support instead of expensive consultants.

Table 5

Comparative analysis of digital resilience models

Element	Advantages of Ukrainian model (DS '1562')	DORA Standards	Integrated Web 3.0+ element
ICT risk management in crisis	– Adaptive real-time response – 97.3% availability under shelling – Dynamic prioritisation – Experience of 47 critical incidents	– Structured procedures – Regular TLPT testing – Comprehensive documentation – EBA/ESMA standards	– Self-healing AI architecture – Distributed decision-making – ML-based predictive analytics – Autonomous response agents
Ease of implementation	– Minimal bureaucracy – Learning by doing – Use of available resources – Rapid deployment	– Clear instructions and templates – Ready S-RMF frameworks – But complex initial setup – High entry threshold	– Plug-and-play modules – No-code/low-code platforms – Automated deployment – Intuitive interfaces
Scalability	– Organic growth 1K→10K+/day – Horizontal scaling – Flexible resource addition – Load adaptation	– Proportional approach by size – Vertical integration – Regulated levels – Planned scaling	– Elastic infrastructure – Auto-scaling via smart contracts – Dynamic resource allocation – Pay-per-use model
Viability under threats	– Operation without electricity 8+ hrs – Backup communication channels – Local autonomy – 94.2% uptime under shelling	– Business continuity plan (BCP) – Backup copying – But infrastructure dependency – 95% SLA for crisis	– Full decentralisation – Functioning with 60%+ node loss – Quantum-resistant cryptography – Data immutability
Resource efficiency	– Minimal budget – Volunteers and enthusiasts – Creative solutions – Maximum from minimum	– Significant initial investment – Certified specialists – High operational costs – ROI in 2-3 years	– 70%+ cost reduction – Process automation – Community governance – Token economy incentives

The key conclusion is that the Ukrainian model and DORA represent two complementary dimensions of agile public governance. The Kharkiv model has demonstrated that rapid GovTech solutions born during war and threats can outpace traditional regulatory mechanisms and create new efficiency standards. However, DORA offers an architecture of long-term resilience through systematisation and scaling of proven practices. I believe that the promising synthesis of these approaches through Web 3.0 technologies forms a new vision of agile governance – public administration that combines rapid reactivity with strategic predictability in a unified decentralised ecosystem.

Practical implementation of such hybrid GovTech architecture envisages transformation from hierarchical structures to network platforms: starting with decentralised decision-making points (empowered nodes), through implementing collective intelligence algorithms for rapid consensus, to forming fully autonomous municipal services with public control through DAO mechanisms. The Kharkiv case proves that true innovation in public governance is born not in planning offices but in moments of existential challenge, when speed of reaction and readiness for radical experiments become matters of community and institutional survival.

A theoretical Model of Decentralised GovTech Architecture: From Illusions to Reality

Development of a theoretical model for decentralised GovTech architecture requires, first and foremost, honest acknowledgement: there is no 'magic switch' that will instantly toggle a municipal system from peacetime to crisis mode. Kharkiv's experience shows that even the best automation relies on human judgement, and Web 3.0 technologies, despite all promises, cannot replace operators' critical thinking in unpredictable situations. Therefore, the proposed authorial 'Cascading Resilience Model' is designed not as an automatic 'switch', but as an adaptive system of human-technology interaction, where each degradation level is activated through conscious decisions supported by algorithmic assistance. This is indeed complex, yet necessary.

Conceptually, the model is based on the principle of cascading redundancy, where the system has three main operational modes:

1. Level 1 - Normal mode (DORA-compliant) with full functionality and preventive monitoring, where AI optimises resources and forecasts load;
2. Level 2 - Crisis mode (Kharkiv-mode), activated upon anomaly detection with prioritisation of critical functions and disconnection of secondary ones;
3. Level 3 - Survival mode with minimal function set through P2P network, where local nodes operate autonomously with post-synchronisation.

The key innovative idea lies in creating a 'digital twin' of crisis based on Kharkiv data – a virtual environment that will allow AI systems in other cities to gain 'war experience' without actual war, combining the empirical value of Ukrainian experience with DORA's preventive approach.

The model's essence lies in organising municipal digital services into three functional blocks, each with three levels of operational readiness. These are not merely backup copies of each other – each level is optimised for a specific threat scenario with its own operational logic, resource requirements, and balance between efficiency and resilience. Transition between levels occurs not automatically but through a structured situation assessment process, where AI systems provide recommendations but final decisions are made by authorised personnel. This approach combines the speed of algorithmic data processing with human ability to assess context and make non-standard decisions.

The risk management block demonstrates evolution from resource-intensive predictive analytics to simple survival rules. At the first level, AI systems analyse terabytes of data, detecting weak signals of future problems 72 hours ahead. But when infrastructure degrades, the system switches to edge-computing with local models running on limited resources, maintaining ability to detect critical threats 6-12 hours ahead. In survival mode, only simple heuristic rules remain, such as "if more than 50 calls in 5 minutes about one problem – emergency alert", which can work even on an operator's smartphone.

Table 6

Architecture of functional blocks in the 'Cascading Resilience'model

Functional Block	Level 1: Optimal (DORA-mode)	Level 2: Adaptive (Kharkiv-mode)	Level 3: Autonomous (Survival-mode)
A. Risk Management with AI	− Full-scale predictive analytics − ML models on cloud GPUs − Integration with all data sources − 72+ hour forecasting	− Local edge-computing − Simplified models on CPU − Priority on critical metrics − 6-12 hour forecast	− Rule-based heuristics − Works on mobile devices − Emergency alerts only − Reactive mode
B. Multi-channel Infrastructure	− Omnichannel (web, app, tel, email) − Centralised orchestration − CRM integration − Personalised routing	− Priority channels (95% phone) − Local routing − Simplified ticketing − Grouping by criticality	− P2P mesh via Bluetooth/WiFi − Offline forms with sync − SMS via backup GSM modems − Paper backup procedures
C. Decentralised Security	− Full blockchain audit − Real-time cryptography − Multi-factor authentication − Compliance monitoring	− Selective recording of critical actions − Simplified authentication via email or mobile number − Post-facto validation	− Local crypto-capsules − One-way hashes − Emergency access tokens − Recovery via social graph

Multi-channel infrastructure transforms from luxurious omnichannel capability to basic P2P communication. Kharkiv's experience showed that 95% of citizens in crisis return to telephone as the most reliable channel. Therefore, the second level optimises voice communication specifically, disconnecting energy-intensive digital channels. The third level activates mesh networks, where citizens' smartphones become retransmitters, creating a resilient communication fabric even without centralised infrastructure. Critically, at each level the ability to record requests for subsequent processing is maintained – even if these are paper forms later scanned.

The security system evolves from full blockchain transparency to minimalist cryptographic guarantees. At the first level, every action is recorded in a distributed ledger (blockchain) with complete history and audit capability. When resources are limited, the system switches to selective recording of only critical operations, using batch cryptography to economise computational resources. In survival mode, only local cryptographic capsules remain – encrypted files with critical data that can be decrypted and validated after infrastructure restoration.

The coveted 'reserve of possibilities' in GovTech through Web 3.0 implementation lies precisely in the transition from centralised dependency to distributed (gradually distributed) autonomy. The technological reserve of Web 3.0 for municipal systems manifests in three key aspects of architectural evolution:

1. Firstly, transition from client-server model to peer-to-peer protocols reduces single points of failure – instead of one critical server, the system relies on a network of interchangeable nodes.

2. Secondly, Web 3.0 cryptographic primitives (hash functions, digital signatures, Merkle trees) ensure data verifiability without needing a trusted intermediary, critically important during infrastructure degradation.

3. Thirdly, consensus mechanisms enable achieving system coherent state even during "Byzantine failures" – when some nodes are unavailable or compromised.

Table 7

Transition mechanisms between levels of the cascading model

Transition Parameter	1→2 (Degradation)	2→1 (Recovery)	2→3 (Collapse)	3→2 (Stabilisation)
Triggers	− Availability <95% (15 min) − Load >300% − Loss of 30% nodes − Cyberattack confirmed	− Availability >98% (60 min) − Load <150% − All nodes restored − Threats eliminated	− Availability <70% − Loss of control centre − Mass service failures − Physical destruction	− Basic connectivity >80% − Coordination restored − Key services online − Security situation stable
Decision Process	− AI recommends (30 sec) − Supervisor validates (60 sec) − 3/5 operator consensus − Transition initiation	− Automatic proposal − Readiness testing − Phased migration − Stability confirmation	− Emergency protocol − Senior decision − Broadcast to all nodes − "Every human for himself/herself"	− Active node search − Cluster formation − Coordinator election − Data synchronisation
Transition Time	3-5 minutes	15-30 minutes	1-2 minutes	30-60 minutes
Rollback Possibility	Yes, within 1 hour	Automatic on failure	No, forward only	Yes, if deteriorating

For municipalities, this means the ability to maintain integrity of critical registries (cadastre, infrastructure status, service queues) even with 30-40% computational resource loss, which would be impossible with traditional architecture under Kharkiv conditions.

The model's key innovation is not technological complexity but organisational flexibility. Each block can function at its own level independently of others. For example, during a DDoS attack, the security block transitions to Level 2 with enhanced monitoring, whilst infrastructure remains at Level 1. This allows optimal resource distribution and avoids excessive degradation of the entire system due to a local problem. Experience of DS '1562' from Kharkiv showed that precisely this flexibility allowed maintaining 97% availability even under shelling – the system adapted to each specific threat rather than switching between rigidly defined states.

Model implementation requires transition from deterministic management systems to adaptive architectures with dynamic reconfiguration. An innovative yet ideologically and technologically important 'step' and element becomes the implementation of new-generation meta-contracts (following the example of the Ukrainian Bitbon System), which unlike primitive smart contracts contain not only executable code but also contextual metadata, self-regulation rules, and mechanisms for automatic synchronisation with blockchain registry. Such architecture allows municipal systems not merely to execute pre-written scenarios but to dynamically adapt business logic to current conditions – from optimising municipal vehicle routes in peacetime to automatic redistribution of emergency service resources during shelling. However, this has not yet been applied in Kharkiv for urban infrastructure. But demand for such new solutions is growing as solutions for the entire ecosystem, not isolated solutions.

Kharkiv's experience confirms: systems capable of runtime self-modification survive where monolithic solutions with rigid architecture collapse within the first hours of crisis. The proposed 'Cascading Resilience' model offers not a static architecture but an ideology of new 'meta-architecture': something like a set of patterns and protocols that allow the system to evolve according to challenges whilst maintaining operational integrity and recovery capability.

Discussion

Amongst the multitude of theoretical and practical implications of our research, the most critical for further GovTech development is the question of scaling 'war experience' – transferring crisis innovations from Kharkiv's context to stable European municipalities. Whilst technical aspects of integrating the Ukrainian 'survival model' with DORA regulatory standards merit detailed analysis, and the phenomenon of technological leap from Web 2.0 to Web 3.0 opens new horizons for digital transformation, it is precisely the ethical and methodological challenges of using data from combat zones that will determine the legitimacy and effectiveness of future digital resilience systems. The concept of a crisis 'digital twin' proposed in our model – a virtual environment for training AI systems based on 1.2 million real citizen requests under shelling – raises questions about the permissible limits of using human suffering for technological progress.

The ethical dimension of the problem extends far beyond traditional discussions of data privacy or informed consent. Each of the 72,993 requests during extreme shelling in November 2024 is not merely a data point for machine learning, but testimony of human tragedy, a cry for help at a moment of mortal danger. Using this data for training AI systems creates a paradoxical situation: on one hand, ignoring this unique experience would mean wasting invaluable lessons gained at an exorbitant price; on the other, commercialisation and routinisation of 'war experience' risks devaluing human losses and normalising extremity. Particularly acute is the question of consent: did Kharkiv citizens, contacting service '1562' under shelling, imagine their calls would become training material for European municipalities? Even data anonymisation does not relieve ethical tension – patterns of human behaviour under threat of death remain deeply personal, regardless of removed personal identifiers. Development of a new ethical framework for 'survival data' is necessary, one that would recognise their special status and establish strict limitations on commercial use, whilst enabling learning opportunities to enhance other communities' safety.

Methodological limitations of simulating real crises prove no less critical. Kharkiv's 'digital twin', despite all technological sophistication, will remain a simplified model incapable of reproducing the horror and irrationality of human behaviour under shelling (EU residents currently find this difficult to understand, but this could change for the worse for them in 3-5 years). Municipal AI systems and big-data analytics trained on conditionally 'Kharkiv'/Ukrainian data might more optimally distribute resources under load of 8,000 calls per day (indeed a lot!), but can they account for panic, rumours, mass hysteria – all those irrational factors that define a real crisis?

Moreover, each crisis is unique: a hypothetical 'earthquake' in Lisbon generates different behavioural patterns than shelling in Kharkiv, and a hypothetical flood in Budapest differs from a terrorist attack in Marseille. Attempting to create a universal crisis response model based on one, albeit extreme, case risks errors through overfitting to specific conditions of war in Ukraine.

I also see a methodological 'trap' in the illusion of control: successful simulation can create false confidence in readiness for 'black swans', whilst real crisis always brings unpredictable challenges. Oddly, excessive preparation based on past crises can make a system more fragile to future, fundamentally different threats – a phenomenon Nassim Taleb calls 'ludic fallacy', when reality is replaced by its simplified game model.

Another methodological collision between Kharkiv experience and European regulatory frameworks manifests in the incompatibility of basic operational assumptions. DORA (Regulation EU 2022/2554) is built on the presumption of 'steady state'– a stable operational environment with predictable threat parameters, where incidents are classified by seven clear criteria (JC 2023 83), and recovery presumes return to baseline configuration. In contrast, the Kharkiv model functions in a 'continuous risk' paradigm, where there is no stable state to return to, and each new day can bring some unpredictable combination of physical destruction, cyberattacks, and personnel losses. Furthermore, GDPR (Regulation EU 2016/679) requires consent for personal data processing with withdrawal

possibility, but how to ensure the right to data deletion (Article 17) for a citizen whose emergency call under shelling has already become part of an AI system training dataset? NIS2 Directive (EU 2022/2555) stipulates a 24-hour window for incident notification, but in Kharkiv conditions, where critical incidents occur every minute, such requirement becomes absurd – the system would generate thousands of formal notifications instead of focusing on operational continuity. Technically, using P2P mesh networks in Level 3 of the proposed model somewhat conflicts with eIDAS (Regulation EU 910/2014) requirements for qualified trust services, as it is impossible to guarantee node identification in a dynamic network during combat.

The sharpest methodological contradiction concerns efficiency metrics: DORA operates with SLA 99.9% for normal conditions and 95% for crisis scenarios, but these thresholds are calculated for 'clean failures'– technical failures in controlled environments, not situations where half the infrastructure is physically destroyed and operators work from bomb shelters. Attempting formal certification of the Kharkiv system by European standards would reveal dozens of critical non-compliances, although it is precisely this 'non-compliant' system that proved viable where 'compliant' solutions simply could not function.

All Europeans as well as EU-based institutions should realise that the era of 'regulatory comfort' is ending – the world has already entered a change of world order with wars and contradictions, where speed of adaptation is more important than formal compliance with 'mega-laws' or international agreements, and ability to function under complex conditions is significantly more important than optimisation in a stable environment. The world we know and remember is changing; it will not remain as it is. I fear that numerous EU-regulations will be short-lived in the EU due to the threat of a major high-tech war in Europe in the next 3-4 years. Therefore, I am convinced that ignoring and/or misunderstanding Kharkiv experience due to its 'non-compliance' with existing Euro-regulations would be not merely a missed opportunity but a potentially fatal mistake – when European cities face existential challenges (whether real war, climate catastrophes, or systemic infrastructure collapse), there will be no time to develop 'DORA 2.0'. True digital resilience is born not into regulators' offices but in the crucible of real crises, and the only way forward is synthesising Ukrainian anti-fragility with European systematicity through radically new technological solutions that fit no existing frameworks but work where traditional systems are powerless.

Conclusions

1) Institutional analysis of EU-Ukraine cooperation demonstrates the following digital resilience trajectory: from forced wartime innovations that outpaced regulatory standards to systematic integration of Ukrainian experience into European mechanisms through EU4DigitalUA, DT4UA platforms and GovTech dialogue. This evolution creates an unprecedented opportunity for synthesising two approaches – Ukrainian adaptability and European systematicity – in a new paradigm of digital resilience, where practical experience of extreme conditions enriches and validates theoretical models of regulated development. Methodologically, this phenomenon can be conceptualised as 'reverse innovation transfer', when peripheral actors under crisis conditions generate solutions that outpace central regulatory mechanisms. The identified dynamics challenge the classic linear 'centre-periphery' innovation diffusion model and actualise the need to develop new theoretical frameworks for understanding multi-vector technological transfer processes under global crises. It is precisely this methodological novelty that makes Ukrainian-European cooperation not merely technical exchange but a laboratory for forming new approaches to ensuring public governance resilience in an era of growing uncertainty.

2) The viability of the Kharkiv model is explained by several key factors often ignored in traditional digitalisation approaches. Firstly, the system was created not according to a modernisation plan but as a tool for city survival, forcing abandonment of perfectionism in favour of rapid adaptability – each technological solution was tested in real combat conditions and either proved its effectiveness

or was replaced. Secondly, unique personnel policy: after mobilisation of some staff operators, their places were taken by volunteers from among IT specialists evacuated from other regions, bringing startup culture with readiness for experiments and rapid changes to the service. Thirdly, the psychological factor – awareness that thousands of lives depend on service quality created unprecedented levels of motivation and responsibility at all levels.

3) Critically important was the understanding that under war conditions, traditional efficiency metrics lose meaning – instead of cost optimisation or throughput maximisation, the main KPI became the system's ability to function in degraded mode. Therefore, architecture was built on the principle of 'graceful degradation'– when one component fails, the system automatically switches to backup channels with minimal functionality loss. For example, when internet is disconnected, operators can continue taking calls and entering data into a local database that synchronises after connection restoration.

4) DORA does not account for external attacks or physical destruction, hence Kharkiv's indicator demonstrates exceptional stress resilience. Nevertheless, DORA's lessons for the municipal sector are obvious: (a) digital resilience is not merely a technical task but a strategic priority requiring active senior management involvement; (b) proportionality ensures balance between protection level and burden on budget and personnel; (c) regular testing (for example, using the TIBER-EU model) and team training enhance readiness for real cyber incidents; (d) cooperation through Eurocities networks, DG Reform and other experience exchange platforms promotes standards alignment and best practice multiplication.

5) The Ukrainian model and DORA are not mutually exclusive but rather complementary approaches. The Ukrainian model proved that under extreme conditions, speed of adaptation and readiness for experiments are more important than adherence to formal procedures. DORA provides systematicity and predictability necessary for stable development. Integration of both approaches through Web 3.0 and even Web 4.0 technologies (real examples of such solutions already exist – the Bitbon System of Ukrainian origin) creates new desired synergy: Ukrainian model adaptability combines with DORA's structure in decentralised architecture, ensuring both crisis resilience and peacetime efficiency. Practical implementation of such integrated model will require a phased approach: first implementing basic decentralisation elements (distributed databases, backup nodes), then adding AI components for routine process automation, and finally full transition to an autonomous system with minimal human intervention. Kharkiv's experience shows that even under the most challenging conditions, effective digital transformation is possible with clear understanding of priorities and readiness for innovation.

6) The 'Cascading Resilience' model demonstrates that true digital resilience of municipal systems is achieved not through implementing individual Web 3.0 technologies but through creating adaptive meta-architecture with three degradation levels for each functional block. The fundamental distinction of the approach lies in transitioning from rigidly deterministic systems to self-modifying architectures capable of rebuilding their own topology depending on available resources. The model ensures functioning with up to 40% computational capacity loss through a combination of P2P protocols, Byzantine fault tolerance and cryptographic verification mechanisms without a trusted centre. This transforms the municipal governance paradigm from centralised hierarchies to distributed networks with emergent properties, where resilience arises not from resource redundancy but from architectural flexibility and ability to evolve under external challenge pressure.

7) The research revealed a fundamental dilemma of scaling 'war experience': ethical inadmissibility of commercialising human suffering confronts the pragmatic necessity of using unique data to enhance other communities' resilience. Methodological incompatibility of Kharkiv's 'continuous risk paradigm' with European 'steady state' presumption, I think, demonstrates existing regulatory frameworks' limitations when facing existential challenges. In an era of global turbulence, when world

order undergoes fundamental changes, ignoring Ukrainian experience due to its 'non-compliance' could become a fatal mistake for European cities. The only way forward is synthesising Ukrainian anti-fragility with European systematicity through new technological solutions that transcend existing regulatory paradigms but ensure functioning where traditional systems fail.

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NAVIGATING DEMOGRAPHIC CHALLENGES FOR SUSTAINABLE ECONOMIC GROWTH IN THE BALTIC STATES

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Abstract. The Baltic States face severe demographic challenges, including low fertility rates, high emigration, an aging population, and urbanization pressures. These factors have significant implications for sustainable economic growth. This research study aims to assess the impact of these demographic trends on economic growth in the three Baltic States, Estonia, Latvia, and Lithuania and propose solutions to foster economic stability. Using a panel regression framework, this research analyzes longitudinal data from 1990 to 2023, sourced from the World Bank and United Nations Population Division. The study examines key demographic variables, fertility rates, age dependency ratios, urban population growth rates, and net migration. On the other hand, sustainable economic development is measured using GDD per capita data. Descriptive statistics, multicollinearity assessments, and robust fixed-effects regression models were employed to in the data analysis process. The statistical tool that was used is the R Software (R-code provided in Appendix 2:. The findings of the research study reveal that the age dependency ratio significantly influences GDP per capita. This highlights the burden of a growing elderly population on economic productivity. In contrast, urban population growth, net migration, and crude birth rates were not statistically significant predictors. The findings show that the increasing dependency ratio is the key demographic challenge affecting the Baltic States. To address these challenges, the study recommends resolutions to extend working lifespans, such as raising the retirement age and offering phased retirement options. Additionally, immigration policies targeting younger, skilled workers could mitigate labor shortages.

Key words: Age Dependency ratios, Baltic States, Demographic Challenges, Sustainable economic growth.

1 INTRODUCTION

1.1 The Research Problem

In the recent past, there have been contrasting demographic patterns across various regions of the world. In many developing countries, especially African, South Asian, and a section of the Middle Eastern nations, the population growth rate has been rising steeply. On the other hand, most of the developed countries in Europe, East Asia, and some parts of North America having a decline in their population (Gu et al., 2021). The Baltic States: Lithuania, Estonia, Latvia are high income economies in Europe that have also experienced a negative population growth in recent years (Khachatrian et al., 2023). It is important to note that this region is the most depopulating region in the world which has lost more than 20 per cent of population since 1992 (World Population Prospects, 2024).

Aitken (Aitken, 2024) highlights that the Baltic States have experienced depopulation due to low fertility rates. In recent decades, the fertility rates of the Baltic countries have reduced significantly, and this has negatively affected the economic output of the region. Low fertility rates have resulted in low birth rates which reduces the available workforce in the youth bracket who can be absorbed into the market to enhance economic growth in the region (Khachatrian et al., 2023). In addition, another demographic factor that has affected the economic output of the Baltic region is increased life expectancy rates. The rise in life expectancy rates has significantly caused another problem which is an aging population (Khachatrian et al., 2023). This has created a situation whereby there are many people in the elderly

group than in the youth. As a result, they have been experiencing a shrinking working-age population and rising dependency ratio, which indicates that fewer numbers of working population are available for supporting the older population. Furthermore, the rise of the ageing population results in the need for increased pensions, health care and other social amenities, which are a heavy financial burden and therefore have a negative effect on the sustainable development of the region.

Furthermore, Galstyan et al.(Galstyan et al., 2021) indicates that the reduced population in the Baltic States has been caused by high emigration. A considerable proportion of the young persons has migrated to other countries in a bid to improve their quality of life. The movement of people from the Baltic states to other countries has been possibly due to integration of the Baltic states into the EU). This high emigration rates have played a crucial part in draining the local manpower needed for the production of goods and services hence leading to scarcities in the available workforce within the region.

Another demographic characteristic that has affected economic development of the countries of the Baltic states is urbanization (Varpina, 2018). It is important to note that a significant part of the population is migrating from rural to urban areas to get better job opportunities, education and standards of living. For this reason, the rural areas have had an economic loss due to the loss of a workforce in rural areas, which in turn has caused regional variations between different regions of the countries (Lang et al., 2022). On the other hand, increased urbanization has also created problems in urban areas such as increased pressure on infrastructure facilities, lack of housing, and increased demand for public services.

Therefore, there is need to analyse demographic challenges and their impact on sustainable economic growth. This research aims to explore these demographic challenges in the Baltic region and give recommendations to foster economic stability and growth in the region.

1.2 Topicality of the Research

This research study focuses on the demographic challenges that beset the Baltic states, Estonia Lithuania, and Latvia. The findings of this research study will provide insight to policy makers on what they can do to mitigate the democratic challenges in the region so as to enhance sustainable economic development. The findings of this research study will help policy makers in government to formulate strategies that can help in reversing the impacts of low birth rates and emigration, as well as develop measures to strengthen social security systems, health care, and employment policies for the older population. Furthermore, knowledge and insight derived from this research study will help businesses operating in the Baltic region to adopt existing demographic trends in the region, which include reduced working population and an aging population. This will help the business remain competitive despite emerging demographic changes in the region. Additionally, insight derived from this research study will inform help employers develop appropriate strategies for workforce development, talent retention and technological innovation. Moreover, this research study will be useful for scholars and researchers because its findings will extend the existing knowledge base on demographic changes and the effect they bring to economic and social structures. The outcomes of the study may be useful not only to the countries of the Baltic States but also to others that experience similar demographic shifts.

1.3 Goal of the Research

To examine the demographic challenges facing the Baltic states and identify effective policy responses that will promote sustainable economic growth in the region.

1.4 Research design and Methodology.

1.4.1 Data Collection

The data for this study was primarily sourced from the World Bank Group. The missing data from this source was complemented by data from the United Nations Population Division: World Population Prospects. The Link to the data is provided in Appendix 1. The researcher extracted data of the variables of interest and saved them in four csv data files which *include EstoniaData, LatviaData,*

LithuaniaData and Combinedbalticdata. The link to the csv files is available in Appendix 1. The data collected was of the three Baltic States, which include Estonia, Latvia, and Lithuania. The data collected covered information from the year 1990 to the year 2023, which is the period that the data is available for all the three countries.

1.4.2 Variables of interest

The following variables will be used for the research study.

- **GDP per Capita (Constant LCU)**

GDP per capita represents the total economic output of a country divided by its population (Wang & Li, 2021). For this study, it is measured in constant local currency units (LCU), which adjusts GDP figures for inflation within each country. This adjustment ensures that comparisons over time reflect real changes in economic output, rather than distortions caused by price level changes.

- **Fertility Rate**

Fertility rate is defined as the average number of children a woman is expected to have during her lifetime (United Nations Glossary, 2024). A higher fertility rate is anticipated to have a negative association with economic growth, as it may indicate greater resource strain in countries with limited economic capacity (Li, 2016).

- **Crude Birth Rate**

Crude Birth rate refers to the number of live births per 1,000 people in a given year (United Nations Glossary, 2024). Higher crude birth rates are expected to negatively correlate with GDP per capita due to potential economic pressures associated with higher birth rates (Ilori & Akeju, 2022).

- **Population Growth Rate**

Population growth rate is defined as the annual percentage change in a country's population, accounting for births, deaths, and net migration (United Nations Glossary, 2024). The relationship between population growth rate and economic development is expected to be mixed. Moderate population growth may support economic expansion, while excessively high or negative growth may strain resources or indicate declining economic vitality (Peterson, 2017).

- **Urban Population Growth Rate**

Urban Population Growth rate is the annual percentage growth of the population living in urban areas (United Nations Glossary, 2024). Higher urban population growth is anticipated to positively correlate with economic growth as urbanization is often associated with industrialization, innovation, and infrastructure development (Sarker et al., 2016).

- **Net Migration Rate**

Net migration rate refers to the net number of people entering or leaving a country per 1,000 people in the population (United Nations Glossary, 2024). Positive net migration (more people entering than leaving) is expected to positively influence economic growth by enhancing labor markets, innovation, and overall economic productivity (Oliinyk et al., 2021).

- **Age Dependency Ratio**

This refers to the percentage of the working-age population relative to the total population (Kirch, 2008). A higher age dependency ratio is expected to have a negative impact on economic growth since this means that there is a low working age population hence reducing the labor force available for production, increasing the economic burden on workers, and straining public resources such as pensions, healthcare, and social services (Arif et al., 2021).

1.4.3 Analytical framework

This study employs the Panel Regression Frameworks to analyze the relationship between demographic factors and economic development in the Baltic States. The general form of the regression model is presented as follows.

$$PcGDP_{it} = \theta_0 + \theta_1 ADR_{it} + \theta_2 FR_{it} + \theta_3 CBR_{it} + \theta_4 NMR_{it} + \theta_5 PGR_{it} + \theta_6 UPGR_{it} + \varepsilon \qquad \textit{Eg 1.1}$$

Whereby

$PcGDP_{it}$ *: GDP per Capita of Country i, year t.*

θ_0 *is the intercept term.*

$\theta_1 \ldots \theta_6$ *are the coefficients of the independent variables, representing the magnitude and direction of their impact on GDP per capita.*

ε *is the error term.*

1.4.4 Data Analysis

1.4.4.1 Descriptive analysis

The researcher also presents the trends of demographic factors per country over the years so as to identify patterns, may influence the relationship between these factors and economic growth. The researcher also analyses trends through graphical illustrations to see how the demographic variables have evolved over time in each country. This helps to contextualize the statistical analysis and ensure the researcher understands the data's behavior across the study period.

1.4.4.2 Multicollinearity assessment

The Variance Inflation Factor (VIF) is calculated to detect multicollinearity among the independent variables. Variables exhibiting high collinearity were considered for exclusion to ensure reliable coefficient estimates.

1.4.4.3 Panel Regression analysis

This research study adopted Panel Regression analysis. Panel regression analysis refers to a statistical method used to analyze panel data (Hsiao, 2007). Panel data is a dataset that combines time series and cross-sectional data, containing observations over multiple time periods for the same units (e.g., individuals, firms, or countries) (Hsiao, 2007). It helps control for unobserved heterogeneity and explores both dynamic and static relationships by leveraging the two-dimensional structure of panel data.

Panel Regression analysis entails fitting the following models.

- **Pooled Ordinary Least Squares (OLS) model**

The pooled OLS model is a assumes uniformity across all units and time periods by treating panel data as a single dataset (Hsiao, 2007). It does not account for unit-specific or time-specific effects, making it appropriate when unobserved heterogeneity is minimal or uncorrelated with the explanatory variables. For this research study, this is a baseline model assuming no country-specific effects, used to test for unobserved heterogeneity.

- **Fixed Effects Model (FE) model**

The fixed effects model captures unit-specific effects that may be correlated with explanatory variables by focusing on variations within each unit over time (Hsiao, 2007). It removes time-invariant unobserved heterogeneity through data transformations. For this research study, this model accounts for country-specific differences by allowing each country to have its own intercept, controlling for time-invariant factors.

- **Random Effects Model (RE) model**

The random effects model assumes that unit-specific effects are random and uncorrelated with the explanatory variables (Hsiao, 2007). It leverages both within-unit and between-unit variations, offering greater efficiency than the fixed effects model when its assumptions are valid. For this research study, this model assumes country-specific effects are random and uncorrelated with the independent variables.

The Pooled OLS model was estimated first as a baseline. The Breusch-Pagan Lagrange Multiplier test was conducted to determine whether significant country-specific effects were present. This was done to determine the most appropriate model for inference.

1.4.4.4 Model Validation

Diagnostic tests are performed on the selected model to ensure the validity of results. the researcher conducts the test of heteroscedasticity. The researcher used The Breusch-Pagan test to detect non-constant variance. If heteroskedasticity is found, robust standard errors are applied.

2 LITERATURE REVIEW

2.1 Demographic factors affecting sustainable economic growth.

2.1.1 Population Growth Rate

Multiple Research studies have investigated the relationship between population growth and sustainable economic growth. The research study by Khursanaliev (Khursanaliev, 2023) highlighted the existence of a positive relationship between population growth and economic growth. The findings of this research study established that a greater population density implies a higher demand for products and services, which positively affects consumption patterns. However, the researcher highlights that higher demand and consumption of products and services depends on factors such as the availability of job opportunities and access to education.

Moreover, Adeosun & Popogbe (Adeosun & Popogbe, 2021) have also made a contribution toward the discussion on the effect of population growth on the use of human resources. The analysis of empirical data in their research study shows that the rate of population growth weakens the employment rate, which characterizes human resources utilization. A growing population makes the labour market fail to provide sufficient employment opportunities for the increasing labour force, hence leading to increased unemployment rates.

Peterson (Peterson, 2017) also analysed the role of population growth on economic growth. When emphasizing the implications of the research study, it was mentioned that low population growth in high-income countries is detrimental to labour and can hinder economic growth. When the population growth rate is low, it means a small number of working-age persons joining the workforce, coupled with rising numbers of early retirement and aged persons. This can result in a scarcity of human capital, thus affecting economic growth and development in the region.

Research conducted by Ubarevičienė, van Ham (Ubarevičienė & van Ham, 2017) highlighted the challenge of depopulation in the Baltic country of Lithuania. The research study highlights that a rapid rate of population decrement is likely to slow down the economic development of the region in the future. Additionally, the research study highlights that population reduction has a negative impact on demand for consumption in Lithuania. Low consumption patterns cause businesses to experience a sales decline, which slows down economic activity in the region.

It is important to note that rural-to-urban migration may lead to socioeconomic disparities in a region (Lang et al., 2022). When young people who are in the economically productive age decide to migrate from the rural areas to the urban centers in search of improved employment, education, and other necessities, the rural areas are left with a less productive populace, mostly the aged and the uneducated. That population trend is likely to slow the pace of economic growth and local investments as well as produce poorer quality public services in the rural regions (Lang et al., 2022). Therefore, rural regions can experience growing rates of poverty and the general worsening of the living conditions of the remaining populace.

On the other hand, emigration may lead to a loss of skilled labor and brain drain Bhardwaj & Sharma (Bhardwaj & Sharma, 2023). This is especially the case where people, especially those who have academic qualifications and or specialized skills, move to other countries in search of better employment opportunities for themselves and their families, thus leaving behind their home countries. This drain of human capital is more anticipated to have negative impacts on the economy since it decreases the pool of human capital required by different business lines and sectors. The loss of talent is detrimental to innovation, productivity, and capacities necessary for economic growth and development.

2.1.2 Age Structure

Age structure is an important demographic factor because it affects various socioeconomic factors such as productive population capacity, dependency ratios, and consequentially economic growth. The research study by Zhang (Zhang et al., 2015) focused on the fact that there is a positive correlation

between population growth and the age structure of the population, which in turn affects economic development. According to the research study, labour force increases if the country's populace comprises a young working population. A young demographic composition promotes economic development since young, skilled professionals are more innovative, leading to increased productivity.

The research study by Varpina (Varpina, 2018) analysed the impact of an aging population on economic development in Estonia, Lithuania, and Latvia. The findings of the research study suggested that an aging population negatively affects economic development in the Baltic states. As the proportion of elderly individuals increases, the working-age population shrinks, leading to a smaller labor force and reduced productivity. This demographic shift results in higher dependency ratios, where fewer workers support old people, which in turn increases the burden on social security and healthcare systems.

Varpina (Varpina, 2018) adds that an aging population leads to lower consumption rates. As the population ages, older individuals tend to spend less compared to younger, economically active individuals. This reduction in consumption is due to several factors, including lower income levels after retirement, decreased mobility, and a shift in spending priorities towards healthcare and basic needs rather than discretionary goods and services. The decline in consumer demand results in reduced business activities and, consequently, slower economic growth.

3 RESULTS AND FINDINGS

3.1 Descriptive statistics

In the preliminary stages of the data analysis, the researcher conducted a descriptive analysis to summarize the characteristics of the dataset and gain insights into the distribution and variability of the variables. The results of the descriptive analysis for each of the three countries are presented in the table below.

Table 1

Showing descriptive statistics.

Variable name	Country	Mean	Sd	Min	Max	Skewness
FR	Estonia	1.52	0.21	1.23	2.03	0.82
	Latvia	1.46	0.22	1.09	7.60	0.35
	Lithuania	1.53	0.18	1.20	2.05	0.44
CBR	Estonia	10.32	1.83	7.80	15.40	1.39
	Latvia	9.79	1.51	7.60	14.20	0.83
	Lithuania	10.36	1.30	7.50	14.20	0.51
PGR	Estonia	-0.73	0.77	-2.26	1.41	0.72
	Latvia	-1.03	0.47	-2.08	0.13	-0.07
	Lithuania	-0.41	0.85	-2.57	1.34	-0.47
UPGR	Estonia	-0.69	0.84	-2.28	1.75	0.92
	Latvia	-1.05	0.54	-2.05	0.32	0.23
	Lithuania	-0.47	1.01	-2.84	1.62	-0.25
NMR	Estonia	-1.75	8.22	-24.93	29.44	0.75
	Latvia	-5.52	5.72	-19.95	11.71	0.00
	Lithuania	-4.67	8.70	-25.47	25.59	1.28
ADR	Estonia	51.30	2.30	48.67	57.84	1.17
	Latvia	51.64	4.01	47.40	60.45	0.88
	Lithuania	51.57	3.73	48.88	59.16	0.58
PcGDP	Estonia	9748.09	4021.64	4274.08	16705.60	0.27
	Latvia	9499.09	3648.10	4290.04	15335.22	0.01
	Lithuania	12565.20	4339.52	6016.43	19400.12	-0.08

3.1.1 Fertility rates

The results in Table 1 show that Estonia demonstrates stable fertility rates with a mean of 1.52 and low variability (SD = 0.21). Latvia and Lithuania have slightly lower means of 1.46 and 1.53, respectively, and similar levels of variability (SD = 0.22 and 0.18, respectively). Skewness values for all three countries are low (Estonia = 0.82, Latvia = 0.35, Lithuania = 0.44), indicating near-symmetric distributions. This stability across the Baltic States reflects common demographic trends and policy influences impacting fertility.

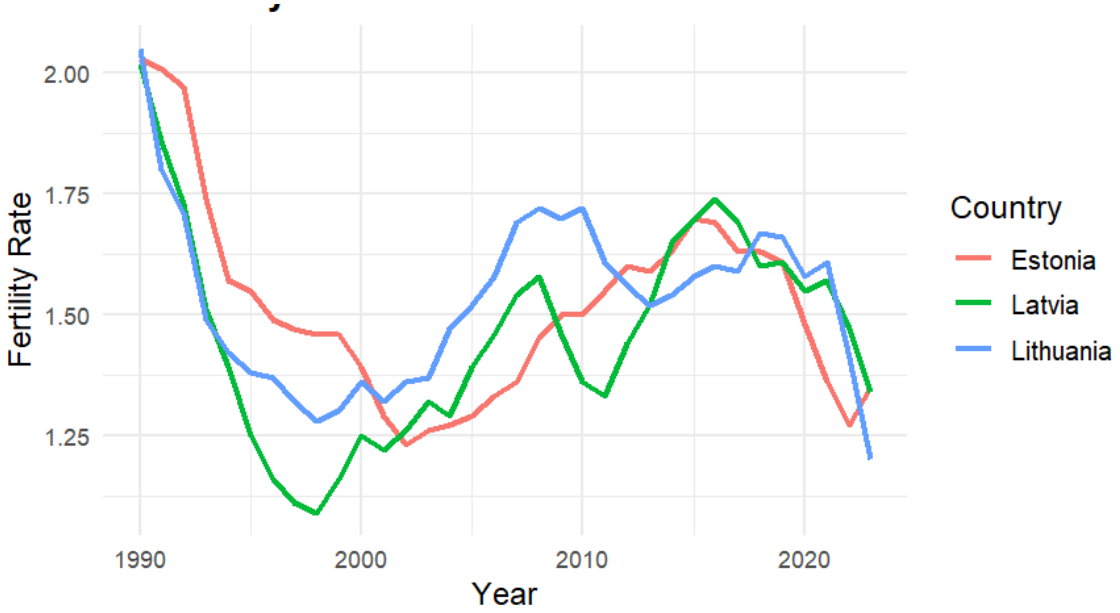

Fig. 1. Showing Trends of Fertility rates in the Baltic States Appendix 2:

The plot shows a decline in fertility rates across Estonia, Latvia, and Lithuania during the 1990s. Fertility rates began recovering in the early 2000s, with Estonia and Lithuania showing steadier trends, while Latvia experienced more fluctuations. By 2015, the rates converged, but a decline is observed again towards 2020, particularly in Lithuania.

3.1.2 Crude Birth Rates

The results presented in table 1 show that Crude birth rates are slightly higher in Estonia (mean = 10.32) and Lithuania (mean = 10.36) compared to Latvia (mean = 9.79). Variability is moderate across the three countries, with standard deviations ranging from 1.30 (Lithuania) to 1.83 (Estonia). Skewness values are positive (Estonia = 1.39, Latvia = 0.83, Lithuania = 0.51), suggesting occasional periods of higher birth rates.

The plot illustrates the crude birth rate trends in Estonia, Latvia, and Lithuania from 1990 to 2020. All three countries show a sharp decline during the 1990s. From the early 2000s, crude birth rates exhibit a gradual recovery, with Estonia and Lithuania displaying steadier increases compared to Latvia, which shows more variability. Around 2015, the rates converge across the countries but decline again towards 2020, reflecting continued demographic challenges in the Baltic States

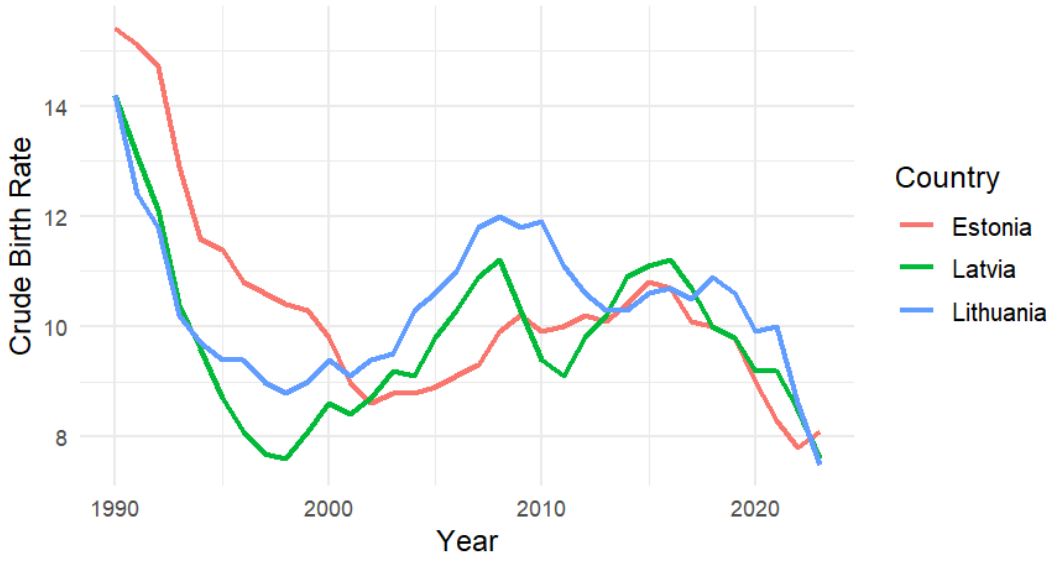

Fig. 2. Showing Trends of Crude Birth rates in the Baltic States Appendix 2:

3.1.3 Population Growth Rate

Additionally, the descriptive statistics presented in table 1 show that Population growth rates are negative for all three countries, reflecting ongoing demographic declines. Latvia shows the steepest decline (mean = -1.03) but with the least variability (SD = 0.47). Estonia and Lithuania have less negative growth rates (means = -0.73 and -0.41, respectively) but display higher variability (SD = 0.77 and 0.85, respectively). Skewness values indicate near-symmetry for Latvia (-0.07) and slight asymmetry for Estonia (0.72) and Lithuania (-0.47), highlighting differing dynamics in population trends.

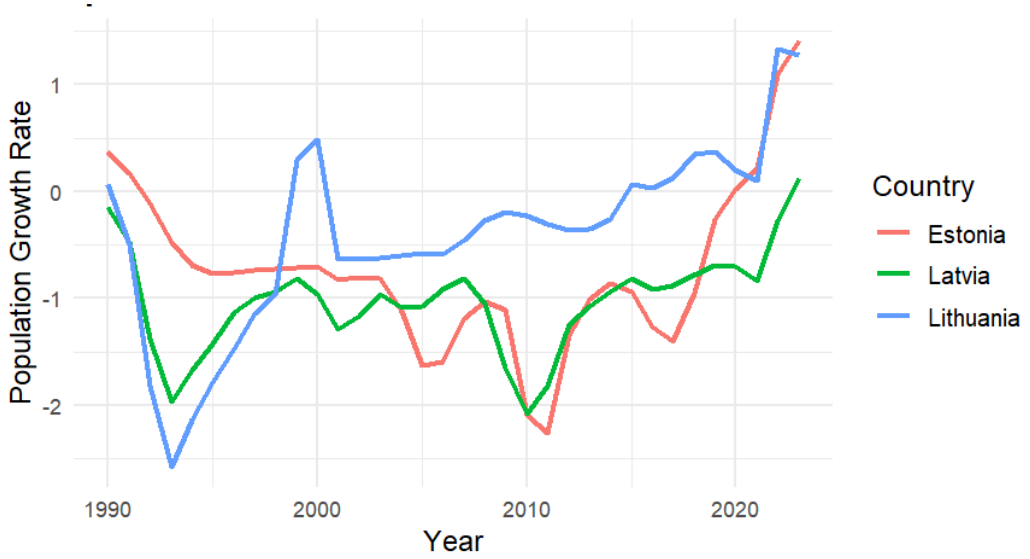

Fig. 3. Showing trends of Population Growth Rates in the Baltic States Appendix 2:

3.1.4 Urban Population Growth Rate

Moreover, table 1 shows that Urban population growth rates are negative across all countries, with Latvia recording the lowest mean (-1.05) and the least variability (SD = 0.54). Lithuania has the highest mean (-0.47) but also the greatest variability (SD = 1.01). Estonia falls in between with a mean

of -0.69 and variability (SD = 0.84). Skewness values are low across the board, with Estonia (0.92), Latvia (0.23), and Lithuania (-0.25), indicating mostly symmetric trends. These figures suggest differing levels of urbanization pressures across the countries.

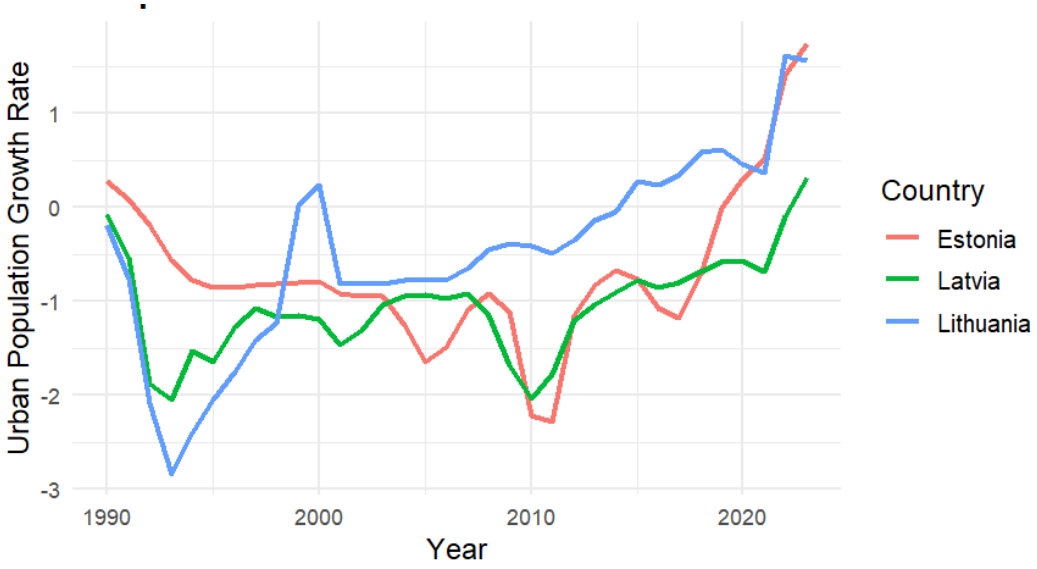

Fig. 4. Showing Trends in Urban Population Growth Rates in the Baltic States Appendix 2:

All three countries exhibit negative growth rates during the 1990s, reflecting post-Soviet population declines. Latvia and Estonia display consistent negative trends throughout most of the period, while Lithuania shows higher variability, including periods of recovery in the 2000s. Notably, all three countries experience a marked improvement after 2015, with Lithuania showing the most significant increase.

3.1.5 Net Migration rate

Furthermore, table 1 shows that Net migration rates vary significantly, with Estonia showing the greatest variability (SD = 8.22) and a wide range (-24.93 to 29.44). Lithuania exhibits similar variability (SD = 8.70) and a range of -25.47 to 25.59, with a higher skewness (1.28) indicating occasional positive spikes. Latvia has more stable migration rates, with a mean of -5.52, SD of 5.72, and skewness of 0.00.

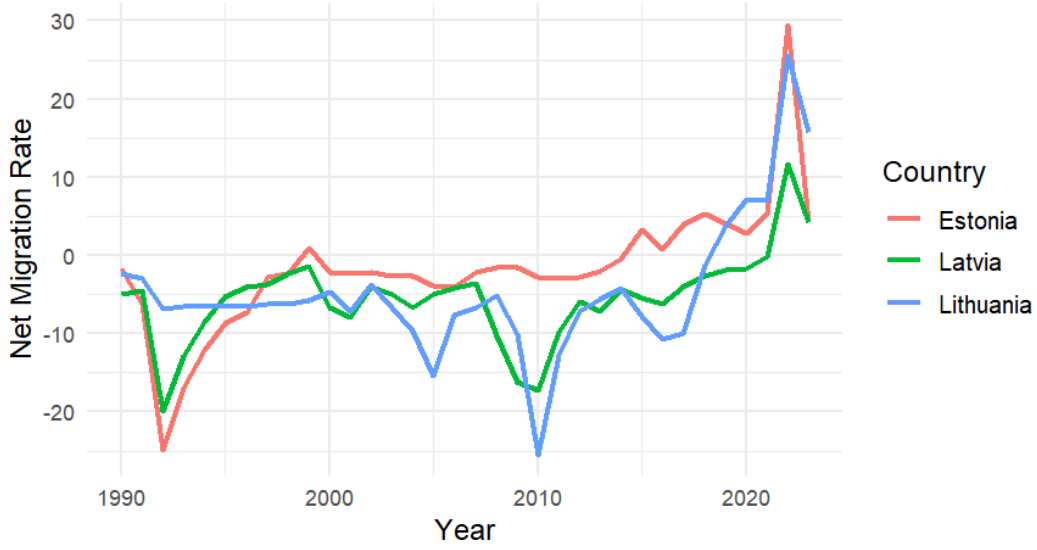

Fig. 5. Showing the trends in Net Migration Rates in the Baltic States Appendix 2:

All three countries experienced negative net migration during the 1990s, reflecting significant outflows following the collapse of the Soviet Union. In the 2000s, migration rates began to stabilize, with occasional fluctuations, particularly in Lithuania. A noticeable upward trend emerges after 2015, with all three countries transitioning to positive net migration by 2020. Estonia shows the sharpest increase around 2020, suggesting a recent reversal in migration patterns, potentially due to improved economic opportunities and policy changes in the region.

3.1.6 Age Dependency ratios

The results in table 1 show that Age dependency ratios are similar across the three countries, with means around 51.5 (Estonia = 51.30, Latvia = 51.64, Lithuania = 51.57). Variability is highest in Latvia (SD = 4.01) and lowest in Estonia (SD = 2.30). Skewness values are moderate, with Estonia (1.17), Latvia (0.88), and Lithuania (0.58), suggesting slight asymmetry in dependency structures.

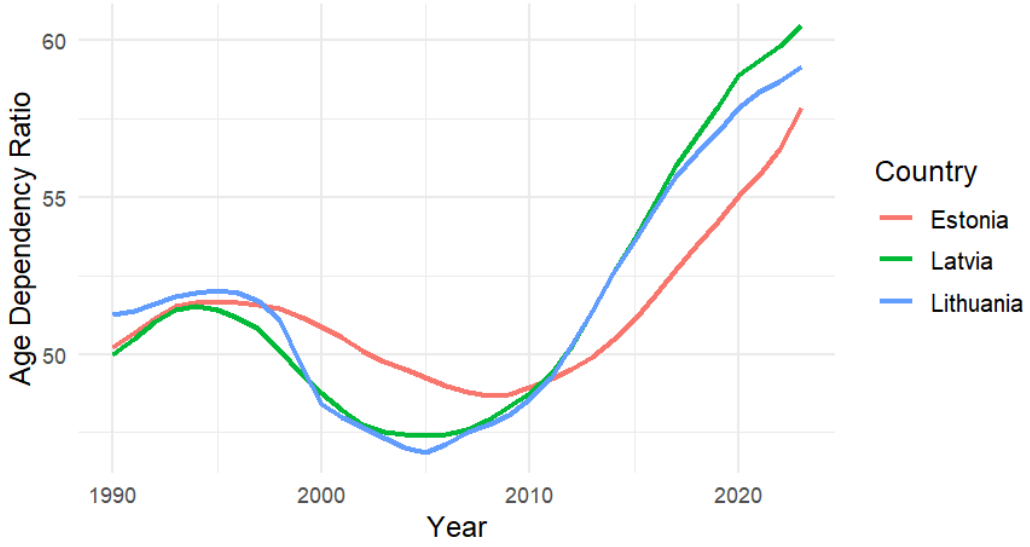

Fig. 6. Showing trends in Age Dependency Ratios in the Baltic States Appendix 2:

All three countries exhibit a decline in dependency ratios during the 1990s and early 2000s, reflecting a shrinking proportion of dependents relative to the working-age population. Around 2010, the trend reverses, and dependency ratios begin to rise steadily across all countries, with Latvia showing the steepest increase. By 2020, Latvia has the highest dependency ratio, followed by Lithuania and Estonia. This upward trend highlights the aging populations in the Baltic States, posing challenges for economic sustainability and social support systems.

3.1.7 GDP Per Capita

Lithuania leads economically with the highest GDP per capita (mean = 12,565.20, range = 6,016.43 to 19,400.12) and variability (SD = 4,339.52). Estonia (mean = 9,748.09, SD = 4,021.64) and Latvia (mean = 9,499.09, SD = 3,648.10) have lower but comparable GDP levels. Skewness values are close to zero for all three countries (Estonia = 0.27, Latvia = 0.01, Lithuania = -0.08), indicating symmetrical distributions.

All three countries show relatively low GDP per capita in the early 1990s, followed by significant growth starting in the late 1990s. Lithuania consistently leads with the highest GDP per capita, showing rapid growth, particularly after 2010. Estonia and Latvia have similar trajectories, with Latvia lagging slightly behind. The upward trend reflects economic development in the region, with Lithuania achieving the strongest performance overall. This economic growth highlights improvements in productivity and living standards across the Baltic States.

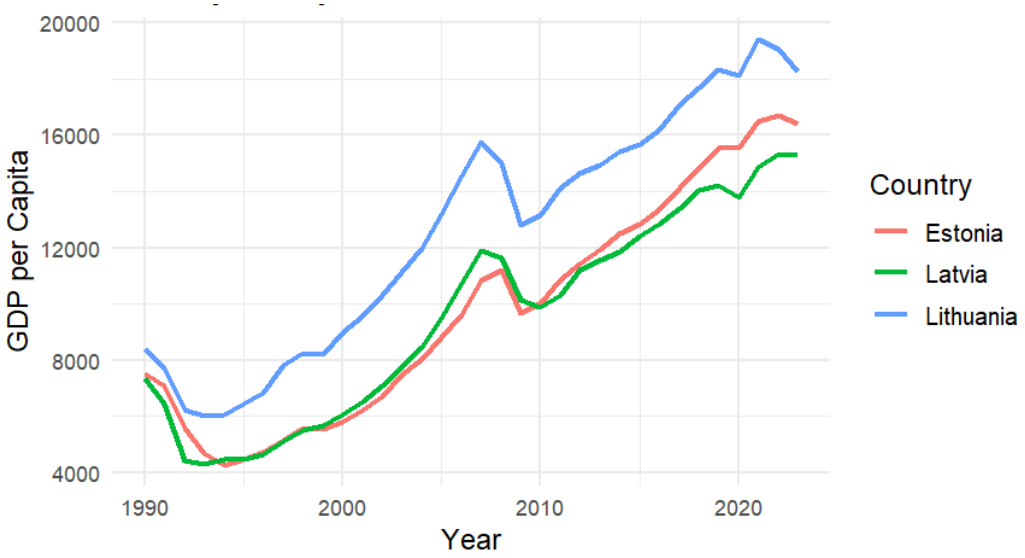

Fig. 7. Showing trends in GDP per Capita in the Baltic States Appendix 2:

3.2 Multicollinearity analysis

After analysng the trends, the researcher conducted a multicollinearity analysis to analyse the level of correlations between the independent variables. This was achieved through a VIF analysis. The results of the VIF factors are presented in Table 2 below.

Table 2

Showing results of VIF analysis. Appendix 2:

Variable	ADR	CBR	FR	NMR	PGR	UPGR
VIF	2.595132	19.223396	17.075025	2.142514	37.955552	42.075840

The results above show that CBR and FR both had VIF values of 19.22 and 17.08, respectively, indicating high multicollinearity because they exceeded the conventional value of 10. Likewise, PGR and UPGR exhibited high multicollinearity with VIF values of 37.96 and 42.08, respectively, which exceeded the conventional threshold of 10, confirming that the inclusion of both variables in each pair would lead to unreliable coefficient estimates due to inflated standard errors. Therefore, the decision was made to eliminate Fertility rates, and retain Crude Birth rate. In addition, PGR was excluded and UPGR included due to its stronger association with economic growth. The refined regression model is as follows.

$$PcGDP_{it} = \theta_0 + \theta_1 ADR_{it} + \theta_2 CBR_{it} + \theta_3 NMR_{it} + \theta_4 UPGR_{it} + \varepsilon \quad \text{Eq 3.1}$$

Whereby

$PcGDP_{it}$ *: GDP per Capita of Country i, year t.*

θ_0 *is the intercept term.*

$\theta_1 \ldots \varepsilon$ *are the coefficients of the independent variables, representing the magnitude and direction of their impact on GDP per capita.*

ε *is the error term.*

3.3 Panel Regression modelling

3.3.1 Pooled Ordinary Least squares

In the first step of the panel regression modeling, the researcher began by fitting the Pooled Ordinary Least Squares (OLS) model and conducting the Breusch-Pagan Lagrange Multiplier (LM)

test to determine whether there were significant entity-specific effects that needed to be accounted for. The following hypothesis was set.

H_0 : No Significant entity specific effects

H_1 : Significant entity specific effects

The results of the Breusch-Pagan Lagrange Multiplier (LM) test are presented in Table below.

Table 3

Showing the Breusch-Pagan Lagrange Multiplier (LM) test results Appendix 2:

Lagrange Multiplier Test – (Breusch-Pagan)		
Chi-Square	df	p-value
12.838	1	0.002391

The results presented in the table above imply that the null hypothesis of no significant entity-specific effects is rejected at a 0.05 significance level. This finding confirms the presence of unobserved heterogeneity across entities (countries) in the dataset, indicating that the Pooled OLS model is inappropriate for the analysis. Therefore, the next step in the analysis involves fitting both the Fixed Effects and Random Effects models to account for these significant entity-specific effects.

3.3.2 Choosing between the Fixed effects model and the Random effects model

The researcher proceeded to fit the fixed effects model and random effects model to account for potential entity-specific effects identified. However, during the estimation of the Random Effects model, an error occurred due to the limited number of entities in the dataset. With only three countries (Estonia, Latvia, and Lithuania), the Swamy-Arora method could not estimate the "between" variability, making the Random Effects model infeasible. Given this limitation, the researcher selected the Fixed Effects model, which addresses unobserved heterogeneity by allowing each country to have its own unique intercept, accounting for time-invariant differences across countries.

Therefore, the fixed effects model is as follows.

Table 4

Showing the Fixed effects model. Appendix 2:

Fixed effects model				
Variable	**Estimate**	**Standard error**	**t-value**	**P-value**
Intercept	2277.112	6942.719	0.3280	0.74363
ADR	240.931	119.143	2.0222	0.0451*
CBR	-205.592	235.807	-0.8803	0.38085
NMR	34.436	57.732	0.5965	0.55224
UPGR	2495.344	492.849	5.0631	$1.962\,e^{-06}$ ***
Significance:'***' 0.001 '**' 0.01 '*'0.05 '. '0.1'				

To validate this model, a test for heteroskedasticity was conducted using the studentized Breusch-Pagan test. A hypothesis was set.

H_0 : Assumes homoscedasticity (Constant variance of residuals)

H_1 : Presence of heteroscedasticity (non-constant variance)

The results are presented in the table below.

Table 5

Showing the results of the studentized Breusch-Pagan test Appendix 2:

Studentized Breusch-Pagan test Data: Fixed effects model		
BP	df	p-value
15.878	4	0.003187

According to the results presented in the above table, the null hypothesis of homoscedasticity is rejected at the 0.05 significance level, as the p-value is below the threshold. This indicates the presence of heteroskedasticity in the model. To address this issue, robust standard errors will be applied to ensure the reliability and validity of statistical inferences. The robust standard errors correct for the non-constant variance. The results of the final regression model are presented in the table below.

Table 6

Showing the results of the final regression model Appendix 2:

Final Fixed effects Regression Model				
Variable	**Estimate**	**Standard error**	**t-value**	**P-value**
ADR	240.641	118.352	2.00333	0.04481*
CBR	-143.748	166.296	-0.8644	0.38954
NMR	79.152	118.601	0.6674	0.50615
UPGR	2059.202	1089.609	1.8899	0.06183
Significance:'***' 0.001 '** '0.01 '*'0.05 '. '0.1'				

The results from the Fixed Effects model with robust standard errors reveal that Age Dependency Ratio (ADR) is a statistically significant predictor of GDP per capita at the 5% level with a positive estimated coefficient of 240.641. These findings suggest that variations in the Age Dependency Ratio variable have a meaningful relationship with economic growth in the Baltic States. On the other hand, Net Migration Rate (NMR), Crude Birth Rates, (CBR) and Urban Population Growth Rate (UPGR) are not statistically significant, this indicates that changes in migration, birth rates and urbanization do not have a significant impact on GDP per capita in this model.

4 CONCLUSION

4.1 Key findings

The focus of this research study was to assess the demographic factors that affect the economic growth within the Baltic States. Based on the findings of the data analysis, the researcher pointed out that Age Dependency Ratio played a major role in the economic development of the Baltic States. An increase in the overall ADR means that a larger proportion of the population is in the dependent age groups. This raises the pressure on the working-age population, lowering their output and also pushes the costs of social security and health care to higher levels. This finding supports Varpina (Varpina, 2018) who observed that ageing population in the Baltic States reduces the labour force and economic productivity as a result of the growing dependency ratios. Figure 3.6 presented above show a trend of increasing dependency ratios. The shrinking workforce and growing elderly population pose challenges to economic sustainability for the Baltic States.

4.2 Policy responses to Emerging Demographic Challenges

A key strategy to mitigate the impact of an aging population is to extend working lifespan. Raising the retirement age will allow older individuals to remain economically active for longer, which will play a crucial role in reducing the dependency burden. Additionally, the researcher recommends Flexible retirement options, such as phased or partial retirement. This can help ease the transition for older workers while retaining their valuable experience and expertise. In addition, the researcher also recommends creating immigration policies that attract younger and skilled immigrants. This will play a crucial role in addressing the labor shortages in the Baltic States and in the long run sustain economic productivity.

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5 APPENDIX

5.1 Appendix 1

Link to the data.

World Bank Open Data | Data

World Population Prospects - Population Division - United Nations

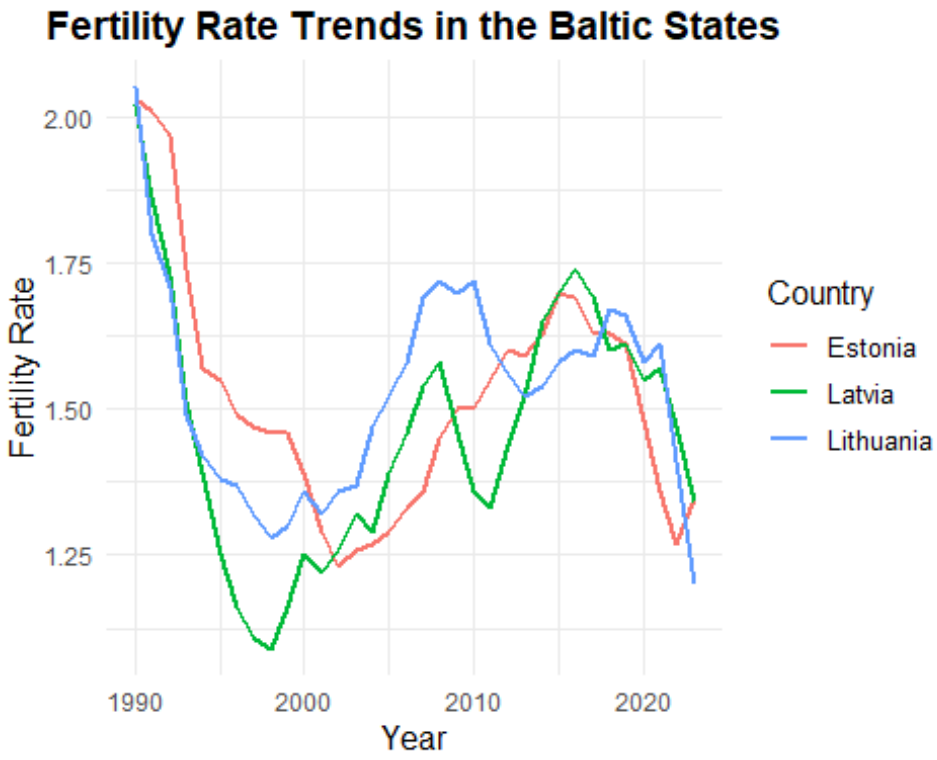
https://drive.google.com/drive/folders/1kh9ETgn2CqrF4WY4VOr5NRGOXsjacgYq?usp=sharing

5.2 Appendix 2:

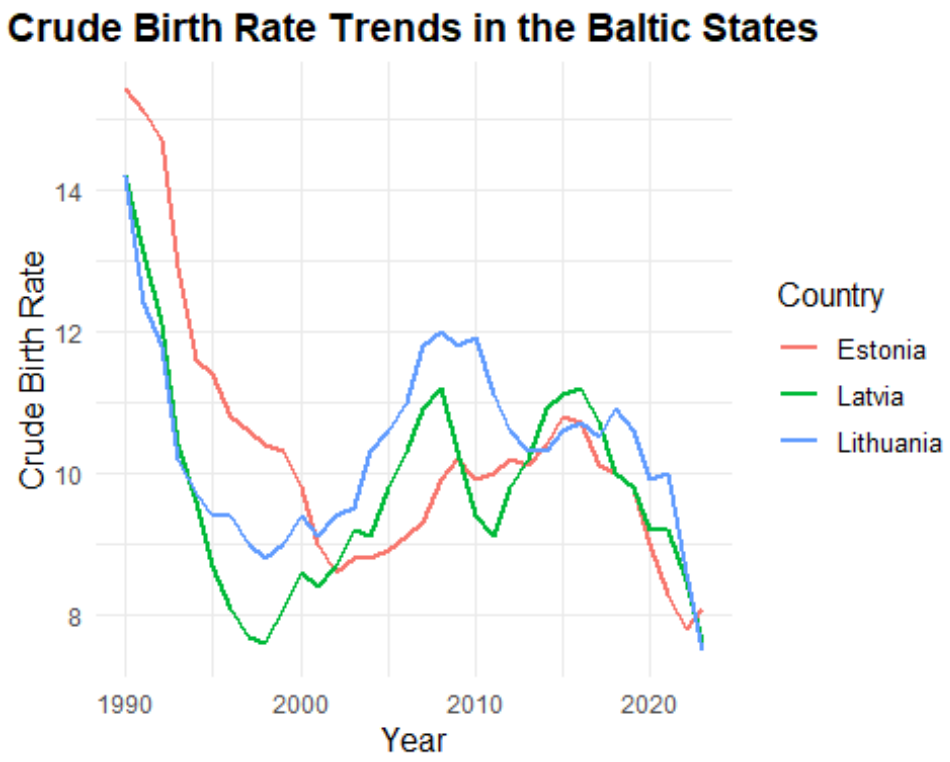
Rcode

```
#Load package
library(psych)
library(tidyverse)
library(plm)
library(ggplot2)
library(tidyr)
library(dplyr)
library(car)
library(lmtest)
library(sandwich)
library(lmtest)

# Read the datasets
estonia_data <- read.csv("D:/EstoniaData.csv")
latvia_data <- read.csv("D:/LatviaData.csv")
lithuania_data <- read.csv("D:/LithuaniaData.csv")

# Exclude the Year column from the analysis
estonia_data_numeric <- estonia_data[, -which(names(estonia_data) == "Year")]
latvia_data_numeric <- latvia_data[, -which(names(latvia_data) == "Year")]
lithuania_data_numeric <- lithuania_data[, -which(names(lithuania_data) == "Year")]

# Compute descriptive statistics
estonia_stats <- describe(estonia_data_numeric)
latvia_stats <- describe(latvia_data_numeric)
lithuania_stats <- describe(lithuania_data_numeric)

# Print the results
print("Descriptive Statistics for Estonia:")

## [1] "Descriptive Statistics for Estonia:"

print(estonia_stats)

##       vars  n    mean      sd  median trimmed     mad     min      max
## ADR      1 34   51.30    2.30   50.98   51.00    1.71   48.67    57.84
## CBR      2 34   10.32    1.83   10.05   10.05    1.11    7.80    15.40
## FR       3 34    1.52    0.21    1.50    1.50    0.20    1.23     2.03
## PcGDP    4 34 9748.09 4021.64 9625.48 9585.70 5285.59 4274.08 16705.60
## NMR      5 34   -1.75    8.22   -2.20   -1.62    2.56  -24.93    29.44
## PGR      6 34   -0.73    0.77   -0.81   -0.78    0.48   -2.26     1.41
## UPGR     7 34   -0.69    0.84   -0.83   -0.75    0.38   -2.28     1.75
##          range skew kurtosis     se
## ADR       9.17 1.17     0.71   0.39
## CBR       7.60 1.39     1.54   0.31
## FR        0.80 0.82     0.23   0.04
## PcGDP 12431.52 0.27    -1.32 689.71
## NMR      54.37 0.75     5.46   1.41
## PGR       3.67 0.72     0.81   0.13
## UPGR      4.03 0.92     1.34   0.14

print("Descriptive Statistics for Latvia:")

## [1] "Descriptive Statistics for Latvia:"

print(latvia_stats)

##       vars  n    mean      sd   median trimmed     mad     min      max
## ADR      1 34   51.64    4.01    50.64   51.21    3.51   47.40    60.45
## CBR      2 34    9.79    1.51     9.70    9.66    1.48    7.60    14.20
## FR       3 34    1.46    0.22     1.46    1.45    0.21    1.09     2.02
## PcGDP    4 34 9499.09 3648.10 10004.09 9440.42 5078.98 4290.04 15335.22
## NMR      5 34   -5.52    5.72    -4.97   -5.36    2.89  -19.95    11.71
## PGR      6 34   -1.03    0.47    -0.97   -1.03    0.26   -2.08     0.13
## UPGR     7 34   -1.05    0.54    -1.03   -1.06    0.39   -2.05     0.32
##          range  skew kurtosis     se
## ADR      13.06  0.88    -0.52   0.69
```

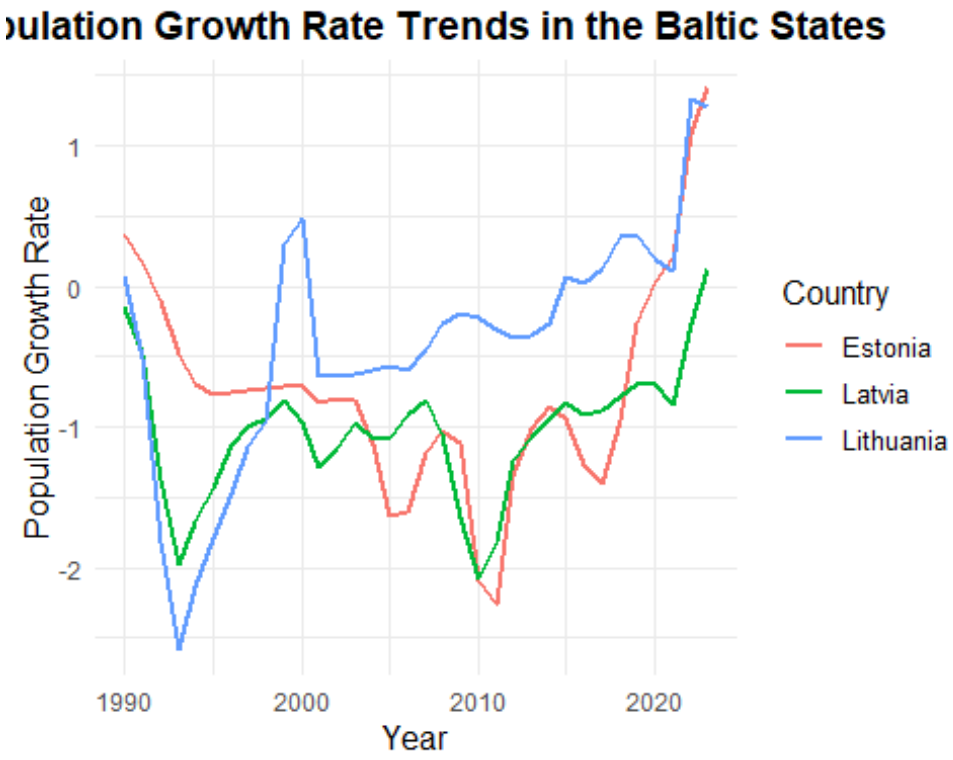
```
## CBR       6.60  0.83     0.61   0.26
## FR        0.93  0.35    -0.39   0.04
## PcGDP 11045.17  0.01    -1.45 625.64
## NMR      31.66  0.00     1.89   0.98
## PGR       2.21 -0.07     0.32   0.08
## UPGR      2.37  0.23     0.03   0.09

print("Descriptive Statistics for Lithuania:")

## [1] "Descriptive Statistics for Lithuania:"

print(lithuania_stats)

##       vars  n     mean      sd   median  trimmed     mad     min      max
## ADR      1 34    51.57    3.73    51.38    51.30    4.63   46.88    59.16
## CBR      2 34    10.36    1.30    10.30    10.31    1.26    7.50    14.20
## FR       3 34     1.53    0.18     1.55     1.53    0.21    1.20     2.05
## PcGDP    4 34 12565.20 4339.52 13166.69 12577.12 6014.70 6016.43 19400.12
## NMR      5 34    -4.67    8.70    -6.47    -5.48    3.05  -25.47    25.59
## PGR      6 34    -0.41    0.85    -0.33    -0.37    0.59   -2.57     1.34
## UPGR     7 34    -0.47    1.01    -0.44    -0.45    0.83   -2.84     1.62
##           range  skew kurtosis     se
## ADR      12.28  0.58    -0.85   0.64
## CBR       6.70  0.51     0.64   0.22
## FR        0.85  0.44     0.24   0.03
## PcGDP 13383.69 -0.08    -1.44 744.22
## NMR      51.06  1.28     3.49   1.49
## PGR       3.91 -0.47     0.36   0.15
## UPGR      4.45 -0.25    -0.05   0.17

# Add a 'Country' column
estonia_data$Country <- "Estonia"
latvia_data$Country <- "Latvia"
lithuania_data$Country <- "Lithuania"

# Combine the datasets
combined_data <- bind_rows(estonia_data, latvia_data, lithuania_data)

#Graph showing trends in Fertility rates

# Filter the data for Fertility Rate
fertility_rate_data <- combined_data %>%
  select(Year, Country, FertilityRate = FR)  # Replace "FR" with the actual column name for fe
rtility rate if different

# Create the plot
ggplot(fertility_rate_data, aes(x = Year, y = FertilityRate, color = Country, group = Countr
y)) +
  geom_line(size = 1) +
  labs(
    title = "Fertility Rate Trends in the Baltic States",
    x = "Year",
    y = "Fertility Rate",
    color = "Country"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    axis.title = element_text(size = 12),
    legend.title = element_text(size = 12),
    legend.text = element_text(size = 10)
  )
```



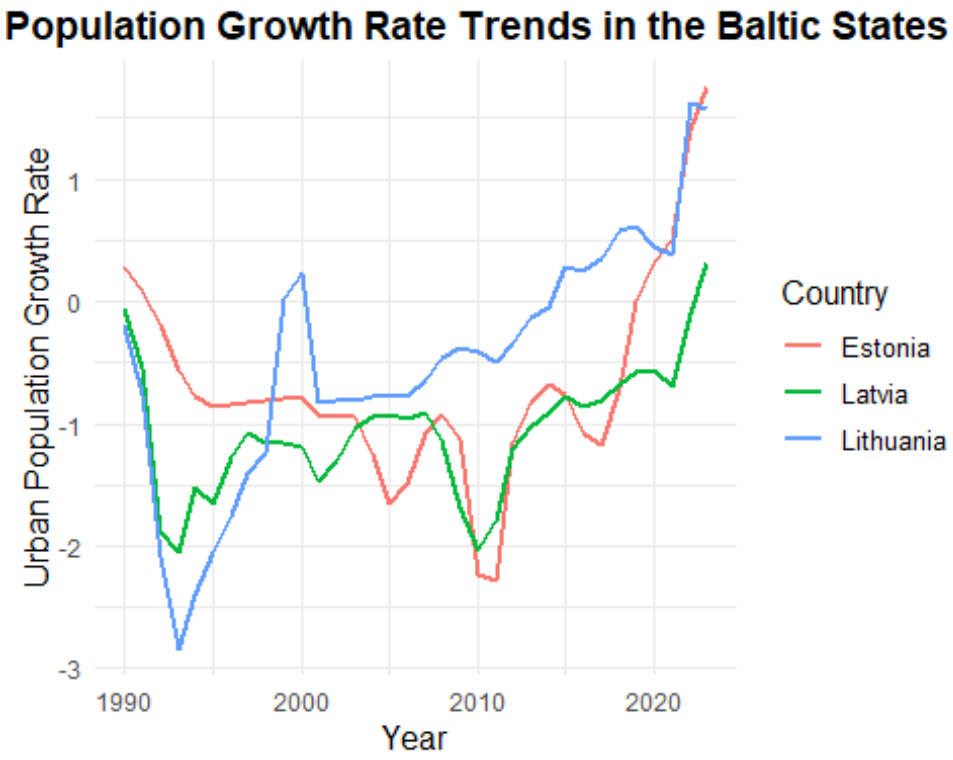

```r
#Graph Showing trends in Crude Birth Rates

# Filter the data for Crude Birth Rate
crude_birth_rate_data <- combined_data %>%
  select(Year, Country, CrudeBirthRate = CBR)  # Replace "CBR" with the actual column name for crude birth rate if different

# Create the plot
ggplot(crude_birth_rate_data, aes(x = Year, y = CrudeBirthRate, color = Country, group = Country)) +
  geom_line(size = 1) +
  labs(
    title = "Crude Birth Rate Trends in the Baltic States",
    x = "Year",
    y = "Crude Birth Rate",
    color = "Country"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    axis.title = element_text(size = 12),
    legend.title = element_text(size = 12),
    legend.text = element_text(size = 10)
  )
```



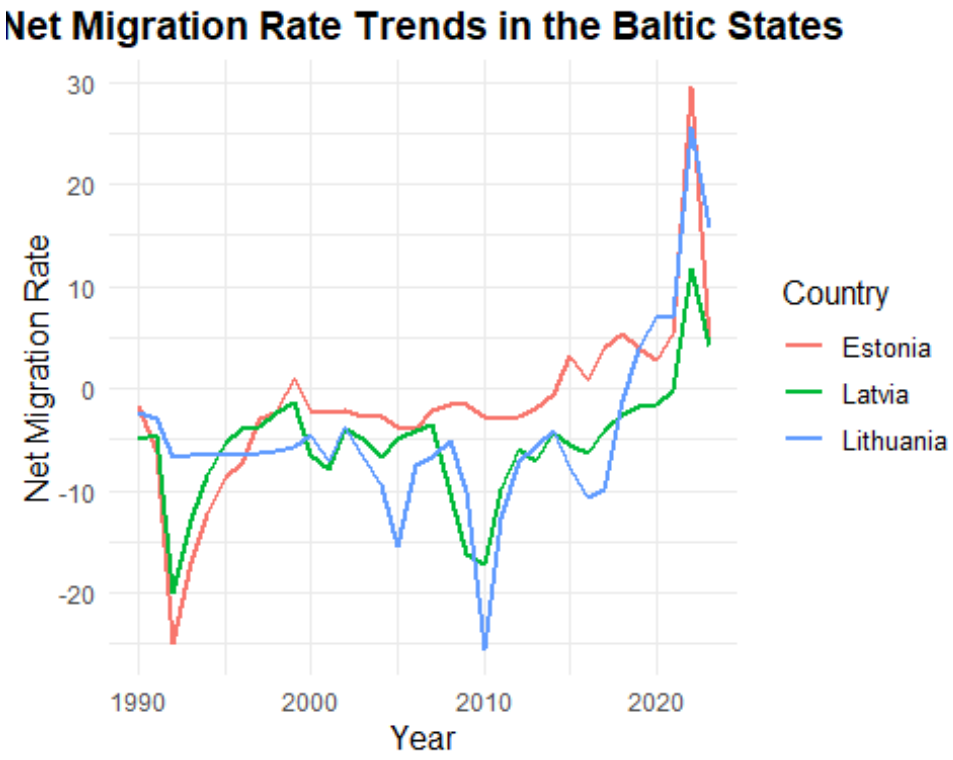

```r
#Graph Showing trends in Population growth rate
# Filter the data for Population Growth Rate
population_growth_rate_data <- combined_data %>%
  select(Year, Country, PopulationGrowthRate = PGR)  # Replace "PGR" with the actual column na
me for population growth rate if different

# Create the plot
ggplot(population_growth_rate_data, aes(x = Year, y = PopulationGrowthRate, color = Country, g
roup = Country)) +
  geom_line(size = 1) +
  labs(
    title = "Population Growth Rate Trends in the Baltic States",
    x = "Year",
    y = "Population Growth Rate",
    color = "Country"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    axis.title = element_text(size = 12),
    legend.title = element_text(size = 12),
    legend.text = element_text(size = 10)
  )
```



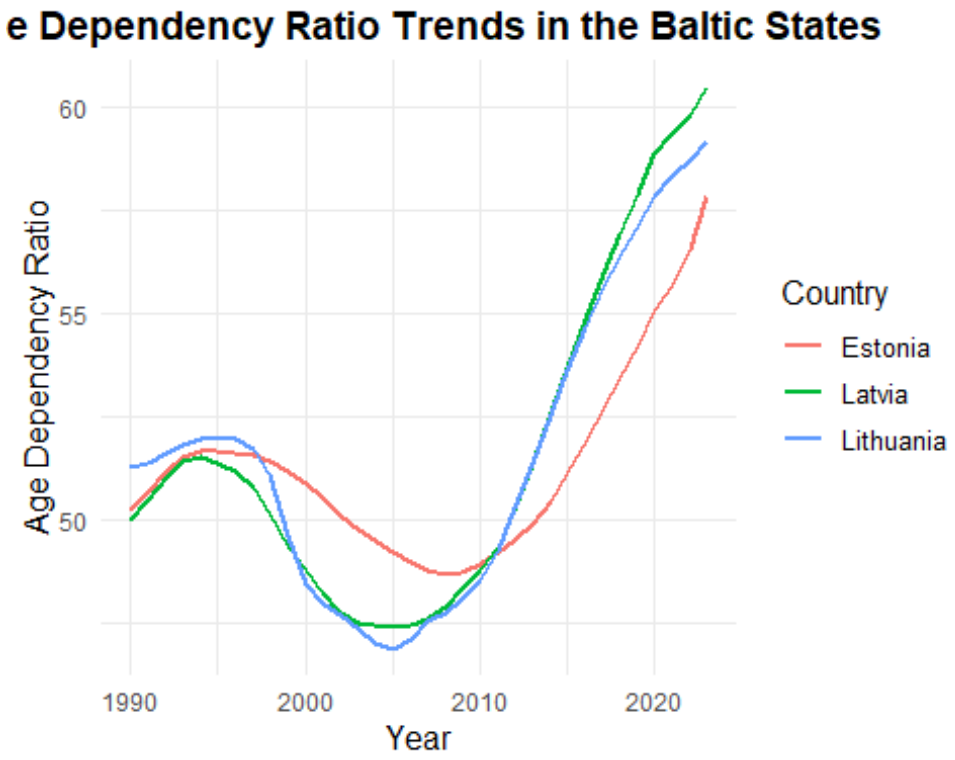

```r
#Graph Showing trends in Urban Population Growth RateS

# Filter the data for Urban Population Growth Rate
urban_population_growth_rate_data <- combined_data %>%
  select(Year, Country, UrbanPopulationGrowthRate = UPGR)  # Replace "UPGR" with the actual co
lumn name for urban population growth rate if different

# Create the plot
ggplot(urban_population_growth_rate_data, aes(x = Year, y = UrbanPopulationGrowthRate, color =
Country, group = Country)) +
  geom_line(size = 1) +
  labs(
    title = "Urban Population Growth Rate Trends in the Baltic States",
    x = "Year",
    y = "Urban Population Growth Rate",
    color = "Country"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    axis.title = element_text(size = 12),
    legend.title = element_text(size = 12),
    legend.text = element_text(size = 10)
  )
```



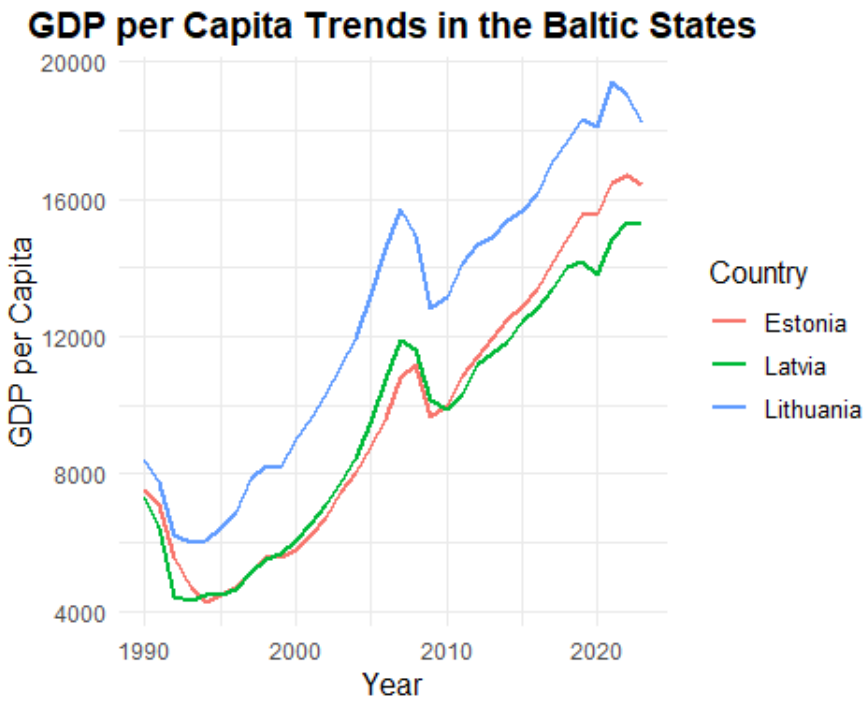

```r
#Graph Showing trends in Net Migration Rates
# Filter the data for Net Migration Rate
net_migration_rate_data <- combined_data %>%
  select(Year, Country, NetMigrationRate = NMR)  # Replace "NMR" with the actual column name f
or net migration rate if different

# Create the plot
ggplot(net_migration_rate_data, aes(x = Year, y = NetMigrationRate, color = Country, group = C
ountry)) +
  geom_line(size = 1) +
  labs(
    title = "Net Migration Rate Trends in the Baltic States",
    x = "Year",
    y = "Net Migration Rate",
    color = "Country"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    axis.title = element_text(size = 12),
    legend.title = element_text(size = 12),
    legend.text = element_text(size = 10)
  )
```




```r
#Graph Showing trends in Age Dependance Ratios

# Filter the data for Age Dependency Ratios
age_dependency_ratio_data <- combined_data %>%
  select(Year, Country, AgeDependencyRatio = ADR)  # Replace "ADR" with the actual column name for age dependency ratios if different

# Create the plot
ggplot(age_dependency_ratio_data, aes(x = Year, y = AgeDependencyRatio, color = Country, group = Country)) +
  geom_line(size = 1) +
  labs(
    title = "Age Dependency Ratio Trends in the Baltic States",
    x = "Year",
    y = "Age Dependency Ratio",
    color = "Country"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    axis.title = element_text(size = 12),
    legend.title = element_text(size = 12),
    legend.text = element_text(size = 10)
  )
```




```r
#Graph Showing trends in GDP per Capita
# Filter the data for GDP per Capita
gdp_per_capita_data <- combined_data %>%
  select(Year, Country, GDPPerCapita = PcGDP)  # Replace "PcGDP" with the actual column name f
or GDP per capita if different

# Create the plot
ggplot(gdp_per_capita_data, aes(x = Year, y = GDPPerCapita, color = Country, group = Country))
+
  geom_line(size = 1) +
  labs(
    title = "GDP per Capita Trends in the Baltic States",
    x = "Year",
    y = "GDP per Capita",
    color = "Country"
  ) +
  theme_minimal() +
  theme(
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    axis.title = element_text(size = 12),
    legend.title = element_text(size = 12),
    legend.text = element_text(size = 10)
  )
```




```r
#Combining the three data sets to have Panel data
# Load the Combined dataset
data1 <- read.csv("D:/Combinedbalticdata.csv")

#Multicollinearity Tests

# Fit the full linear regression model with all variables, including UPGR
model <- lm(PcGDP ~ ADR + CBR + FR + NMR + PGR + UPGR, data = data)

# Calculate VIF for the full model
vif_values <- vif(model)

# Display VIF results
print(vif_values)
```

```
##       ADR       CBR        FR       NMR       PGR      UPGR
##  2.595132 19.112296 17.075025  2.142514 37.955552 42.075840
```

```r
#Transform data to panel data
pdata <- pdata.frame(data, index = c("Country", "Year"))

# Fit the Pooled OLS model
pooled_model <- plm(PcGDP ~ ADR + CBR + NMR + UPGR, data = pdata, model = "pooling")

# Summarize the Pooled OLS results
summary(pooled_model)
```

```
## Pooling Model
##
## Call:
## plm(formula = PcGDP ~ ADR + CBR + NMR + UPGR, data = pdata, model = "pooling")
##
## Balanced Panel: n = 3, T = 34, N = 102
##
## Residuals:
##     Min.  1st Qu.   Median  3rd Qu.     Max.
## -5668.57 -2646.68   698.04  2641.79  6294.32
##
## Coefficients:
##             Estimate Std. Error t-value  Pr(>|t|)
```

```
## (Intercept) 2277.112   6942.719  0.3280   0.74363
## ADR          240.931    119.143  2.0222   0.04591 *
## CBR         -207.592    235.807 -0.8803   0.38085
## NMR           34.436     57.732  0.5965   0.55224
## UPGR        2495.344    492.849  5.0631 1.962e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    1791500000
## Residual Sum of Squares: 980360000
## R-Squared:      0.45279
## Adj. R-Squared: 0.43022
## F-statistic: 20.0653 on 4 and 97 DF, p-value: 4.5881e-12

# Perform Breusch-Pagan LM test
plmtest(pooled_model, type = "bp")

##
##  Lagrange Multiplier Test - (Breusch-Pagan)
##
## data:  PcGDP ~ ADR + CBR + NMR + UPGR
## chisq = 9.2224, df = 1, p-value = 0.002391
## alternative hypothesis: significant effects

# Fit the Fixed Effects model
fixed_effects_model <- plm(PcGDP ~ ADR + CBR + NMR + UPGR, data = pdata, model = "within")

# Summarize the Fixed Effects results
summary(fixed_effects_model)

## Oneway (individual) effect Within Model
##
## Call:
## plm(formula = PcGDP ~ ADR + CBR + NMR + UPGR, data = pdata, model = "within")
##
## Balanced Panel: n = 3, T = 34, N = 102
##
## Residuals:
##     Min.  1st Qu.   Median  3rd Qu.     Max.
## -5022.97 -2857.91   927.83  2366.15  4947.81
##
## Coefficients:
##      Estimate Std. Error t-value  Pr(>|t|)
## ADR   240.641    116.531  2.0650   0.04164 *
## CBR  -143.748    230.576 -0.6234   0.53450
## NMR    79.152     58.167  1.3608   0.17680
## UPGR 2059.202    492.079  4.1847 6.371e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    1594400000
## Residual Sum of Squares: 871480000
## R-Squared:      0.45339
## Adj. R-Squared: 0.41887
## F-statistic: 19.6999 on 4 and 95 DF, p-value: 7.806e-12

# Test for heteroscedasticity
bptest(fixed_effects_model)

##
##  studentized Breusch-Pagan test
##
## data:  fixed_effects_model
## BP = 15.878, df = 4, p-value = 0.003187

# Apply robust standard errors
fixed_effects_robust <- coeftest(fixed_effects_model, vcov = vcovHC(fixed_effects_model, type
= "HC1"))
print(fixed_effects_robust)
```

```
##
## t test of coefficients:
##
##      Estimate Std. Error t value Pr(>|t|)
## ADR   240.641    118.352  2.0333  0.04481 *
## CBR  -143.748    166.296 -0.8644  0.38954
## NMR    79.152    118.601  0.6674  0.50615
## UPGR 2059.202   1089.609  1.8899  0.06183 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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PROBLEMS OF EMPLOYMENT STATUS OF COURIERS IN EUROPE

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Abstract. In given article authors of the study examine the main challenges food and goods delivery market are facing, including but not limited with a focus on employment conditions of delivery couriers, market competition, technology, safety, competitive strategies, and possible solutions. Given article reviews academic work published over the past five years by paying special attention to algorithmic management, burnout, inequality, and the legal status of couriers. The courier-delivery sector underwent rapid growth during the 2019 pandemic, and the number of couriers delivering groceries and other items has continued to rise each year. Yet labor legislation for couriers remains poorly structured, resulting in unfair working conditions and inadequate social protection. The authors surveyed courier employment in several countries around the world, and the findings enable them to propose recommendations for improving working conditions and strengthening regulation of the delivery market within the European Union.

Keywords: couriers, delivery platforms, labor relations.

Introduction. The rapid expansion of online-commerce platforms, coupled with the COVID-19 pandemic, has dramatically accelerated growth in the delivery market. According to international estimates, the global delivery sector was valued at US $1.1 trillion in 2022 and is projected to reach US $1.5 trillion by 2027 [1]. Couriers forms the backbone of this industry, yet their employment and legal status remains a pivotal issue intertwined with safety concerns, algorithmic pressure, and a lack of employment benefits. Countries in Europe and around the world are attempting to address these challenges in different ways. Employer associations and trade unions are involved in the search for solutions, and disputes frequently end up in court. The present study seeks to synthesise the key problems associated with courier employment and working conditions, and to analyse how these issues have been tackled in England and the European Union, using the Deliveroo platform as a case study. On the basis of this analysis, the authors draw a series of essential conclusions and propose paths to resolving accumulated problems.

Basic theoretical and practical provision. Over the past five years a considerable number of scholars and researchers worldwide have examined courier-delivery platforms. In France, for example, Anne Aguilera, Laetitia Dablanc, Camille Krier, Nicolas Louvet and others have addressed the subject. In their article "Platform-based food delivery in Paris before and during the pandemic: profile, motivations and mobility patterns of couriers" they explore couriers' work motivations and mobility models in Paris [2].

Finnish scholars Henri Kervola, Soili Hyvönen, Erika Kallionpää and Heikki Liimatainen, in "Flexibility and freedom suit me better: food-delivery couriers' preferred employment status," investigate the reasons behind choosing courier work and the employment status couriers themselves prefer [3].

Pinar Ozyavas, Evrim Ursavas, Paul Buijs and Ruud Teunter, in "Integrating shift planning and pick-up and delivery problems under limited courier availability," consider how to fulfil all incoming delivery orders when staff numbers are constrained [4].

Ashish Nair, Rahul Yadav, Anjali Gupta, Abhijnan Chakraborty, Sayan Ranu and Amitabha Bagchi, in "Gigs with Guarantees: Achieving Fair Wage for Food-Delivery Workers," study the quest for fair remuneration in courier delivery [5].

Yet in turn, the same group of researchers: Anjali Gupta, Rahul Yadav, Ashish Nair, Abhijnan Chakraborty, Sayan Ranu and Amitabha Bagchi also focus on fairness in food delivery in their work FairFoody: Bringing in Fairness in Food Delivery [6].

Researchers Oleksandr Rossolov, Anastasiia Botsman, Serhii Lyfenko and Yusak O. Susilo, in "Does courier gender matter? Exploring mode-choice behaviour for e-groceries crowd-shipping in developing economies," place special emphasis on courier gender and delivery-mode choice behaviour in developing countries [7].

Ankush Chopra, Mahima Arora and Shubham Pandey, in Delivery Issues Identification from Customer Feedback Data, investigate how to detect problems by analysing feedback from customers who have used delivery services [8].

All of these studies have made significant contributions to understanding courier work globally and in individual countries. Yet none addresses simultaneously the intertwined questions of courier employment, wage determination, protection of couriers' social and economic interests, the role of trade unions, and court decisions in the United Kingdom and Europe.

The authors of the present study therefore set themselves the task of examining courier work from hiring through termination, analysing the legal framework in the European Union and the United Kingdom.

The courier food-delivery market first took shape in Japan, where stable forms of ready-meal delivery already existed in the 17th century. In the 20th century, however, commercial leadership and large-scale expansion shifted to the United States, which introduced major chain-based and technological solutions [9].

In Europe, food delivery began to develop much later, mainly from the mid-20th century. At first it revolved around traditional takeaway dishes, especially Chinese, Indian and pizza, reflecting the multicultural make-up of urban populations. During the 1970s and 1980s British cities, and London in particular, actively adopted the practice of telephone orders from restaurants and takeaway outlets [10].

A real leap came with the spread of the internet and digital platforms. The early 2000s saw the launch of the first online food-ordering services, such as Just Eat, founded in Denmark and firmly established in the UK market after 2006 [11]. The 2010s ushered in a new phase: app-based delivery. In 2013 entrepreneurs Will Shu and Greg Orlowski founded Deliveroo in the United Kingdom, and the company quickly became a European market leader [12]. Today Deliveroo operates in the UK, France, Belgium, Ireland, Italy, Singapore, the United Arab Emirates and Hong Kong. The platform pioneered an algorithmically managed delivery model that relies on independent couriers. Meanwhile rival platforms such as Uber Eats, Glovo and Foodora were expanding worldwide, so that by the 2020s food delivery had become an integral part of urban infrastructure.

The COVID-19 pandemic markedly accelerated the shift to digital channels, making couriers indispensable in the "last-mile" segment [14]. Figure 1 illustrates the rapid growth of European platform-based deliveries after 2019 driven in large part by the pandemic. As the sector has grown, attention has increasingly focused on couriers' social vulnerability. Most couriers are self-employed and receive no health insurance, paid sick leave or pensions. In Scotland 60% of couriers have faced racist or physical attacks, and 100% of female couriers have encountered sexual harassment; in New York 21% of couriers have been assaulted (nypost.com). Migrants and women, whose qualifications are often unrecognised, have proved especially vulnerable, suffering both discrimination and a lack of legal protection [10].

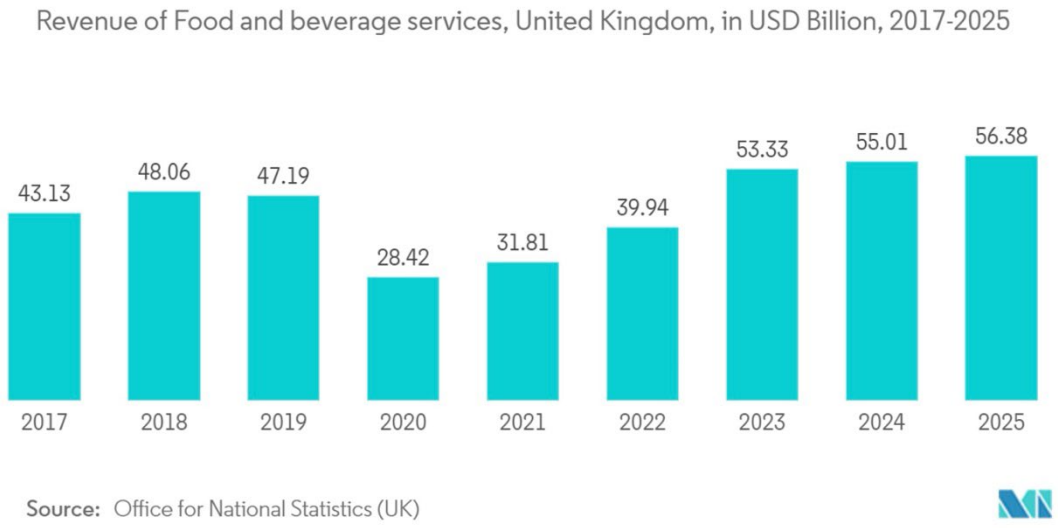

Fig. 1. Revenue of Food and beverage services, United Kingdom, in USD Billion, 2017-2025 [14]

It should be noted that algorithmic management plays a central role in how labour is organised on the platform. Under such a system couriers do not know the criteria by which orders are allocated to them, which reduces the predictability of their earnings and heightens work-related stress [15]. At the same time, the employer's constant pressure to deliver ever faster triggers dangerous driving and increases the number of traffic accidents and injuries not only among couriers but among other road users as well [17]. In response, couriers in China have begun forming protest communities against algorithmic diktats, and the government has started to introduce regulatory legislation [16]. Similar trends are beginning to appear in Europe, where the European Union is debating the creation of transparent algorithms and minimum protection standards for couriers.

Competition both between platforms and among couriers themselves intensifies this instability. Without guaranteed employment, couriers work for several services at once and target peak hours to raise their income. High turnover, particularly visible in India, is explained by rising costs, falling earnings and a lack of career prospects, highlighting the weakness of platforms' retention strategies [19]. Training and communication are often purely formal: instruction is delivered online with no human support, leading to frustration and isolation [20].

In response, the EU and other jurisdictions have begun discussing possible solutions: implementation of so called rider laws for couriers, recognition of hybrid employment forms, guarantees of a minimum income (e.g. the WORK4FOOD model), transparent algorithms, broader insurance cover, regular training and feedback, and stronger collective representation through unions, co-operatives or online communities [18]. These measures are seen as prerequisites for a fairer and more durable model of platform work worldwide.

Yet Finnish research shows that 68.4% of couriers actually prefer self-employment even though it yields little or no pay when orders are scarce [3]. They do not wish to bond themselves to a single employer.

One of the platforms that has decisively shaped working practices in food delivery is Deliveroo. Subsequent sections of the study examine how Deliveroo manages relations with couriers through a flexible-employment model that scales services quickly yet also creates labour vulnerability and attracts criticism for exploiting platform workers. The analysis focuses on algorithmic control, the legal status of couriers and the impact of such models on union activity and the defence of labour rights.

Founded in 2013, Deliveroo has grown into one of the world's largest food dnd goods delivery platforms, working with more than 160 000 restaurants and supermarkets including Marks&Spencer, Whole Foods and Waitrose [28]. It embodies the gig-economy model, marked by short-term contracts arranged

through digital apps. While this arrangement offers flexible schedules and a low entry threshold, it also lacks the classic guarantees of paid holidays, sick leave, steady wages and union protection [22].

In the United Kingdom Deliveroo couriers are officially classed as self-employed contractors, not employees. They are therefore ineligible for the National Minimum Wage, unprotected by employment law and unable to demand collective bargaining. Couriers may refuse orders, wear no uniform and work for competitors simultaneously. Deliveroo invokes a "substitution clause" that lets couriers hand orders to someone else, something that the UK Supreme Court views as inconsistent with an employment relationship [21].

This interpretation proved decisive in the IWGB union's bid to secure collective-bargaining rights for couriers under Article 11 of the European Convention on Human Rights [23]. Despite protests and litigation, in 2023 the Supreme Court upheld the Central Arbitration Committee's decision: Deliveroo couriers have no statutory right to union representation [25]. Although this was a serious setback, the IWGB continues to mobilise couriers and pursue international legal channels [24].

Self-employment can have harsh outcomes. Courier Celia Campos, for instance, worked 333 hours in July 2024 yet earned only £6.27 an hour, much below the legal minimum. "You have to do a lot of deliveries when they pay one or two pounds per order," she says. "The people who own these companies don't think about us, they think only about themselves" [27].

Deliveroo's stance contrasts sharply with Uber, whose drivers were recognised as "workers" (an intermediate status between self-employed and employee) by the UK Supreme Court in 2021. The Court stressed that Uber controls prices, sets contract terms and sanctions drivers who reject orders control that it deemed absent in Deliveroo's more arm's-length model [26]. The level of platform control thus proves decisive for legal status.

Regulatory trajectories are now diverging. The EU is debating a Platform Work Directive that could classify couriers as employees and grant them labour rights [18]. The UK, favouring flexibility and deregulation [23], is unlikely to follow suit. British firms may therefore try to export the Deliveroo model to other markets, complicating the fight for fair conditions.

Conclutions.

Problems in the delivery industry are multi-layered, ranging from algorithmic exploitation and job insecurity to gender- and migration-related risks. The study's authors recommend legislative reform, transparent algorithms and social insurance.

Entrepreneurs, keen to cut costs, will marshal expensive legal talent to argue against social guarantees for couriers; the UK experience shows that this strategy can succeed. Even unions do not always prevail. Because Deliveroo operates internationally, EU countries must anticipate such risks. Without coordinated action, the Deliveroo model could spread, eroding labour standards elsewhere.

Therefore the European Union must side firmly with delivery workers. Only by extending the full suite of social-protection mechanisms to couriers can this form of work be turned into civilised employment. A comprehensive solution will require state regulation, technological improvements and organisational innovation within the platforms themselves.

Based on all above mentioned, authors of the study formulated the following recommendations to EU member states regarding to the platform/gig-work:

1) Legally cap working hours. Courier hours should not exceed the limits set in the labour code of the country in which they perform their work.

2) Set a statutory minimum hourly wage. Courier-delivery workers must receive at least the national minimum hourly rate applicable in the country where the service is provided.

3) Guarantee paid sick leave and holiday. Courier-delivery workers should be granted rights to sick leave and annual leave, calculated in proportion to the hours they have worked on a given delivery platform.

The authors acknowledge that these measures will inevitably raise the cost of courier services and may therefore dampen demand. Nonetheless, they argue that such steps will help the EU and, by extension, other jurisdictions, advance toward a rule-of-law society that protects the interests of its citizens and residents.

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DEVELOPING CRITICAL AND LOGICAL THINKING SKILLS FOR BANKING PROFESSIONALS: CHALLENGES OF THE INFORMATION AGE

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Abstract. The modern era of digital transformation and information overload (Industry 4.0 and Industry 5.0) creates unprecedented challenges for banking sector professionals. The exponential growth of information volumes, spread of misinformation (manipulation), increasing complexity of financial instruments, and high level of market regulation demand that banking professionals develop strong critical and logical thinking skills. This study analyses key risks in the modern educational process for banking, including information overload, declining ability for deep analysis, and vulnerability to manipulative techniques. The systematic development of critical and logical thinking skills is essentially a strategic imperative for financial organizations and the government institutions that regulate them. A possible response (though not a panacea) could be implementing a comprehensive methodology for developing critical thinking, including practical tools for information verification, logical analysis techniques, and protection against cognitive biases. Special attention should be paid to specific risks in the banking sector related to making financial decisions under conditions of uncertainty and information asymmetry.

Key words: critical thinking, logical thinking, banking education, information security, misinformation, financial risks, cognitive biases.

"The illiterate of the 21st century will not be those who cannot read and write,
but those who cannot learn, unlearn, and relearn."
Alvin Toffler

Introduction. Modern banking business is experiencing a period of fundamental changes driven by digital transformation, changing consumer behaviour, and growing complexity of financial products. According to McKinsey Global Institute research, the volume of data in the global economy doubles every two years, with 90% of all data created in the last two years [1]. For banking professionals, this means the need to process and analyse unprecedented volumes of information when making critically important decisions.

Alongside the growth of information flows, we observe a general degradation in information quality. Research by the Reuters Institute shows that 38% of respondents avoid news because of its negative impact on their mood, while 43% believe they cannot distinguish reliable information from unreliable [2]. The latter has been defined by Tom Nichols as the phenomenon of "the death of expertise," when people having nothing to do with either professional knowledge or expert qualifications gained access to expert platforms through the internet and social networks [3]. This "militant ignorance" can provide answers to any question and explain any ongoing processes in primitive, everyday (but therefore understandable and accessible, and consequently popular for the masses) terms. Gone are the days of science popularisers like Stephen Hawking, Sergey Kapitsa, and other prominent scientists. Their places are occupied by numerous bloggers, “experts”, often lacking proper education or practical work experience, but getting media presence. The scientific approach has been replaced by "hype," "reels," and fragmented, non-systematic information, which is presented to both common people and professionals as practical knowledge.

The digital rhythm of life set by the 4th Industrial Revolution (Industry 4.0) has led to a specialized process of information perception, especially among the so-called "digital natives" – Generations Z and Y. This means a significant reduction in attention and the tendency towards so-called "clip thinking." First and foremost, more and more attention is being transferred to visual information processing. The length of video frames in this situation is a good criterion for evaluating the changes that have occurred. According to experts, Generation X and Baby Boomers could comfortably perceive a "frame" lasting 25 seconds or longer – just recall the films from the middle and end of the last century that became classics. And what about films by masters like Andrei Tarkovsky, where the "frame length" seems endless? Generation Y on average concentrates their attention for 12 seconds, while for Generation Z this indicator is already eight seconds [4].

The term "clip thinking" (or "clip consciousness") is used to describe the peculiarities of perception and information processing in the digital environment: when a person, within their work information flow or at home, encounters a stream of short, fragmented messages (posts, stories, videos up to a minute, etc.). In his work "The Third Wave," Alvin Toffler defined such content as "clip culture," namely – a mosaic of disconnected visual and emotional fragments, its brightness and short duration, quick replacement by others; illogical, disjointed, fragmentary information, dissolution of its holistic models [5].

The most dangerous risks of clip thinking for intellectual work include:

1. Superficial information perception. The ability to deeply analyse, compare, and synthesize information decreases.
2. Weakening of logical and critical thinking. Due to fragmented perception, the ability to build cause-and-effect relationships and reach conclusions based on them significantly deteriorates.
3. Decline in concentration. It becomes harder and harder for professionals to focus on one subject or text; a habit of constant "switching" develops.
4. Loss of linear reading and writing skills (the habit of "Z-reading"). It becomes more difficult for professionals to absorb long texts, arguments, and narratives.
5. Emotional superficiality. Reaction to perceived information is impulsive, with the effect of "instant impression," but without meaningful understanding.
6. Dependence on external stimulation. A person develops "information addiction" – a constant need for new emotional stimuli (clips, notifications).

Separately, we should consider the effect of "Z-reading" (different from the standard Z-shaped eye movement across text) formed by clip perception of information. This is the loss of sequence and depth in reading, where a person's eyes catch individual bright elements, such as headlines or images, almost completely ignoring the main part of the text.

Characteristics of "Z-reading" include:

1. Fragmentation, when a person perceives separate parts of text (headlines, highlighted words, visual images and videos).
2. Lack of sequence – a person does not strive for logical construction of thought from what they read, skipping entire sentences and paragraphs.
3. Superficiality – attention is focused on external form rather than content, analysis, or critical reflection on information.
4. Speed and impulsivity: constant change of stimuli occurs, excluding the possibility of deep immersion in material.
5. Habit of short content formed by clip thinking (information from social networks, YouTube, Internet), where short-term videos and posts predominate. This trains the brain to perceive information in the form of separate, bright "clips."
6. Low concentration, when the ability for prolonged attention focus decreases, making full reading difficult and burdensome.

7. Superficial analysis, when a person is increasingly incapable of deep analysis due to the habit of instant, superficial data processing.

Of course, existing research also provides positive characteristics of clip thinking, explaining that this is not a disease (degradation) but a kind of adaptive reaction of new generations to the world of digital technologies and the colossal information flow of Industries 4.0 and 5.0. This is a protective brain reaction that filters excessive data, focusing on key moments [6].

Positive characteristics typically include skills in rapid information processing, adaptation to the digital environment, multitasking, improved visual perception, emotional engagement, flexible thinking (easy adaptation to new forms of information presentation), and time savings. However, these same researchers agree that such adaptation still negatively affects concentration, impairs long-term memory, and influences cognitive skills of analysis and critical thinking.

The world of "clip thinking" forms a stable and favourable environment of "fragmented knowledge" and a "mosaic-fragmentary world," in which, according to French sociologist Abraham Moles, people live with "fragmented consciousness": "A series of emotionally saturated images does not allow for the formation of a complete picture of the world. Thus, modern postmodern culture forms individuals with split consciousness, incapable of systematic thinking" [7].

Philosopher Sergey Kara-Murza points out that the more a person is involved in the world of mosaic culture, the smaller the role logic plays and the more susceptible consciousness becomes to manipulation [8].

All these aspects are increasingly manifesting in the training of specialists, whether in specialized secondary education or higher education. It should be noted that existing standard – generally accepted education is still full of traditional approaches and is dogmatic, with emphasis still placed on memorizing procedures and regulatory requirements, rote learning, paying almost no attention to developing analytical abilities. This is an additional trauma for representatives of new generations who have already absorbed the approaches of the clip thinking world: the boring nature of the information and subjects being presented creates no motivation to study and analyse, but to solve the problem for the quickest as "Z-reading": quick work with digital information sources (for example, Wikipedia) without investing time in deep study. Operating with information, but not forming stable – systematic knowledge and skills – often such knowledge (and the students themselves) are called "Wikipedia-based" or "Instagram-based." Surveys conducted among students show that for 80% of students, Wikipedia is the priority source when searching for information [9].

A significant number of students read summaries of textbooks or literary works, study reviews from bloggers and journalists, thereby adding to the "mosaic" in their own knowledge system. Opponents of negative assessments point out that despite all this, students are capable of being multitasking: parallel to "studying" textbooks, they actively communicate on social networks, watch video content, and much more.

But such a rhythm creates the effect of information overload and, as a consequence, cognitive distortions, when students essentially have no time left for full-scale study. They don't read additional literature, remaining within the circle of "Wikipedia knowledge," and even here not everyone knows how to work correctly with information, analysing details and investigating root causes.

Obviously, all the difficulties listed above are fully present both in university education (training specialists in the financial sphere) and in training within specialized programs. Traditional approaches to banking education establish systematic vulnerabilities:

1. Focus on memorizing procedures – a significant part of the educational process is devoted to studying instructions and procedures, while insufficient attention is paid to developing analytical skills.

2. Lack of critical analysis practice – during the educational process, students are practically not taught actions in ambiguous situations requiring independent analysis and decision-making under conditions of uncertainty and limited time resources.

3. Ignoring behavioral aspects – traditional banking education is based on theories assuming market participant rationality, which showed its failure during the 2007-2008 crisis.

4. Fragmentation of knowledge – training occurs in separate disciplines without forming a holistic understanding of interconnections in the financial ecosystem. A specialist may possess expert-level knowledge of regulatory requirements but not understand their economic logic.

Then a specialist with such habits and "fragmented knowledge" enters the workplace. As a result, specialists become vulnerable to information manipulation, cognitive biases, and are unable to effectively identify and filter critically important information and data in the general information flow.

Basic Theoretical and Practical Provisions. Modern banking business faces a fundamental contradiction defining the paradox of Industry 4.0 and 5.0: as access to information becomes practically unlimited, a person's ability to meaningfully process this information becomes a critical and rare resource. This paradox manifests daily in the professional activities of banking experts, exacerbated by specific risks of banking business, among which I would like to highlight three:

1. Regulatory risks and information asymmetry
2. Technological risks
3. Market risks under conditions of information uncertainty

Banking (financial) business is historically characterized by a high degree of regulation, carrying specific information challenges. Firstly, the complexity of the regulatory environment and requirements itself: financial institutions must comply with the requirements of multiple regulators at national and international levels. Experts are forced to navigate regulatory documents of unprecedented complexity and volume: for example, the Basel III document contains more than 300 pages, and MiFID II regulatory requirements include about 1,400 pages of executive regulations [10, 11]. Secondly, the requirements themselves are constantly changing, which requires experts to quickly study and adapt changes to the bank's rhythm of work and business processes.

Besides, information asymmetry between regulators and financial institutions: regulators do not always have complete information about market practices, which often leads to the creation of ineffective, delayed, or contradictory requirements.

Technological risks, due to the active digital transformation of banking business, act as creators of new types of information risks for banks and banking experts.

Cybersecurity and digital fraud risks. Obviously, the development of digital technologies creates new opportunities for fraud. According to various estimates, due to the high professional level of training of digital criminals and the technologies used by frauds, this "industry" is becoming one of the most advanced, second only to the economies of China and the USA [12]. Banking experts are required to be able to recognize signs of fraud and critically comprehend information from clients (while clients are not ready to “waste” time on verification procedures).

According to IBM, the average cost of a data breach in the financial sector is 5.85 million USD [13].

It is worth noting the growth over the past couple of years of algorithmic risks, the use of artificial intelligence and machine learning, as a result of which risks arise related to the opacity of decision-making algorithms. Banking experts bear responsibility for understanding the limitations of automated systems and the ability to critically evaluate their recommendations and assess their potential consequences.

At the same time, due to professional activities, experts must analyse market data in real time, client portfolios, macroeconomic forecasts, and emerging risks. This occurs under quite strict time restrictions that do not allow for prolonged deliberation or comprehensive analysis.

This is aggravated by market risks. Financial market volatility is significantly amplified by the spread of information through social networks and messengers (speed and mass reach in terms of users, its reliability). As examples of such risks, we can point to the 2021 events with the price jump of American video game retailer GameStop, when coordinated actions on social networks influenced

the stock price, thereby creating systemic risks [14]. In a certain sense (the influence of information flows in social networks and user reactions), a similar situation is related to the cryptocurrency token $TRUMP, which was condemned by some prominent professionals in this field [15].

High-frequency trading is already operated based on automated algorithmic protocols, with minimal human control. This again puts forward requirements for experts in understanding the principles of algorithm operation and their potential vulnerabilities.

The emerging cognitive overload of experts represents not simply an operational inconvenience but a systemic threat to the quality of decisions made by one specialist or another: in an industry where individual errors can escalate into institutional failures, which may be followed by the collapse not only of one organization but of the financial system. It is always necessary to remember that to a certain extent, clients entrust their well-being in the present and future to banking professionals and banks (pension savings, targeted projects, etc.). Responsibility and risks are always high.

Accordingly, one of the fundamental factors can be identified: information overload of specialists as a systemic risk.

The concept of information overload was first systematized by Alvin Toffler in his work "Future Shock," in which he describes psychological disorientation caused by the acceleration of changes and destruction of epistemological foundations that previously allowed professionals to effectively manage complexity [16]. The scientist showed that rapid technological and social acceleration, accompanied by avalanche-like growth of information, causes psychological disorientation and decision-making paralysis, a state he brought into the book's title: future shock. He predicted that knowledge would become the main "currency" of post-industrial society, but information excess would produce the opposite effect: a decrease in the ability to process it rationally. For banking specialists, this dynamic manifests in constant changes in market conditions, legal and regulatory financial requirements, new asset classes (such as crypto assets), technological tools, and high client expectations requiring quick, if not instant, adaptation.

In the banking context, this phenomenon (information overload) acquires special relevance. According to IBM research, banking analysts spend up to 80% of their working time searching for and verifying information, and only 20% on its analysis [17]. Excessive data flow reduces decision quality, as the analytical system is forced to transition from deep analysis to superficial scanning. The effect of premature cognitive closure emerges: the aim to make a decision before complete information analysis [18]. The current situation is complicated not only by information excess and time deficit for its processing, but also by active use of misinformation and various types of artificial manipulation: AI-generated information, "echo chambers," algorithmic filters, and other content not amenable to traditional verification.

The main manifestations of information overload in the banking sector are:

1. Quantitative overload – excessive volume of data that is physically impossible to analyse within available time resources. A modern banking analyst daily encounters hundreds of reports, thousands of transactions, and multiple information flows from various sources.

2. Qualitative overload – decreased ability for deep analysis due to the need for constant switching between different types of information.

3. Temporal overload – time deficit for quality information analysis under conditions of need for quick decisions. In high-frequency trading, decisions are made in milliseconds, which excludes the possibility of deep analysis due to technology.

We should add interconnected processes that have fundamentally influenced the cognitive landscape of banking activities, adding to the tension created by information overload:

1. Fragmentation of knowledge systems**.** If previously professionals relied on a fairly stable hierarchy of authoritative sources, today they have to deal with multiple competing interpretations without built-in and unambiguous reliability verification mechanisms. The lag of government institutions

with reactions in the form of clear norms – procedures – metrics adds its own negative aspect in terms of interpreting various data. Algorithmically amplified misinformation often receives wider distribution than expert and peer-reviewed data.

2. Loss of expert filter function**.** Digital platforms provide equal visibility for both certified specialists and self-proclaimed experts (that very moment of Tom Nichols's "death of expertise"). Professionals are forced to constantly compare competing sources, often without reliable heuristics for assessing their reliability. The problem of authenticating expertise in the digital age has acquired exceptional acuteness [3].

3. Emergence of artificial intelligence as a source of analytical falsifications. Modern AI systems that have rapidly burst into expert and scientific life create texts and analytical reviews comparable in quality to the best examples formed by human experts, but containing fabricated data, fictitious references, and false statements (which look quite creadible) [19]. Traditional data verification methods are ineffective, as they require time expenditure.

An additional influencing factor creating significant risks for banking business is misinformation and its impact on financial decisions.

The spread of misinformation in the financial sphere has acquired a systemic character. Oxford University research identified 70 countries where government or political structures actively use social media to spread misinformation [20]. In the financial sector, such practices can lead to artificially created panic, asset price manipulation, and market destabilization.

Types of misinformation in the banking sector:

1. Manipulative information – facts falsification with the goal of influencing decision-making. For example, spreading false information about the financial condition of competitors or intentional distortion of macroeconomic indicators.

2. Selective information presentation – highlighting only part of the information that supports a certain point of view. This is especially dangerous when analysing investment projects, where silence about risks can lead to wrong decisions.

3. Emotional manipulation–using emotional triggers to suppress rational analysis. In banking practice, this can manifest when selling high-risk products to clients unable to adequately assess risks.

Particularly, we should analyse the factor of cognitive biases in banking activities. Behavioural economics has identified many cognitive biases that influence financial decision-making. Researchers Daniel Kahneman and Amos Tversky in their works define stable cognitive biases as regular deviations of human judgment from the rational model [21]. The authors showed that in the process of evaluating information, people resort to heuristics – simplified rules that speed up problem-solving but lead to systematic errors.

For banking professionals, the most critical are:

1. Confirmation Bias – the tendency to seek, interpret, and remember information in a way that confirms already existing beliefs or hypotheses. In banking analysis, this can lead to ignoring negative signals about a borrower if the initial assessment was positive.

2. Anchoring Effect – excessive dependence on the first information received when making decisions (manager's opinion, analytical information about the initial asset price, etc.). When assessing creditworthiness, initial information about client income can unjustifiably influence the final decision, even if subsequent data disproves it.

3. Clustering Illusion – the tendency to see patterns in random data. In trading operations, this can lead to building investment strategies based on false correlations.

4. Overconfidence Effect – overestimating one's own abilities and knowledge. In banking, this can lead to underestimating risks and making excessively aggressive decisions. A striking example is research showing that 93% of drivers consider themselves better than average, which is statistically impossible [22].

Complementary (or aggravating) factors in cognitive biases are cognitive limitations researched by John Sweller, who formulated the theory of cognitive load [23]. According to this theory, human working memory can only process a limited number of information elements. J. Sweller identified three types of cognitive load:

1. Intrinsic – determined by material complexity
2. Extraneous – related to unsuccessful methods of information presentation
3. Germane – directed at forming cognitive schemas and automating thinking

As already examined, in the banking system, intrinsic cognitive load is initially high: financial and legal regulations, mathematical evaluation models possess an extremely complex structure. Additional load sources: poorly organized databases, cumbersome reporting forms, critical time deficit – sharply reduce cognitive resources available for meaningful analysis and decision-making.

Research confirms: cognitive load leads to decreased decision quality, increased errors, and strengthened dependence on heuristic strategies [24]. In banking business, this manifests in choosing simplified but inaccurate behavioural models, which again increases the probability of erroneous investments and inadequate risk assessment. For representatives of regulatory bodies (including intra-bank committees), this problem has an important consequence: when executors' cognitive capabilities are exceeded, even formally correct procedure compliance turns into routine "box-ticking" without real understanding, which undermines the very essence of regulatory control.

As the crisis of 2007-2008 showed, critical situations with banks in the USA in 2022-2023, the crisis of brands like Credit Suisse – all these are individual errors multiplied by exceeding cognitive limitations that received institutional distribution [25].

Moreover, professional experience itself does not guarantee immunity from such biases: experts are often subject to them even more seriously, especially considering pressure and limited time resources [26]. This emphasizes once again the urgency of the problem and the necessity of training targeted at studying methods of recognizing and compensating for cognitive errors.

Even with a high level of professional training, the mentioned problems of life in the digital world of Industry 4.0 and emerging Industry 5.0 prove difficult to overcome, as there is a deficit of basic cognitive skills ensuring the ability for systematic thinking. Thus, another significant factor manifests: the deficit of logical education.

Logic, once a mandatory component even of ordinary secondary education in schools in the mid-20th century, including teaching the four classical laws of thought (identity, non-contradiction, excluded middle, and sufficient reason), the structure of argumentation, and recognition of logical errors, has practically disappeared from educational programs over recent decades [27].

As researchers show, this change was not the result of someone's insidious intrigues or malicious intent: it reflected a shift in educational priorities toward applied disciplines and narrow professional competencies. This seemed correct at the time.

An even greater shift toward narrow specialization occurred in the 1990s, when against the backdrop of the bipolar world's collapse, globalization and, as a consequence, unification were prized.

However, the consequences of such specialization and the transformations of recent decades in general (including the "digital boom") proved significant. Most banking experts enter the profession without systematic training in logical analysis: they are not trained in methods of argument evaluation; are not familiar with the typology of logical errors; and do not possess formal tools for checking reasoning.

The assumption that a professional with university education by definition possesses basic logical culture is, unfortunately, deeply mistaken. This educational deficit forms systemic vulnerabilities precisely in those areas where maximum cognitive accuracy is required (obviously, this is not limited to banking business alone). Experts without proper training in logic are more susceptible to:

1. Emotional manipulation in market communications
2. False dichotomies in strategic discussions

3. Ambiguity in interpreting regulatory documents
4. Circular reasoning in risk assessment

Experts lack tools for recognizing the substitution of evidence with rhetoric, distinguishing appeals to authority from factual arguments, and identifying cases where complexity is used to hide weak argumentation. In the context of banking business – where decisions directly affect client welfare, institutional stability, and financial system stability – these individual cognitive weaknesses become sources of systemic risks.

The solution is obvious: returning a course (or group of courses) forming logical and critical thinking skills at minimum to university and specialized education programs.

The modern understanding of critical thinking formed from several complementary intellectual traditions established by a significant number of researchers. Let us focus on several that allow us to at least briefly explore the conceptual foundations.

Robert Ennis was one of the first to propose a systematic model, defining critical thinking as "reasonable, reflective thinking focused on deciding what to believe or do" [28]. He identified twelve aspects of critical thinking, thereby laying the foundation for its teaching and assessment.

Peter Facione developed this tradition within the Delphi Report project, which united expert opinions and defined six key cognitive skills of critical thinking [29]:

1. Interpretation
2. Analysis
3. Evaluation
4. Conclusion
5. Explanation
6. Self-regulation

He also emphasized the importance of dispositions – stable personal inclinations to use these skills: curiosity, open-mindedness, honesty in acknowledging errors, flexibility, and striving for justified judgments.

Special pleasure and pride comes from the contribution of Ukrainian scholars to the study of critical and logical thinking, namely in advocating for principles of full return of teaching these skills to university education.

In his monograph "Critical Thinking," O. Tiahlo proposed a comprehensive methodology for teaching critical thinking in Universities. He emphasized the need to integrate logic and critical analysis, developed the course "Logic with Elements of Critical Thinking," included in Kharkiv Universities, and emphasized the practical orientation of logical knowledge: their application to identify manipulations and evaluate arguments in real communications [27]. His ideas were developed by A. Konverskyi, who identified four key factors in forming critical thinking: teaching methods, learning format, assessment methods, and style of cognitive activity [30]. He argued that problem-oriented methods (evidence-seeking, hypothesis-testing) most effectively develop the ability for critical judgment. He considered an important component to be creating an educational environment where systematic doubt is permitted and asking questions is encouraged – an approach especially valuable for banking education, where formal adherence to procedures and traditional conservatism often substitute for substantive analysis.

Works by M. Popovych, though not dedicated to aspects of critical thinking, directly touch on aspects of analyzing financial texts and regulatory documents. In his work "Philosophical Questions of Semantics," he laid the foundations for analyzing scientific language and knowledge structure, thereby developing principles of semantic precision and verification of scientific statements [31].

Thus, critical thinking includes both skills and the inclination to apply them. For banking experts, this means that educational programs must develop not only analytical tools but also professional values: readiness to ask questions, verify sources, reconsider conclusions, acknowledge errors. The con-

servatism, traditionalism, and hierarchical culture of most financial institutions, which highly value procedure compliance and subordination, often suppress precisely those qualities that constitute the essence of critical thinking.

A systemic solution could be developing a comprehensive theoretical-practical model designed to form critical and logical thinking competencies in banking experts working under conditions of high cognitive load, excess (and continuing growth) of information volume, and transformation of traditional models of expertise and verification.

As already shown, the general decline in quality of professional decisions in banking is not a consequence of individual incompetence but reflects structural cognitive and institutional limitations formed over recent decades.

Three levels of such limitations can be identified, to which attention should primarily be paid when building a model for forming critical and logical thinking competencies:

1. Individual-cognitive level. At this level, cognitive overload, heuristic biases, and deficit of logical-analytical training dominate.

– Inability for systematic information assessment with multiple variables;
– Dependence on authority or intuitive templates;
– Weak distinction between reliable argument and rhetorical impact;
– Influence of validity illusion and overconfidence in own judgments.

The main cause is the absence of formal cognitive self-regulation tools, which are formed through teaching logic and critical analysis.

2. Organizational-institutional level. At this level, the key factor is organizational culture oriented toward procedure compliance and error minimization rather than critical assessment of assumptions. The main problem is so-called institutional barriers (conformism, bureaucratic thinking, fear of expressing alternative opinions) that do not allow realization of critical thinking skills even for trained employees.

– Fear of expressing alternative opinions contradicting management
– Encouragement of conformism and bureaucratic thinking
– Use of reporting as a form of analysis imitation
– Absence of structures for interdisciplinary discussion of complex and controversial cases

3. System-regulatory level. At this level, the main problems are inconsistency between educational, professional, and regulatory standards.

– Banking specialist training programs are oriented predominantly toward technical knowledge rather than cognitive analysis skills.

– Certification exams assess knowledge of regulations but not the ability to critically interpret information.

– Regulatory bodies focus on formal compliance with requirements rather than cognitive quality of decisions.

Such inconsistency leads to institutional replication of cognitive weaknesses: the system of education and control unintentionally, due to already established attitudes, reproduces the same limitations it should eliminate. In summary, the interrelationship of levels can be presented in Table 1.

As seen from the table presented, the implementation of such a model will be successful only with systematic coordination of actions by the state in the form of regulatory bodies and the education system, as well as the banking system and institutions from other industries involved in this business. With coordinated interaction, transformation must be carried out at each of the three levels. For regulators, as a complex of professional competency assessment and development of educational requirements. For universities and specialized professional training programs, as a methodological base for designing courses on practical and logical thinking (economics and finance specialties). For financial institutions, as a basis for corporate programs developing analytical skills and open discussion culture.

Table 1

Interrelationship of limitation levels and directions of transformational impact within the comprehensive theoretical-practical model designed for forming critical and logical thinking competencies in banking employees

Level	Main Limitations	Key Action Directions	Target Result
Individual	Cognitive biases, absence of logical culture	Teaching logic, critical analysis, self-reflection	Improved quality of thinking
Organizational	Conformism culture, bureaucratic thinking, fear of errors and alternative opinions	Creating discussion structures, correcting incentives	Environment of cognitive autonomy
Regulatory	Formal approach to competencies, disconnection from educational practice	Introducing analytical standards and cross-industry programs	Institutional cognitive resilience

Source: author's development

At the individual-cognitive level, emphasis should be placed on developing cognitive and analytical knowledge and skills. The simplest measures appear to be:

1. Introducing mandatory logic and critical thinking courses into banking specialist training programs
2. Teaching methods of recognizing cognitive biases, argumentation analysis, and information verification
3. Using cases with cognitive error analysis–analysing specific situations where decisions were made under bias influence
4. Implementing regular self-reflection and analysis of decisions made in the corporate training process

The goal is transition from unconscious intuitive thinking to conscious cognitive self-regulation–the ability to track one's own reasoning, identify errors, and correct them.

At the organizational-cultural level, actions are needed aimed at creating an institutional environment conducive to critical thinking, namely:

1. Forming a culture of open discussion and permissibility of intellectual disagreement.
2. Creating cross-functional analytical groups (committees) where employees and management can discuss complex cases without fear of sanctions. For example, quality committees, ethics and risk management committees.
3. Implementing feedback systems allowing identification and discussion of errors as a learning tool, not punishment.
4. Developing an incentive system: increasing evaluation not for (or more precisely not only for) formal procedure execution, but for quality of analytical decisions.

Such an environment promotes development of professional autonomy and reduces thinking dependence on hierarchical pressure.

Finally, the regulatory-institutional level, which can be considered the macro-level of changes. At this level, development of logical and critical thinking should become a strategic priority of government and professional policy, within which:

1. Integration of cognitive and analytical competencies into financial sector expert certification standards
2. Revision of regulatory approaches providing for assessment of judgment quality, not just formal compliance with regulations
3. Support for inter-university and cross-industry programs for developing logical-critical skills
4. Creation of joint platforms for knowledge exchange between banks, regulators, and academic institutions

It is important to note that in the long term, precisely cognitive resilience, not exclusively technical competence, will become the key indicator of banking specialist professionalism.

Conclusion. The development of critical and logical thinking skills among banking professionals constitutes a critically important task for transforming the paradigm of professional training in the banking sector: a transition must be made from the dominance of technical and regulatory competencies to their integration with cognitive, analytical, and ethical competencies.

As has been demonstrated, the professionalism of banking specialists has traditionally been measured by the degree of mastery of financial instruments, knowledge of regulatory instructions and laws, and precision in executing procedures. However, in the context of the digital economy (Industry 4.0 and 5.0), when algorithms and digital platforms begin to perform a significant portion of routine analytical functions, it is precisely the ability to think critically, logically, and independently that becomes the determining factor of professional value.

The professional identity of the banking expert-professional must transform from a "financial process manager" to an analyst capable to reflective thinking, reasonable thinking, and intellectual responsibility.

The key conclusion is that the crisis of critical and logical thinking in the professional environment begins in the education system. Contemporary curricula in economics, finance, and management are dogmatic, oriented toward applied skills, but practically fail to develop fundamental cognitive discipline of thought. To restore such discipline, systemic reform is necessary within the framework of the proposed comprehensive theoretical-practical model, including several levels: individual, organizational, and regulatory. Without changing organizational culture and without incorporating these competencies into regulatory standards, any educational initiatives will remain fragmentary in nature.

From the perspective of possible transformations in the education system, the following points are important:

1. The reintroduction of logic and critical thinking into core curricula for finance, economics, and management specializations.
2. Integration of interdisciplinary courses combining cognitive psychology, philosophy, and professional ethics.
3. Transition from a reproductive learning model to one based on inquiry-based and problem-oriented approaches.

At the macro level, state and international regulators must regard the development of critical thinking as an integral element of financial stability. Current professional certification standards (e.g., the well-known CFA, EFPA programs, risk management programs, corporate governance programs, etc.) are focused on technical skills: risk management, reporting, compliance, yet do not include cognitive competencies of analytical judgment.

Possible reforms within the framework of the proposed model (at the regulatory level) may include:

1. Incorporation of indicators of analytical and cognitive maturity into the professional certification system.
2. Collaboration between regulators and the academic community to develop standards for cognitive quality of decisions.
3. Creation of professional development programs aimed at mastering methods of critical data analysis and argumentation.

New requirements emerge from the fundamental presence of digital technologies in everyday human life and, naturally, in the financial and banking sector. The implementation of generative artificial intelligence, the use of big data and automated analytical systems, trading robots and advisors is changing not only the forms but also the epistemology of professional knowledge. On the one hand, this has undoubtedly increased the volume of information processed and minimized human errors; on the other hand, it creates a new level of cognitive risks:

1. Automation reduces critical vigilance and creates dependency on algorithms.
2. AI models often represent "black boxes" whose decisions are difficult to verify logically.
3. Generative systems are capable of producing pseudo-scientific or unreliable analytical content of high quality.

Consequently, the contemporary expert-professional must possess the competency of technological scepticism, the ability to critically evaluate not only data but also the algorithms themselves, their assumptions, logic, and limitations. This capability becomes a new form of professional literacy, without which it is impossible to ensure the reliability of decisions in a world of digital solutions and AI.

A separate issue, practically unaddressed within the framework of the present study and requiring dedicated analysis and recommendations, is the ethical dimension of critical thinking. In the broader sense of subsequent research, this concerns the relationship to humans and to the AI algorithms created by humans.

The ability to ask questions, to doubt and verify sources is not merely an intellectual habit but, above all, a form of moral responsibility for the quality of professional decisions made and conclusions drawn. As has been demonstrated, banking business affects the interests of millions of clients and the economic stability of states' financial systems, requiring not only high technical competence but also intellectual integrity: the willingness to acknowledge uncertainty, errors, and the limitations of one's own knowledge and capabilities.

Logical and critical thinking in this context functions as an ethical filter: it ensures the maximum possible transparency of reasoning, prevents manipulation, and contributes to building trust among all levels of the proposed model (individual – society – financial institution – state). Errors of thinking here rapidly transform from the individual level to the systemic level, affecting the stability of financial institutions and public trust. Thus, the development of critical thinking should be regarded not as some optional "soft" competency, but as an ethical necessity of professional activity in the banking business.

Despite the fact that the analysis conducted within this article was carried out in the context of banking specialization, the challenges identified, the patterns revealed, and the proposed directions of work have broad (if not universal) applicability.

The phenomenon of cognitive overload, erosion of logical education, and technological dependency is observed in most spheres of professional activity, from law to public administration.

The proposed model of transformation at three fundamental levels can be considered as a high-level tool for designing professional development systems in the digital era of Industries 4.0 and 5.0. It demonstrates that the formation of a culture of logical and critical thinking is not a narrowly disciplinary task, but a strategic priority for the humanitarian and institutional development of society.

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THE IMPACT OF BOARD MEMBERS' EDUCATIONAL LEVEL ON THE PROSPECTS OF SUCCESSFUL DEVELOPMENT OF SMALL BUSINESS ENTREPRENEURSHIP

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Abstract. This article examines the influence of the educational level of board members on the success of small business development. Based on the analysis of theoretical approaches and empirical data from EU countries and Latvia, the study reveals how the education of executives affects strategic planning, innovation activity, and business sustainability. The findings highlight the necessity of enhancing the educational potential of managerial staff to ensure the competitiveness of small enterprises.

Key words: small business, education level, management, human capital, innovation, competitiveness, sustainability.

Introduction. Introduction In the contemporary economy, characterized by a high degree of uncertainty, accelerated digitalization, and global competition, the successful development of small business has become one of the key priorities of socio-economic policy. This issue is particularly relevant for the European Union, where small and medium-sized enterprises (SMEs) constitute more than 99% of all companies and provide approximately 67% of employment in the private sector (European Commission, 2022). SMEs form the backbone of the European economy, generating around 65% of jobs and more than 50% of added value in EU countries (European Commission, 2023). In Latvia, SMEs play a particularly significant role, accounting for 98% of all enterprises and ensuring employment for 70% of the workforce (Central Statistical Bureau of Latvia, 2024). The success of these enterprises is largely determined by the quality of governance, where a central role is played by the members of the board. The educational level of executives – including formal higher education, specialized programs (such as MBA), and professional development courses – shapes their ability to make strategic decisions, adapt to changes in the market environment, and implement innovations.

The theory of human capital (Becker, 1993) conceptualizes education as an investment that enhances productivity and efficiency. In the context of small business, where managerial decisions are often made under uncertainty and resource constraints, the educational level of executives becomes a critical success factor. According to the resource dependence theory (Pfeffer & Salancik, 1978), the knowledge and competencies of board members represent strategic resources that contribute to organizational adaptability and long-term resilience. Within the cognitive theory of management (Hambrick & Mason, 1984), the educational background of decision-makers determines their capacity for strategic thinking, information processing, and problem-solving efficiency. Thus, education forms the intellectual foundation of managerial activity, fostering innovation, analytical reasoning, and competitive advantage. Higher levels of education among board members enhance the organization's ability to absorb knowledge, recognize market opportunities, and implement effective strategic

solutions. Education therefore serves not only as an individual attribute but as a systemic factor that increases the overall quality of governance and the stability of small business development. One of the key factors determining the efficiency and long-term sustainability of small enterprises is the quality of managerial decisions made by board members. The academic literature emphasizes that the educational level of executives has a direct impact on strategic flexibility, innovation capacity, and the ability to adapt to rapidly changing external conditions (Wiklund & Shepherd, 2003; Unger et al., 2011). At the European level, initiatives such as the Small Business Act for Europe and the SME Strategy for a Sustainable and Digital Europe emphasize the importance of strengthening human capital in the SME sector. They underline the necessity of developing managerial and entrepreneurial competencies through both formal and informal education. In Latvia, the level of education of SME board members positively correlates with innovation implementation, successful digital transformation, and international market expansion (Ščeulovs & Gaile-Sarkane, 2016; Kaščekovs, 2020). Contemporary studies highlight that human capital, including education, is a critical factor in organizational success. According to Paul De Grauwe, Professor at the London School of Economics, "the education of managers determines not only their technical skills but also their capacity for strategic thinking, which is particularly important in times of economic instability" (De Grauwe, 2022). Similarly, Latvian economist Andris Vilks (Vilks, 2023) stresses that "in Latvia, where small businesses are often constrained by limited resources, the education of leadership becomes a key factor of competitiveness in the European market." Recent empirical studies increasingly confirm the significance of board members' educational levels for the effective functioning and strategic development of small and medium-sized enterprises (SMEs). For example, Bužavaitė and Korsakienė (2022), in their study "Does board usage of knowledge and skills affect internationalization performance of SMEs?", demonstrated that managerial knowledge and professional competencies of board members significantly improve internationalization performance, innovation potential, and resilience to global competition. Zehir, Can, and Karaboga (2015) found a direct relationship between education and strategic leadership effectiveness, emphasizing that firms led by highly educated directors tend to exhibit greater adaptability, innovation capability, and financial performance. Similarly, Zakaria, Abas, and Karim (2021), based on a sample of Malaysian SMEs, revealed a positive correlation between directors' education level and profitability indicators such as return on assets and equity growth. The authors noted that the impact of education is particularly strong in high-technology and innovation-driven industries, where analytical and strategic competencies are most essential. Further evidence is provided by Lumenta, Tulung, and Tumewu (2025), who established that the educational background and size of the board jointly influence financial stability. Boards with higher educational diversity were more effective in managing risks and ensuring sustainable growth. Consistent results were obtained by Rashid and Saeed (2023), who argued that companies with well-educated and diverse boards show superior innovation capacity and digital transformation performance, especially during economic crises. Taken together, these studies affirm that the educational level of board members not only enhances managerial practices but also creates long-term competitive advantages for small enterprises. Education strengthens strategic decision-making, supports innovation adoption, and improves resilience in volatile market environments. These arguments confirm the relevance of research into the impact of educational level of board members on the success of small entrepreneurship. The purpose of this article is to analyze how the educational level of board members influences the financial performance, innovation activity, and sustainability of small enterprises in Europe, with a particular focus on Latvia. The research aims to identify correlations between educational attainment and key performance indicators, as well as to provide recommendations for supporting the competitiveness of small business.

Theoretical Approaches to the Study of the Impact of Managers' Education

Human Capital Theory (G. Becker, 1964; T. Schultz, 1961) According to the human capital theory, education represents an investment in knowledge that enhances labor productivity and generates added value. In the context of small business, the education level of board members: increases their ability for strategic analysis and long-term planning; contributes to the formation of an innovative organizational culture; reduces the likelihood of managerial errors and inefficiencies. Well-educated executives are more capable of adapting to technological and market transformations, which improves business resilience under conditions of economic uncertainty.

Agency Theory (M. Jensen & W. Meckling, 1976) Agency theory views the relationship between owners and managers as a system of contractual obligations that requires control and minimization of agency costs. In small enterprises, where owners often serve as board members, a high level of education contributes to: a better understanding of the principles of corporate governance; transparency and accountability in decision-making; reduction of information asymmetry between business participants and investors. Thus, well-educated board members foster a culture of trust and accountability, which increases the investment attractiveness and sustainability of small firms.

Resource-Based View (RBV) (J. Barney, 1991) The resource-based view asserts that unique and hard-to-imitate resources define a firm's competitive advantage. In this framework, the education level of board members represents an intangible asset that enhances organizational capabilities and the firm's innovative potential. Educated board members: possess analytical and strategic decision-making skills; effectively manage knowledge and promote innovation; develop professional networks and partnerships, broadening access to resources and markets.

Institutional Theory (P. DiMaggio & W. Powell, 1983) Institutional theory emphasizes the importance of a firm's conformity to social, legal, and normative expectations. Board members with higher education are better equipped to: understand the regulatory and economic environment; ensure compliance with legal and ethical standards; strengthen the firm's legitimacy and reputation among stakeholders. Therefore, education enhances the institutional legitimacy and external credibility of small businesses.

Scientific Contribution: This study contributes to the understanding of the role of human capital within managerial bodies as a critical factor in the sustainable development of small enterprises. Education is conceptualized not merely as a social attribute but as a pivotal component of managerial competence, shaping the strategic decision-making and behavior of firms.

Practical Implications: The findings of this research offer practical applications in several areas: Establishing robust criteria for evaluating the managerial potential of small enterprises; Designing targeted professional development and executive training programs; Informing and enhancing public policy initiatives that support small businesses, with a particular emphasis on cultivating managerial competencies and advancing management education.

Materials and Methods

To analyze the impact of the educational level of board members on the success of small enterprises, a combined methodological approach was applied, including a literature review and empirical research. The study sample consisted of 200 small enterprises from selected European countries (Germany, France, Sweden, and the Baltic States – Latvia, Lithuania, and Estonia) over the period 2020–2024. Among them, 50 enterprises represented Latvia. The educational level of executives was classified into three categories: – Secondary vocational education; – Higher education (Bachelor's, Master's); – Additional professional education (MBA, professional development courses).

The analysis of enterprise performance was based on key success indicators (Table 1).

Table 1

Key success indicators of small enterprises

Category of success	Key metrics	Relation to educational level
Financial sustainability	ROA, ROE, EBITDA	Improved accuracy of strategic planning
Innovation	New products, R&D participation	Higher readiness for technology adoption
Risk management	Liquidity, debt ratio	Greater resilience in crises, risk diversification
International activity	Export, international projects	Higher openness to new markets and partnerships
Digitalization	Automation, e-commerce adoption	Broader use of IT solutions in business
Human resource management	Retention, training, development	Stronger leadership, engagement, and team development

The research design relied on questionnaires, financial reports, and structured interviews with executives. Analytical methods included correlation analysis, regression modeling, and data visualization. This methodological approach ensures a reliable assessment of how board members' education correlates with strategic decision-making, financial performance, innovation capacity, and overall business resilience.

Results and Discussion. Research evidence consistently demonstrates that the educational level of board members significantly influences the strategic orientation and performance outcomes of small enterprises. The findings of this study confirm the hypothesis that higher education levels among executives are positively associated with innovation, financial resilience, and internationalization. Human capital as a determinant of business development According to human capital theory (Becker, 1964), investments in education and training enhance productivity, innovation capacity, and adaptability. In small enterprises, where decision-making power is concentrated in a limited number of individuals, the importance of education becomes especially pronounced. Human capital can be defined as the combination of knowledge, skills, experience, motivation, and intellectual potential that can be applied in managerial and entrepreneurial activity (Becker, 1964; Sproģe et al., 2024). For SME executives, human capital serves as a strategic asset: – Education and qualifications enhance innovation, adaptability, and strategic thinking (Gonzalez Varona et al., 2024). – Communication and management skills strengthen teamwork, partnerships, and access to financing (Navickas et al., 2025). – Digital competencies enable technology adoption, process optimization, and responsiveness to market changes (Sproģe et al., 2024; DESI, 2020). Unlike physical and financial resources, human capital possesses the properties of reproducibility, scalability, and multiplicativity, making it the critical resource in post-industrial economies. Comparative analysis: the Baltic States and EU experience Studies (Unger et al., 2011) demonstrate that entrepreneurs with higher human capital are significantly more likely to achieve success in SMEs and startups, particularly through competencies in management, finance, marketing, and digitalization. In small enterprises, where staff is limited, the influence of each board member is amplified. Often, a single executive assumes multiple functions (director, accountant, marketing manager, HR specialist), making human capital the cornerstone of business growth. In Latvia and other Baltic States, access to further education, accelerators, and mentoring programs (e.g., ALTUM, Startup Latvia) substantially strengthens entrepreneurial skills, especially in the early stages of company growth. The Global Entrepreneurship Monitor (GEM, 2023) indicates that entrepreneurs with a Bachelor's degree or higher are 45% more likely to demonstrate business resilience and innovation.

Country-level differences are observable. In Germany, the Netherlands, and Finland, the education level of SME executives is strongly correlated with higher export activity. In Latvia, Ščeulovs &

Gaile-Sarkane (2016) report that 63% of successful SMEs are managed by individuals with higher or professional education. Kaščekovs (2020) found that companies with executives educated in economics and management are 30% more likely to demonstrate revenue growth within the first five years. Similar tendencies are evident in Estonia and Lithuania. For example, Estonian Business School graduates (MBA) exhibit higher entrepreneurial activity and export orientation, while ISM University in Lithuania has shown that Master's graduates are more likely to expand businesses internationally.

Table 2

Education of SME executives and business success in the Baltic States

Country	SMEs with executives holding higher education (%)	Business sustainability (5 years)	Example institutions supporting SMEs
Latvia	63	58%	RISEBA, University of Latvia
Lithuania	67	61%	ISM University
Estonia	72	64%	Estonian Business School

Return on investment (ROI) in human capital.

An effective way to measure the contribution of human capital to SME development is through ROI (Return on Investment) from education and training. In the Baltic States, ROI varies, reflecting differences in educational policies and entrepreneurial support ecosystems:

- Estonia demonstrates the highest ROI (~150%), supported by digital platforms, state-funded training, and a well-developed business education system (EBS). However, around 78% of SMEs report a lack of qualified managers and ICT specialists as a barrier to growth and innovation.
- Lithuania achieves an ROI of ~135%, due to a flexible system of professional education and a strong focus on export-oriented SMEs supported by ISM University. Tamasauskiene & Poteliene (2013) found that returns on education in Lithuania are comparable to advanced economies such as Denmark, Germany, and Finland.
- Latvia shows ROI at ~120%. While positive, its efficiency could be improved through closer integration between academia and entrepreneurship (RISEBA, University of Latvia, ALTUM). According to OECD (2024), Latvia's innovation potential requires greater investment in ICT and STEM programs, alongside stronger incentives for academic-industry collaboration. (Figure 1)

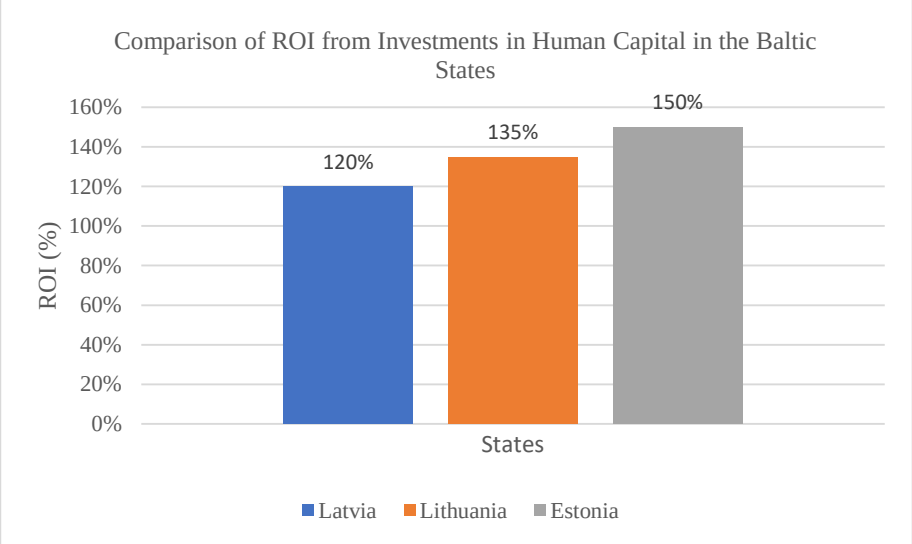

Fig. 1. Comparison of ROI from Investments in Human Capital in the Baltic States

The LV PEAK (2024/25) report proposes a national monitoring model for human capital policy, with indicators designed to increase ROI at the state level. Furthermore, DESI (2020) data reveal that Latvia lags behind in digital skills, hindering the efficiency of investments in human capital and slowing digital transformation in SMEs.

Interpretation of findings.The results highlight that education improves not only technical and managerial competence but also strategic resilience. Higher-educated executives demonstrate better financial management, innovation readiness, and openness to international markets. For Latvia, this is especially critical as SMEs are resource-constrained and exposed to global competition. Education thus becomes a key driver of sustainable competitiveness.

Scientific Contributions

- **Clarification of Human Capital's Role:** The research refines the understanding of human capital as a critical factor in small business sustainability, highlighting its direct impact on strategic behavior and organizational outcomes.
- **Education as a Component of Managerial Competence:** The study positions education as a core element of managerial competence, showing its significance beyond social status or formal qualifications.
- **Systemic Perspective:** By analyzing the interplay between human capital, organizational structures, and external support, the study provides a systemic view of the factors driving small business sustainability, emphasizing the mediating role of managerial competence.

Practical Implications

- **Assessment of Managerial Potential:** The findings can be used to develop robust criteria for evaluating the managerial capabilities of small business leaders, facilitating targeted interventions and talent management.
- **Professional Development Programs:** Insights from the study inform the design of executive training and professional development programs aimed at enhancing managerial skills, strategic thinking, and decision-making capacity.
- **Policy Recommendations:** The study underscores the importance of aligning state and institutional support programs with initiatives that strengthen managerial competence, fostering more resilient, adaptable, and competitive small enterprises.

Methodological Contributions

- **Analytical Framework:** The research proposes a framework for assessing the impact of human capital on small business sustainability, integrating educational, managerial, and strategic dimensions.
- **Empirical Basis for Future Research:** The methodology and findings provide a foundation for subsequent studies, including comparative analyses across regions, industries, and longitudinal assessments of managerial education programs.

Directions for Future Research

- Examination of additional dimensions of human capital, such as social and emotional intelligence, and their influence on strategic decision-making and organizational resilience.
- Comparative studies across industries and economic contexts to validate the generalizability of the findings.
- Longitudinal research to assess the long-term impact of managerial education and training programs on the sustainability and growth of small enterprises.

Conclusion. The research findings confirm that the educational level of board members has a decisive influence on the success of small enterprises, affecting their financial stability, innovation activity, digital transformation, and international competitiveness. Human capital, represented by the knowledge, skills, and strategic competencies of executives, functions as the most valuable intangible resource of SMEs. In the context of Latvia and the Baltic States, education significantly enhances the ability of entrepreneurs to adapt to external challenges, implement innovative solutions, and achieve

sustainable growth. Higher education, complemented by professional development programs such as MBA courses, fosters long-term competitiveness by strengthening strategic decision-making and innovation capacity. The comparative analysis with other EU countries demonstrates that investment in human capital yields substantial returns (ROI) for small enterprises. Estonia and Lithuania show particularly high efficiency of educational investment due to strong integration between academia, business, and governmental support. Latvia, while demonstrating positive results, still faces the challenge of improving digital skills, fostering STEM education, and strengthening cooperation between universities and SMEs.

The study emphasizes the following key conclusions:

1. The educational level of executives directly correlates with the resilience and competitiveness of small enterprises.

2. Human capital should be viewed as a strategic investment rather than an auxiliary resource, with measurable ROI.

3. National policies aimed at fostering innovation and SME growth must prioritize education, digital literacy, and academic-industry collaboration.

4. For Latvia, enhancing managerial education and expanding access to professional training programs are essential for strengthening small business competitiveness in the European market.

Future research should focus on longitudinal studies of SMEs in the Baltic region, with particular attention to digital transformation and the role of executive education in sustainable development under conditions of global economic uncertainty.

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YOUTH READINESS FOR AI-DRIVEN HR PRACTICES IN THE BALTIC STATES: A COMPARATIVE STUDY

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Abstract. This study explores youth readiness for artificial intelligence (AI) applications in human resource (HR) and recruitment practices in Estonia, Latvia, and Lithuania. Based on a cross-country survey and qualitative interviews with individuals aged 18 to 30, the research examines digital competence, exposure to AI tools, and attitudes toward AI in hiring. The findings reveal significant differences across the Baltic states. Estonian youth demonstrate the highest readiness, supported by strong digital education and national AI initiatives. Lithuanian respondents show active use of AI in learning but report moderate institutional support. Latvian participants express interest in AI but indicate limited access and lower digital confidence. While most respondents view AI as a useful and efficient tool in HR, concerns remain regarding data transparency and fairness. The study offers evidence-based recommendations to support the integration of AI in education and employment services, aiming to improve youth adaptability to future AI-driven labour markets.

Key words: youth; artificial intelligence; recruitment; human resource; Baltic states.

Introduction. The rise of AI is transforming human resource management (HRM) and recruitment globally. Organizations increasingly use AI-powered tools to scan résumés, source candidates, and even conduct initial interviews. Studies highlight that AI can enhance efficiency, reduce human bias, and improve hiring decisions through advanced data analysis (Rai, Constantinides, & Sarker, 2019; Jatobá et al., 2023). For example, AI algorithms can rapidly match candidates to job profiles based on skill relevance and predictive analytics, often outperforming traditional methods in speed and scale (Chatterjee, Rana, Tamilmani, & Sharma, 2021). AI adoption in HR leads to better efficiency and decision-making (Tambe, Cappelli, & Yakubovich, 2019). However, scholars also point to ethical concerns. AI systems, when trained on biased historical data, may replicate or amplify existing inequalities (Binns, Veale, Van Kleek, & Shadbolt, 2018; Raghavan, Barocas, Kleinberg, & Levy, 2020). A comprehensive review emphasized the risk of algorithmic discrimination against certain demographics unless developers apply rigorous fairness checks and transparency mechanisms (Chen, Wu, & Wang, 2023). Well-publicized failures, such as Amazon's AI tool that downgraded female applicants (Dastin, 2018), illustrate the potential harms of unregulated AI in hiring. In response, regulatory frameworks such as the European Union (EU) Artificial Intelligence Act classify recruitment-related AI tools as high-risk systems, requiring audits, documentation, and bias mitigation measures (European Commission, 2021). These developments highlight the growing importance of AI literacy, digital ethics, and regulatory compliance for both employers and job seekers in the evolving labour market.

Recent research supports the Eurostat findings that young people in the Baltic states are highly digitally engaged, with daily internet use rates among the highest in the EU and widespread participation

in online social networking activities (Madej-Kurzawa, Pieczarka, & Węgrzyn, 2021; Cino, Lacko, Mascheroni, & Šmahel, 2022). However, there are notable differences in digital skill levels: while 93% of youth in Estonia and Lithuania possess at least basic digital skills, only 75% of Latvian youth do, indicating a significant skills gap (Madej-Kurzawa, Pieczarka, & Węgrzyn, 2021). This disparity suggests that, despite nearly universal internet access, a substantial portion of Latvian youth may lack the fundamental digital competencies enjoyed by their peers in Estonia and Lithuania. Such differences in digital skills are important, as higher digital competencies are linked to greater professional opportunities and more effective participation in digital and AI-driven HR practices and recruitment processes (Madej-Kurzawa, Pieczarka, & Węgrzyn, 2021; Peláez, Erro-Garcés, & Ciriano, 2020). Research also highlights that digital skills – especially informational and problem-solving abilities – are strong predictors of how young people engage with online activities, including those relevant to employment and education (Cino, Lacko, Mascheroni, & Šmahel, 2022; Madej-Kurzawa, Pieczarka, & Węgrzyn, 2021). Therefore, while Baltic youth are generally well-connected and active online, addressing the digital skills gap, particularly in Latvia, is crucial to ensuring equal readiness for the evolving demands of the digital economy and AI-driven workplaces (Madej-Kurzawa, Pieczarka, & Węgrzyn, 2021; Peláez, Erro-Garcés, & Ciriano, 2020; Cino, Lacko, Mascheroni, & Šmahel, 2022).

Despite the growing presence of AI in recruitment, research focusing specifically on the perspective of youth as participants in AI-mediated hiring remains limited, particularly within the Baltic context. International studies examining job applicants' perceptions of AI in recruitment have found that candidates perceive AI-based hiring tools as both useful and easy to use, with notable advantages including accelerated response times in communication, a feature that younger applicants especially value compared to the traditionally slower pace of conventional recruitment processes. Nevertheless, participants also highlight drawbacks such as the lack of nuanced human judgment and concerns regarding the accuracy and reliability of algorithms (Horodyski, 2023). These findings suggest that digitally native youth may appreciate the efficiency offered by AI, while remaining cautious about its limitations (Wang et al., 2021). Another recent study focusing on Generation Z in Germany (born 1995-2010) revealed a similarly ambivalent outlook: on one hand, Gen Z sees AI as an opportunity to reduce human bias and improve diversity in hiring, but on the other, they fear potential job losses for HR staff and mistrust companies' data security measures (Talay, Wolf, & Ruf, 2023). Such insights underscore that "youth readiness" for AI-driven HR involves not just technical skill, but also awareness, attitudes, and trust.

The aim of this study is to empirically assess the readiness of youth in the Baltic states, specifically Estonia, Latvia, and Lithuania, for AI-driven HR and recruitment practices. Specifically, the objectives are: (1) to compare digital skills among youth in each country and assess whether they are sufficient for using AI-based recruitment tools; (2) to measure the level of awareness and understanding of AI applications in HR; (3) to analyze perceptions of benefits and risks associated with these technologies, including concerns about fairness, privacy, and job security; and (4) to identify notable differences between countries and age subgroups (e.g., university students versus late-twenties professionals) in readiness and attitudes.

This research was conducted in February-April 2025 by HR Line EU, a Latvia-based employment agency specializing in HR innovation throughout the EU. The study draws on original survey and interview data to provide new empirical evidence regarding the digital and attitudinal readiness of Baltic youth for the future of AI-mediated recruitment. The results are intended to inform educational policy, HR practitioners, and future research on supporting youth as they enter an increasingly AI-oriented labour market.

Methods. This study employed a mixed-methods approach, combining a quantitative survey of Baltic youth with qualitative interviews to gain deeper insight. The research was based on original data collected from respondents in Estonia, Latvia, and Lithuania. The research design and survey

instruments were developed by the HR Line EU research team in consultation with regional experts, ensuring that the data accurately reflected each country's context.

Survey Design and Sample. An online questionnaire was constructed consisting of multiple sections: (1) respondents' background (age, gender, education, and employment status), (2) digital skills self-assessment, (3) awareness and knowledge of AI in HR, (4) attitudes toward AI-driven recruitment, and (5) personal experiences (if any) with AI tools in job seeking or hiring. Many survey items were designed as statements on a 5-point Likert scale (from "Strongly Disagree" to "Strongly Agree"). For example, participants rated statements such as "I feel confident in my ability to succeed in a job interview conducted by an AI system" and "AI algorithms can evaluate job candidates more fairly than human recruiters." To measure attitudes toward AI, the General Attitudes towards Artificial Intelligence Scale (GAAIS) (Schepman & Rodway, 2022) was included in the survey. The GAAIS consists of two subscales: Positive Attitude (e.g., "Artificial intelligence makes my daily life easier") and Negative Attitude (e.g., "Artificial intelligence makes me feel anxious"). Each subscale comprises five statements rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). For analysis, mean scores for each subscale were calculated for all respondents and by subgroup.

The target population consisted of young people aged 18–30 in Estonia, Latvia, and Lithuania. The final sample included 600 respondents, with 200 participants from each country. Each national subsample was stratified by two age groups (18–24 and 25–30), resulting in 100 respondents per age group in each country. Participants were selected to ensure proportional representation of urban and rural youth, as well as alignment with national distributions in tertiary education enrollment, reflecting varying levels of digital exposure. The gender distribution in the sample was approximately equal, mirroring general survey participation trends among young adults in the Baltic region.

Interview Procedure. To complement the survey, semi-structured interviews were conducted with a smaller sample of participants from each country. In each nation, 10 young people were selected to represent diverse backgrounds, including university students, recent graduates, early-career professionals, and unemployed youth. All interviews were conducted via video call and followed an open-ended interview guide. Key prompts included: "Can you describe what you know about how AI is being used in hiring or at workplaces?", "How would you feel if a company's first interview with you was conducted by an AI (for example, a chatbot or automated video analysis)?", and "In your opinion, what are the biggest benefits and risks of using AI in recruitment processes for young job-seekers?" Interviewers also asked for personal experiences, such as whether the participant had ever applied for a job using an AI-based system, and explored their sense of preparedness (e.g., "Do you think your education or past experience has prepared you to deal with AI in the workplace?"). All interviews were audio-recorded (with consent) and transcribed for qualitative analysis.

Each interview lasted approximately 30–40 minutes. The qualitative data were analyzed using thematic analysis to identify common themes and country-specific differences in perceptions and experiences. For example, some Estonian interviewees described their familiarity with automated systems gained through university e-services and national digital platforms. In contrast, several Latvian participants noted that their awareness of AI in hiring stemmed primarily from news, social media, or recent educational reforms. Lithuanian interviewees often discussed hands-on experiences with digital tools in both education and job-seeking contexts. These qualitative insights helped to contextualize the survey findings, revealing nuanced attitudes and experiences among Baltic youth regarding AI adoption in recruitment and HR practices.

Analysis. For the quantitative analysis, survey responses, including GAAIS scores, were processed using descriptive statistics and comparative analysis across countries and age groups. Mean scores and standard deviations were calculated for each GAAIS subscale (Positive Attitude, Negative Attitude) within each country and age group. Key indicators, such as the proportion of respondents agreeing with core statements (e.g., "AI makes my life easier," "AI makes me anxious"), were compared across groups to identify substantive differences in attitudes and readiness.

Analysis of GAAIS results revealed clear cross-country variation in attitudes toward AI (see Table 1). Estonian youth demonstrated the most positive attitudes toward artificial intelligence (M = 4.0, SD = 0.7), while Lithuanian youth followed (M = 3.7, SD = 0.8), and Latvian respondents reported the lowest positive attitudes (M = 3.4, SD = 0.9). In terms of concerns or negative attitudes, Estonian participants scored lowest (M = 2.2, SD = 0.8), suggesting less anxiety and apprehension about AI. Lithuanian youth had slightly higher concerns (M = 2.5, SD = 0.9), and Latvians reported the highest levels of concern (M = 2.8, SD = 1.0).

Further breakdown by age groups indicated that participants aged 18-24 across all three countries tended to express more optimistic attitudes toward AI (Positive Attitude subscale: M = 3.9) and lower anxiety (Negative Attitude subscale: M = 2.3) compared to those in the 25-30 cohort (M = 3.5 and M = 2.7, respectively). These patterns were consistent across Estonia, Latvia, and Lithuania, although absolute values varied, with Estonian youth consistently showing the greatest openness to AI and the least apprehension.

In addition to attitudes, an "AI readiness index" was calculated for each respondent by aggregating responses related to digital skills, awareness of AI applications, and attitude scores. This index, scaled from 0 to 100, provided a synthetic measure of overall readiness and enabled direct comparison between groups. As expected, Estonian youth had the highest average AI readiness index, followed by Lithuanian and then Latvian respondents.

For the qualitative component, thematic analysis of interview transcripts identified several recurring themes. These included "trust in technology," "importance of human interaction," "concerns about bias and fairness," and "enthusiasm for increased efficiency." Differences emerged between countries: Estonian participants often described greater familiarity and comfort with automated systems, citing personal experiences in educational or public service settings, while Latvian interviewees expressed more uncertainty and a desire for increased transparency in AI-mediated recruitment. Lithuanian youth commonly highlighted the practical benefits of AI but voiced concerns about data privacy and the erosion of personal contact during hiring.

These qualitative findings provided valuable context for interpreting the quantitative data, offering deeper insight into both the origins of optimism and the roots of skepticism among Baltic youth. The integrated analysis thus delivers a nuanced, evidence-based account of readiness for AI-driven HR practices in the region.

Table 1

Mean GAAIS Scores by Country and Age Group

Country	Age Group	Positive Attitude (M, SD)	Negative Attitude (M, SD)
Estonia	18–24	4.1 (0.7)	2.1 (0.7)
Estonia	25–30	3.8 (0.8)	2.3 (0.8)
Lithuania	18–24	3.8 (0.7)	2.4 (0.9)
Lithuania	25–30	3.6 (0.8)	2.6 (0.8)
Latvia	18–24	3.5 (0.8)	2.6 (1.0)
Latvia	25–30	3.3 (0.9)	3.0 (0.9)

Note: Scores range from 1 ("Strongly disagree") to 5 ("Strongly agree").
Source: Developed by the authors

Results. Digital Skills Landscape. The survey results indicate that digital proficiency among Baltic youth is high, with notable disparities remaining between the three countries. In Estonia and Lithuania, nearly all respondents (over 90%) rated their computer and internet skills as "good" or "excellent." By contrast, in Latvia, only 78% of youth described their skills at this level, with the remainder reporting "fair" or "basic" digital competence. Across all countries, younger participants (aged 18–24) tended to

rate their digital abilities higher than those in the 25–30 age group. These findings are consistent with broader European trends but highlight a persistent digital gap for Latvian youth even within the younger cohort (Machackova et al., 2024; Andersson, Dalquist, Ohlsson, & N., 2018).

Awareness of AI in HR. The majority of Baltic youth are aware that AI technologies are being introduced into recruitment, though exposure levels vary by country. The survey asked respondents whether they had heard of specific AI applications in hiring, such as CV-scanning algorithms or AI-powered video interview platforms. In Estonia, 90% of respondents indicated awareness of at least one such application, while the figures were 78% in Lithuania and 64% in Latvia. Estonian youth frequently referenced exposure through university career center workshops and news articles about AI-driven hiring. In contrast, a significant proportion of Latvian respondents, particularly those from outside major urban areas, noted that the concept was relatively new to them. For some participants, taking part in this survey represented their first introduction to AI in recruitment. Lithuanian participants typically reported informal awareness, most often via social media or peer discussions.

Notably, across all countries, few participants reported direct experience as applicants in an AI-mediated hiring process. Only about 10% of the sample believed they had ever been evaluated by an algorithm during recruitment, and many were uncertain due to the lack of employer transparency regarding the use of AI in candidate screening. An exception was a tech-oriented Estonian respondent who described completing an online gamified psychometric assessment, which he suspected was AI-scored. Thus, while general awareness of AI in HR is high, firsthand experience with AI-mediated recruitment remains limited among Baltic youth. These findings are in line with recent international research on youth perceptions of AI in employment (Tanvi, Rutika, & Vidani, 2025; Yarovenko, Kuzior, Norek, & Lopatka, 2024; Weiss, Liu, Mieczkowski, & Hancock, 2022; Yasin, 2022).

Attitudes and Perceptions. Survey results indicate a pattern of cautious optimism among Baltic youth toward AI in recruitment. Most respondents recognized that AI can improve hiring efficiency: 70% of Estonians, 65% of Lithuanians, and 55% of Latvians at least "somewhat agreed" that AI could speed up recruitment and reduce feedback wait times. This emphasis on faster processes aligns with global findings (Gilbert et al., 2020; Kaplan, Klein, Wilson, & Graves, 2020).

Qualitative interviews confirmed this sentiment. One Lithuanian participant remarked, "If an AI system schedules interviews or updates you instantly, that's a big plus. It's better than waiting weeks."

At the same time, concerns about fairness and loss of human touch were pronounced. Only 30% of Estonian, 25% of Lithuanian, and 15% of Latvian youth trusted AI to make fair hiring decisions. More than 60% of Latvian respondents disagreed that AI would improve fairness, suggesting a deeper mistrust in new technologies.

Interviewees, especially in Latvia, worried that AI might overlook unique qualities in CVs: "A human might catch my potential, but a computer might not," explained one. Across all countries, 68% agreed that human recruiters can perceive qualities that AI cannot, echoing other research about the limits of automated assessment (Lashkari & Cheng, 2023; Armstrong, Everson, & Ko, 2023).

Privacy and data security ranked among the most prominent concerns for Baltic youth. Around half of respondents in each country (50–60%) reported unease about how personal data such as video recordings or social media profiles might be used by AI systems. For example, an Estonian participant noted that, even with strong data protection laws, there is uncertainty about where their information might end up and who could access it. About 55% of Lithuanian and 65% of Latvian participants said they felt uncomfortable with AI analyzing their facial expressions or voices. This suggests a significant proportion of young people, particularly in Latvia, feel uneasy about the intrusive aspects of AI evaluation.

Beyond these concerns, respondents frequently identified the potential of AI to increase fairness and mitigate bias in recruitment. Many respondents, especially from Estonia and Lithuania, indicated that AI has the potential to reduce human prejudices in hiring. In Lithuania, 58% agreed that AI might

make recruitment more merit-based by focusing on qualifications rather than personal factors. This proportion was even higher in Estonia, at 65%, while in Latvia it was lower at approximately 45%, suggesting a more cautious or skeptical attitude among Latvian respondents. Several interviewees suggested that, if properly designed, AI would not be influenced by characteristics such as gender or surname, but would prioritize skills and qualifications. Some participants also noted that AI could address issues of nepotism or bias that occasionally occur in local hiring practices. These perspectives are consistent with international findings, including those from Gen Z focus groups in Germany (Talay et al., 2023), which highlight both the perceived opportunities and the condSelf-Reported Readiness.

Survey participants were asked to assess their own preparedness for AI-mediated hiring situations. Results indicate significant variation across countries and age groups. In Estonia, the majority of respondents expressed confidence: 80% of those aged 18–24 and 75% of those aged 25–30 reported feeling "prepared" or "very prepared" to participate in AI-driven recruitment, such as taking an AI-scored assessment or interacting with automated chatbots. In Lithuania, the proportions were slightly lower, with 70% of the younger group and 68% of the older group feeling ready. Latvian youth were the least confident, as only 62% of respondents aged 18–24 and 58% of those aged 25–30 described themselves as prepared for such processes.

The pattern across all three countries suggests that younger respondents (18–24) consistently feel more at ease with AI in recruitment than those aged 25–30, which is consistent with the notion that recent graduates and university students are more familiar with new technologies in daily life and education (Hekkala & Hekkala, 2021; Asif, 2024). Estonia's results, in particular, may be influenced by the greater integration of AI tools in their education system and public services, as documented in national digital transformation reports (Liutkevicius & Yahia, 2022).

These findings align with trends observed in broader European studies (Azzolini & Schizzerotto, 2017; Labudová & Fodranova, 2024; Vasilescu, Șerban, Dimian, Aceleanu, & Picatoste, 2020), where younger digital natives display higher confidence in technology-mediated environments. However, the gap between Estonia and Latvia highlights the ongoing digital skill divide in the region (Caravella, Cirillo, Crespi, Guarascio, & Menghini, 2023; Natalia, 2024; Soshynska & Soshynska, 2020).

Table 2 provides a summary of the main survey indicators that illustrate key dimensions of youth readiness for AI-driven HR practices across Estonia, Lithuania, and Latvia. The table highlights comparative measures, including levels of awareness about AI in recruitment, perceived benefits, concerns about risks, willingness to engage with AI tools in hiring, and preferences regarding human involvement in the final decision-making process.

Table 2

Simulated Survey Findings – Comparative Metrics by Country

Survey Item	Estonia	Lithuania	Latvia
Aware of AI use in recruitment (heard of at least one AI tool)	90%	80%	70%
Believe AI can improve diversity/fairness in hiring	65%	55%	45%
Concerned about AI causing bias or privacy invasion	50%	55%	60%
Comfortable taking an AI-administered interview or test	78%	70%	60%
Prefer final hiring decisions be made with human oversight	85%	90%	95%

Note: All figures indicate the percentage of respondents who answered in the affirmative ("yes" or "agree/strongly agree"). The data are based on the 2025 HR Line EU survey of youth in the Baltic states. "Human oversight" refers to the preference for final hiring decisions to involve human review, even if AI tools are used during the assessment process.

Source: Developed by the authors

As shown in Table 2, Estonian youth demonstrate both higher awareness of AI applications in recruitment and greater comfort with AI-mediated assessments. Furthermore, nearly two-thirds of Estonian respondents see the potential for AI to enhance diversity and fairness in hiring. By contrast, Latvian youth exhibit greater concern regarding the risks of bias and privacy invasion (60%) and express the strongest preference for human involvement in recruitment outcomes (95%). Lithuanian youth are positioned between their Estonian and Latvian peers, expressing moderate optimism about the advantages of AI in recruitment while simultaneously exhibiting caution about its potential risks.

A noteworthy finding is the high level of consensus across all three countries that, while AI systems can improve efficiency and objectivity, the majority of youth believe that human oversight remains essential in hiring decisions. This supports the broader view identified in recent European and international studies that youth prefer a hybrid model, where AI augments rather than replaces human judgment in HR processes (Parul & Alok, 2025; Gonzalez et al., 2022; Will, Krpan, & Lordan, 2022).

Qualitative Insights. The interviews provided essential context for the quantitative findings. In Estonia, participants expressed high levels of trust in digital systems and described the integration of AI in HR as a natural progression from the country's established e-services. A number of Estonian respondents indicated enthusiasm for AI-driven recruitment, viewing it as an opportunity for further innovation in the labour market. Importantly, several also raised concerns about digital exclusion, noting that individuals with limited digital skills, such as older adults or those from rural areas, could encounter new barriers as AI becomes more prevalent in recruitment.

Lithuanian youth demonstrated a pragmatic yet optimistic stance. They welcomed the efficiency and objectivity AI could offer, but emphasized the necessity of transparency and procedural fairness. Participants repeatedly called for clear communication from employers about how AI is used in hiring and requested mechanisms to explain or contest automated decisions. This reflects a broader desire for accountability and aligns with recommendations in the literature regarding AI transparency in recruitment (Xiong & Kim, 2025; Jamal, Aissaoui, & Kassal, 2024; Musrifah & Hasanah, 2025).

Latvian respondents, by contrast, demonstrated greater skepticism and apprehension. Many cited lower confidence in their digital skills and expressed concerns that the introduction of AI in hiring might create a more impersonal process or exacerbate existing inequalities. Some feared that greater reliance on technology could marginalize those less technologically adept or reinforce perceived barriers to employment. Nevertheless, a subset of participants recognized potential benefits of AI, particularly in reducing nepotism or bias in public sector recruitment.

In summary, the qualitative data reveal clear distinctions in attitudes and readiness among Baltic youth. Estonian participants emerged as the most confident and future-oriented; Lithuanians combined openness with a strong demand for transparency and procedural justice; Latvians remained cautious, highlighting both skill gaps and cultural reservations. Across all countries, participants underscored the importance of maintaining human oversight in recruitment, even as AI adoption increases. These findings reinforce the quantitative results and confirm that, while enthusiasm for AI exists, support is contingent on demonstrated fairness, transparency, and the preservation of human involvement.

Discussion. This study examined the preparedness of Baltic youth for participation in AI-driven HR and recruitment practices. Empirical results both corroborate and extend real-world trends, yielding insights of scholarly and practical importance. The findings demonstrate that readiness is unevenly distributed across countries and demographic groups, with certain segments displaying high levels while significant gaps remain in others. In interpreting these results, the discussion draws upon existing literature and analyzes implications for key stakeholders, including youth, employers, educators, and policymakers. The section also presents targeted recommendations and directions for further research.

Country Differences and Digital Context. The results reveal clear differences in youth readiness for AI-driven HR among the Baltic states. Estonian youth consistently demonstrate the highest digital com-

petence and confidence with AI, reflecting the country's sustained investment in ICT education and widespread use of digital government services. Most Estonian participants expressed both preparedness for and trust in AI-based recruitment, with about 80% reporting that they feel ready to engage with these tools. In Lithuania, readiness levels are moderate and attitudes toward AI remain positive, though accompanied by greater caution. Lithuanian youth benefit from recent improvements in digital education and a growing tech sector, which may help narrow the gap with Estonia in the future. Latvian youth, however, show the lowest digital skills and the highest levels of skepticism toward AI in HR. Many Latvian respondents emphasized a need for human involvement in hiring decisions and reported less exposure to digital innovations in education and daily life. These findings suggest that national digital strategies and the degree of technology integration in society play a significant role in shaping how prepared and confident young people are to navigate AI-mediated recruitment (Schiff, 2021; Holmström, 2021).

Youth Attitudes – Parallels with Global Studies. Empirical findings indicate that Baltic youth attitudes toward AI in HR closely reflect patterns observed in international studies. Across Estonia, Latvia, and Lithuania, young people exhibit cautious optimism: they recognize AI's potential to make recruitment faster and more efficient, but consistently voice concerns about its limitations and risks. These results align with recent surveys of European job applicants and studies of German Gen Z, which found that, globally, youth appreciate functional benefits like prompt feedback and reduced human bias, yet remain wary of the technology's lack of nuanced judgment and potential for error (Horodyski, 2023; Talay et al., 2023).

For example, participants in the interviews frequently cited faster communication as a major advantage, echoing the emphasis on speed and efficiency highlighted in prior research (Majumder & Mondal, 2021; Pereira, Hadjielias, Christofi, & Vrontis, 2021). However, concerns about the lack of "human touch" were pervasive, particularly among Latvian youth, who were the least confident in AI's ability to fairly evaluate candidates. This wariness is consistent with recent literature describing "dehumanization by algorithm," where candidates fear being reduced to data points rather than recognized for their unique qualities (Fritts & Cabrera, 2021; Schultz, Clegg, Hofstetter, & Seele, 2024).

This emphasis on transparency and the need for human involvement aligns with broader research on AI acceptance, which underscores the importance of explainability and accountability in fostering trust in AI-driven recruitment (Rigotti & Fosch-Villaronga, 2024; Jamal, Aissaoui, & Kassal, 2024; Chen, 2023). Current European policy developments echo these findings, as regulations increasingly require high-risk AI systems, such as those in hiring, to provide clear explanations for decisions and ensure human oversight (Nannini, Alonso-Moral, Catalá, Lama, & Barro, 2024). The views expressed by Baltic youth in this research provide direct empirical support for these regulatory trends.

Finally, the results underscore strong support for a human-AI hybrid approach in hiring. A clear majority of youth preferred that AI serve as an assistive tool rather than an autonomous decision-maker, in line with current HR technology best practices (Parul & Alok, 2025; Peng, Nushi, Kıcıman, Inkpen, & Kamar, 2022). This "augmented HR" model (Prikshat, Malik, & Budhwar, 2021; Prikshat, Islam, Patel, Malik, Budhwar, & Gupta, 2023) was viewed as a way to maximize AI's efficiency while retaining the empathy and judgment of human professionals.

Implications for Stakeholders. The insights from this comparative study carry several implications:

1. For Youth (Job Seekers). The present study highlights a significant need for digital upskilling and AI literacy among Baltic youth, with particular urgency in Latvia. While many young people express confidence, a notable portion in Latvia and Lithuania report feeling unprepared for AI-mediated hiring. Embedding practical AI training into university and vocational programs – such as modules on applicant tracking systems or AI-based interviews – is supported by recent research, which highlights the growing prevalence of AI in recruitment and the need for both competence and confidence among job seekers (Hunkenschroer & Luetge, 2022; Suen, Hung, & Lin, 2019; Cui, Chen, & Huang, 2025). However, even in digitally advanced Estonia, ongoing learning is necessary as AI

technologies rapidly evolve. Finally, it is essential that young people are informed of their rights in AI-driven recruitment, including the EU provision for human review of automated decisions. Most participants indicated a lack of awareness regarding this right.

2. For Employers and HR Professionals. Organizations in the Baltics that implement AI in recruitment must recognize the range of youth attitudes, from trust to skepticism, especially in Latvia. Transparent communication about the use of AI in hiring processes can help build trust among younger applicants. Companies should clearly state how AI is used and how human oversight is maintained. Providing detailed feedback to candidates is also important, as many young people criticize the lack of clarity in recruitment outcomes, regardless of whether AI is used. Advanced AI systems can generate feedback, such as identifying missing skills, which helps candidates improve and demonstrates responsible use of technology. Employers should ensure that HR staff are trained to critically assess AI outputs and to provide the human element that applicants value. Literature supports developing hybrid HR competencies that blend analytical skills for AI management with the emotional intelligence necessary for fair decision-making (La Sala, Fuller, Riolli, & Temperini, 2024; Tabor-Błażewicz, 2022; McCartney, Murphy, & McCarthy, 2020). Regular training and critical engagement with AI systems will help organizations both use these tools effectively and maintain applicant trust.

3. For Educators and Policy Makers. The study highlights the importance of embedding digital and AI skills into youth development strategies. Latvia, for example, has set a national target of 70% basic digital skills by 2027, underscoring the need for policy interventions to close existing gaps (Pelše & Leščevica, 2020; Cāne, 2021). Achieving such targets will have direct consequences for employment readiness among young people. Updating educational curricula to address AI in the workplace, for example, by incorporating simulations of AI-based recruitment into school and university career guidance programs, can help students build both confidence and competence. Regional cooperation could further accelerate progress: Estonia's advances in digital literacy serve as a model for Latvia and Lithuania. Although cross-border initiatives already exist in the Baltic and Nordic regions, greater emphasis should be placed on youth involvement and knowledge exchange. As the EU AI Act is implemented in the coming years, governments need to inform young citizens about new safeguards and the right to human review of automated hiring. Policymakers should also encourage practical learning, supporting hackathons, workshops, and digital labs that give youth hands-on experience with AI tools, preparing them as both job seekers and future contributors to AI innovation.

Several limitations should be considered when interpreting the findings of this study. Focusing exclusively on Baltic youth aged 18–30 provides valuable insights into this demographic's readiness for AI in HR, but it also introduces several limitations. Research in AI-enabled recruitment emphasizes the importance of including broader perspectives, such as those of employers, HR professionals, and older workers, to fully understand the adoption and impact of AI in HR practices (França, Mamede, Barroso, & Santos, 2023; Budhwar, Malik, Thedushika, Silva, & Thevisuthan, 2022). Studies also highlight that factors like language proficiency, international aspirations, and unique cultural or economic contexts can significantly influence attitudes toward AI-driven hiring, yet these are often underexplored in youth-focused research (Chen, 2023). Additionally, cross-national studies may overlook country-specific variables that shape perceptions and readiness for AI, underscoring the need for more nuanced, multi-stakeholder approaches (Charlwood & Guenole, 2022). Future research is recommended to address these gaps by incorporating diverse age groups, professional backgrounds, and socio-demographic factors, as well as by examining the organizational and societal dimensions of AI adoption in HR. This broader approach would help build a more comprehensive and actionable understanding of digital and AI readiness in the workforce.

Recommendations. Building on the empirical evidence from this comparative study, several targeted recommendations are proposed to advance youth readiness for AI-driven HR practices in the Baltic region.

1. Integrate AI and Digital Skills into Education Systems. Educational institutions across Estonia, Latvia, and Lithuania should systematically embed AI literacy and digital employability modules within school and university curricula. Career development programs should instruct students on the mechanics of algorithmic recruitment, including how to optimize application materials for AI screening and how to prepare for automated interviews. Estonia's successful digital education initiatives could serve as a model, informing curricular reforms in Latvia and Lithuania to bridge persistent skills gaps.

2. Engage Youth in Policy Development. Policy makers and civil society organizations should ensure that youth perspectives are actively represented in the formulation of national and regional AI strategies. This could be achieved through the establishment of youth advisory boards, consultation exercises, and participatory formats such as hackathons and focus groups. Incorporating the concerns and priorities identified in this study, especially those related to privacy, fairness, and access, will foster more responsive and effective policy interventions.

3. Promote Transparency and Feedback in Recruitment Processes. Employers, particularly large firms and multinational corporations operating in the Baltic states, should adopt transparent recruitment practices when deploying AI tools. Providing candidates with clear information about the use of AI in selection processes, as well as individualized feedback generated by these systems, can significantly improve trust and candidate experience. Explicitly communicating the role of both AI and human oversight in hiring decisions is likely to address skepticism and increase applicant confidence, as indicated by participant feedback.

4. Prioritize Digital Empowerment in Latvia. Given Latvia's comparatively lower digital readiness among youth, a focused national initiative to accelerate digital skills acquisition and AI literacy is recommended. This could involve the expansion of government- or EU-funded online courses, targeted outreach to NEET youth, and practical workshops on AI-based hiring methods. Although Lithuania is more advanced, further initiatives aimed at advanced digital skills and innovation would also support alignment with EU digitalization targets.

5. Foster Local Innovation and Language Inclusivity in AI Tools. To ensure equitable opportunities, the Baltic tech sector should prioritize the development of AI recruitment tools that are fully adapted to local linguistic and cultural contexts. The importance of fairness and transparency in AI systems emerges as a key theme, suggesting that future HR technologies should incorporate explainable AI features and robust multi-language support to prevent inadvertent discrimination against local candidates. Involving youth in the co-design and testing of such systems will ensure their relevance and user-friendliness.

By implementing these recommendations, stakeholders across education, policy, and business can collectively foster an environment in which Baltic youth are fully equipped, both technically and attitudinally, to navigate and shape the future of AI-mediated employment.

Conclusion. This empirical study assessed the readiness of youth in Estonia, Latvia, and Lithuania to engage with AI-driven HR and recruitment practices, providing a comparative analysis across digital skills, awareness, attitudes, and perceived risks. The results confirm that Baltic youth are adapting to digital transformation in HR, but substantial disparities remain between countries and subgroups. Estonian youth stand out for their robust digital skills and confidence in AI-assisted recruitment, reflecting sustained national investment in digital education and infrastructure. Lithuanian youth also demonstrate solid preparedness, yet their responses highlight an emphasis on transparency and ethical safeguards in AI use. In contrast, Latvian youth report greater skill gaps and more prevalent skepticism, underlining the need for targeted digital upskilling and awareness initiatives.

Across all three Baltic states, young people recognize the efficiency and objectivity that AI can bring to hiring. At the same time, they express a strong preference for maintaining human oversight in recruitment processes and voice concerns related to fairness, data privacy, and the risk of deper-

sonalization. These attitudes are consistent with global trends and underscore that successful implementation of AI in HR depends on transparent practices, clear communication, and education that empowers applicants to navigate algorithmic systems with confidence.

"Youth readiness" for AI-driven recruitment emerges as a multifaceted concept shaped not only by technical skills, but also by trust, perceived agency, and knowledge of rights. Addressing these multidimensional factors through educational reform, policy measures, and employer engagement will be essential as the Baltic states continue to modernize their economies and labour markets. The experience of Estonia, Latvia, and Lithuania offers valuable lessons for other regions facing similar challenges at the intersection of youth employment and digital innovation.

In summary, fostering both the technical and attitudinal preparedness of young people will determine whether AI in HR acts as a force for inclusion and opportunity, or exacerbates existing divides. With ongoing investment in education, policy alignment, and human-centered implementation, the Baltic states are well-positioned to set a benchmark for responsible and equitable integration of AI in recruitment.

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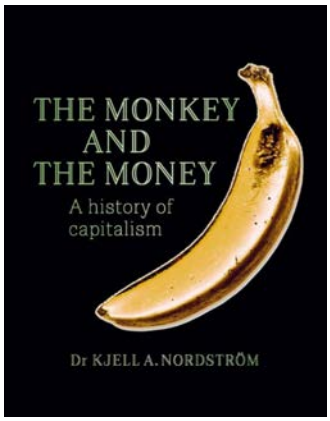
BOOK OVERVIEW

In this journal issue, we continue our tradition of introducing books that have enriched us over the current and previous year. Several authors are renowned for their earlier works; therefore, we have structured this review to combine one or two publications while maintaining our core recommendations for each reviewed book.

This year, we wish to recommend works by famous bankers and equally well-known futurologists who emphasize research on AI and the digital economy, examination of fundamental economic theories, and investment guidance from industry leaders.

We introduce these recommendations through Cicero's famous quotation: "**A house without books is like a body without a soul".**



KJELL. A. NORDSTROM
THE MONKEY AND THE MONEY. A HISTORY OF CAPITALISM.
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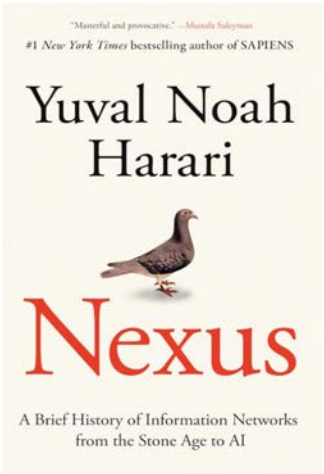
Kjell Nordström is a renowned Swedish economist, scholar, futurologist, and brilliant lecturer. His works "Funky Business," "Karaoke Capitalism," and "Urban Express" are widely recognized. In our previous issue, we provided detailed coverage of his work "Momentum: From Crises to Opportunity."

In the current issue, we recommend a book that can be of high interest: **The Monkey and Money: A History of Capitalism**.

In a vivid, perhaps even provocative manner, the author traces capitalism's history back to monkeys exchanging objects (precursors to a barter economy). He analyses modern economics with its vulnerabilities and challenges (the COVID-19 pandemic, armed conflicts of the 21st century) alongside its prospects driven by human development and ingenuity.

Readers familiar with the author's work and his ideas of being responsible for the planet will appreciate his references to ecology as "key capital" of the 21st century.



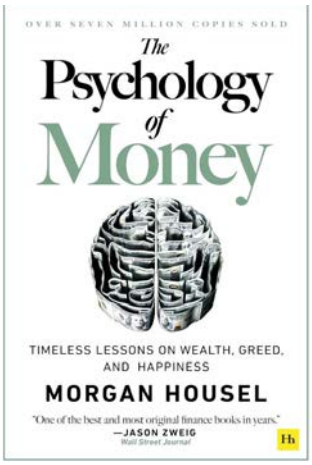
YUVAL NOAH HARARI
NEXUS. A BRIEF HISTORY OF INFORMATION NETWORKS FROM THE STONE AGE TO AI
Publisher: ⁋Random House
Publication date: ⁋September 10, 2024
Language: ⁋English
Print length: ⁋528 pages
ISBN-10: ⁋059373422X
ISBN-13: ⁋978-0593734223

Yuval Noah Harari is a historian, public intellectual, who has delighted readers with widely discussed and engaging books including "Sapiens: A Brief History of Humankind," "Homo Deus: A Brief History of Tomorrow," and "21 Lessons for the 21st Century."

In this review, we recommend the author's recent work: **"Nexus: A Brief History of Information Networks from the Stone Age to AI"**.

Employing his characteristically concise, vivid, and engaging prose, the author analyses AI with its associated risks and prospects. Readers are invited on a historical journey through "information networks" from ancient times to the 21st-century world. "Intersubjective reality"–a conditional space formed through information connections and universally accepted myths–serves as the operational framework for individuals, corporations, states, and monetary systems. Notably, information need not always be truthful; rather, it must facilitate social and governmental order and governance.

Through analysis of computer algorithms, the internet, and social networks, machines become autonomous agents capable of generating ideas and influencing reality. While demonstrating such risks, the author emphasizes the importance of supporting rather than manipulating humanity within the world of information networks and connections.

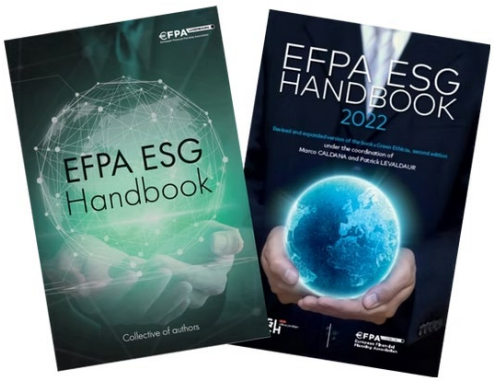


MORGAN HOUSEL
THE PSYHOLOGY OF MONEY. TIMELESS LESSONS ON WEALTH, GREED AND HAPPINESS
Publisher: ⁋Harriman House
Publication date: ⁋September 8, 2020
Language: ⁋English
Print length: ⁋256 pages
ISBN-10: ⁋0857197681
ISBN-13: ⁋978-0857197689

This book teaches conscious financial management based on developing and managing one's habits and expectations as an investor, - "soft skills." While not a textbook on investment, it can be characterized as a guide to financial literacy and financial wisdom.

Like any work built on practical case studies, it makes engaging reading. Throughout the book, the author emphasizes that each investor develops their own financial strategy based on unique life and professional experience. What proves useful and applicable for one investor may be entirely irrational for another, and vice versa.

This book substantially enriches any library of behavioral finance enthusiasts and those interested in behavioral approaches to investing and investment strategy development.



EUROPEAN FINANCIAL PLANNING ASSOCIATION (EFPA) ESG HADBOOK
Publisher: ⁋Publishroom
Publication date: ⁋2022, 2024
Language: ⁋English
ISBN: 978-2919814374
ISBN: 978-2386251061

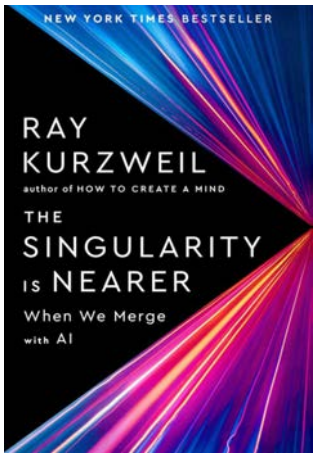
Responsible investment and ESG business practices have been actively gaining adherents since the beginning of the previous decade. With support from Generations Y and Z, who inherited substantial wealth, unprecedented pressure was placed on the asset management industry, fundamentally transforming the Private Banking & Wealth Management sector over the decade. This movement has been vigorously supported by both

the banking system and businesses. The ESG approach has complemented the UN's sustainable development goals and principles.

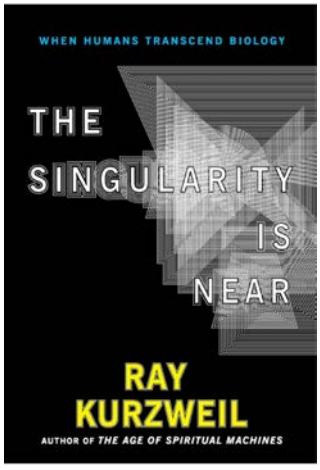
Among the principal challenges have been, and remain, aspects of legal regulation and international coordination. Despite the United States' complicated relationship with the Kyoto Protocol (withdrawal upon the new administration's arrival in 2025) and China's lack of ratification, intensive work continues within the EU.

The ESG practice developed presented here were developed by experts under the patronage of the European Financial Planning Association EFPA (over 70 authors from 50 institutions). They cover ESG definitions, historical context, EU regulatory frameworks, current financial instruments, and corporate ESG strategies.

The books are rich in practical case studies for successful EFPA ESG Advisor certification and, what is more important, have been updated annually with modern relevant cases and additions.



RAY KURZWEIL
THE SINGULARITY IS NEARER. WHEN WE MERGE WITH AI
Publisher: ⁋Viking
Publication date: ⁋June 25, 2024
Language: ⁋English
Print length : 432 pages
ISBN-13: ⁋978-0399562778



Raymond Kurzweil serves as Chief Technical Officer at Google–a scientist, a professional entrepreneur, a futurologist, and inventor, named as a "restless genius" by The Wall Street Journal.

"The Singularity Is Nearer: When We Merge with AI" continues the author's earlier work "The Singularity Is Near. When Humans Transcend Biology" (2005). Kurzweil advances his theory of technological singularity: rapidly accelerating scientific and technological progress culminating in artificial intelligence surpassing human intelligence.

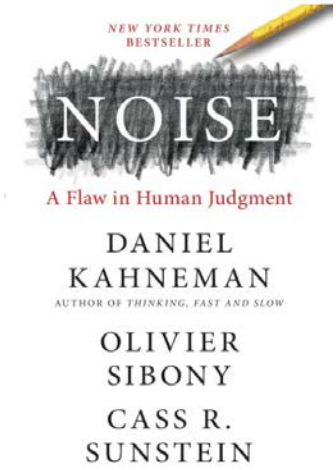
Kurzweil predicts the singularity will occur by 2045.

In this new book, the author is considering the developments that have taken place over the past twenty years: AI progress in medicine, increased human life expectancy and quality of life, and the emergence of solutions enhancing human productivity such as ChatGPT.

A distinguishing characteristic of almost all Kurzweil's works is their positive and optimistic perspective on emerging changes: AI already actively transforms human life, and the foreseeable future integration of humans and machines will unlock previously unimaginable prospects. This represents, in a sense, a manifesto of techno-optimism.

We note the author's predictive timeline:

- AI will reach human-level capability by 2029
- Technological singularity (AI outranking human capabilities) will be achieved by 2045



DANIEL KAHNEMAN, OLIVER SIBONY, CASS R. SUNSTEIN
NOISE. AFLAW IN HUMAN JUDGMENT
Publisher: Little, Brown Spark
Publication date: May 18, 2021
Language: English
Print length: 464 pages
ISBN-10 : 0316451401
ISBN-13 : 978-0316451406

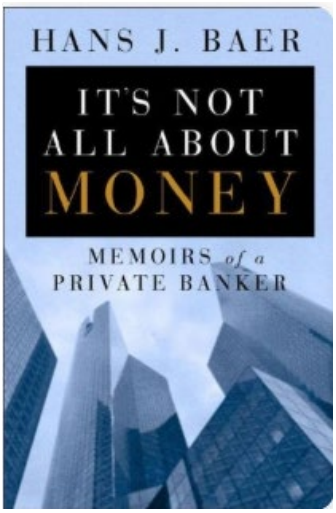
This author gained widespread recognition among readers with his book **"Thinking, Fast and Slow"**, in which he examined systematic cognitive biases in human thinking.

His book **"NOISE: A Flaw in Human Judgment"** investigates how individuals or organizations make errors due to different perspectives on the identical tasks. This may involve the same person in different situations, or employees within the same organization, or business partners.

The author introduces the concept of "noise"–variability in judgment where consistency should exist. Unlike bias, where judgments systematically shift toward an individual's preconceptions, noise lacks systematic patterns; it represents random, non-systematic errors.

Analyzing the harmful and critical consequences of "noise," the author recommends a comprehensive set of solutions ("decision hygiene") including standardization, algorithms, documented and agreed-upon criteria, and independent assessments.

The author's conclusion: reliable, validated decisions require systematic efforts against both biases and "noise." We recommend reading and utilizing both of this author's books.



HANS J. BAER
IT'S NOT ALL ABOUT MONEY. MEMOIRS OF A PRIVATE BANKER
Publisher: Beaufort Books
Publication date: April 7, 2008
Language: English
Print length: 528 pages
ISBN-10: 0825305470
ISBN-13: 978-0825305474

This author's name **BAER** appeals to any expert in Private Banking & Wealth Management: these are the memoirs of a professional who created one of the most renowned private banks, Julius Baer Group.

Sixty years of personal history, experience, ideas, and reflections from a private banker and top executive will become a source for thinking about morality and culture. War and the banking system from the perspective of responsible business conduct: interaction with the Volcker Commission, which investigated financial flows and restored abandoned assets of Holocaust victims.

Bankers are multifaceted; accordingly, the book contains numerous impressions and stories about politicians and scholars of the 20th and 21st centuries, along with passions for music and art.

Above analysis and reflections make this work in its own way, a Guide Book for every private banker or professional who sees his future in the banking profession.

KYRYLO SHEVCHENKO
COMMENTS FROM EXILE
Publisher: Dmytro Burago Publishing House
Publication date: 20024
Language: Ukrainian
Print length: 100 pages
ISBN: 978-966-489-695-2

This book, while not memoirs, represents excellent analytical literary reflection by a professional banker, infused with practical examples and statistical analysis.

Various pressing issues connected to political and economic events of 2023-2024 are addressed, along with professional responses: central bank independence; risks and stress testing of banks during wartime; CBDCs as a promising step for national finances; analysis of Israeli banks' actions at the initial stage of military operations in 2023.

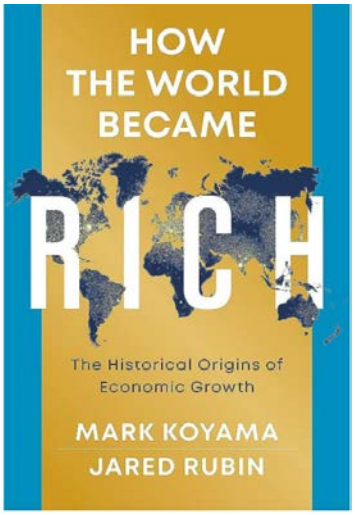
Taking into consideration the author's experience as a Governor of Ukraine's National Bank during 2020-2022, the book can be of serious interest.

ALEKSANDR KUD
INFORMATION-BASED ECONOMY EXPLAINED IN 90 SECONDS. The 50 most significant ideas and phenomena that can help everyone realize their full potential in modern times.
Publisher: Pravo Publishing House
Publication date: 2024
Language: English
Print length: 228 pages
ISBN: 978-617-8411-84-8

This book by a scientist and practitioner is structured as an accessible introduction to the digital economy's development history. It has an unusual but innovative structure, that people who are mindful of their time and efforts will really appreciate. Each section follows this format:

- Key message
- 30-second explanation
- Related theories
- Common myths
- Skills and expertise
- Why the phenomenon emerged
- Social transformations

"Quick, concise - encyclopedic, effective" represents the book's guiding principle.



MARK KOYAMA, JARED RUBIN
HOW THE WORLD BECAME RICH. YHE HISTORICAL ORIGINS OF ECONOMIC GROWTH
Publisher: Polity
Publication date: May 23, 2022
Language: English
Print length: 240 pages
ISBN-10: 1509540237
ISBN-13: 978-1509540235

This excellent work provides a concise yet comprehensive overview of contemporary theories in economic history, explaining the process of "the great enrichment"–the explosive growth in living standards worldwide over the past two centuries. Some critics characterize the book as "a distinctive guide to modern economic history."

Five fundamental factors are identified and analyzed: culture and ideas; geography (climate, access to seas and rivers); institutions (property rights, legal protection and enforcement); demography; colonialism and global interactions.

Through their research, the book leads us to this conclusion: no single magic factor exists. The history of humanity and each individual nation represents the complex historical interaction of all analyzed factors.

The above work can be interesting for the economists and scientists, as it provides real historic research

RUSLAN YUSUFOV
Scenarios of the Future: How to Live and Work in a World Taken Over by Neural Networks and Robots
Publisher: Eksmo
Publication date: 2024
Language: Russian
Print length: 384 pages
ISBN: 978- 5042132155

This renowned analyst and futurologist-researcher proposes examining forecasts of possible "tomorrows" from the perspective of changes introduced by Industry 4.0 and Industry 5.0: which functions will remain human, and what will become the domain of AI and robots.

The author analyses questions of risk and ethics regarding potential human cyberization: aspects of microchipping and systematic control (loss or limitation of personal freedom versus control and crime reduction). Is the development of such technologies a gift or punishment for humanity?

Readers will have the opportunity to evaluate the situation through three basic scenarios:

- Preservation of humanity as the center, with technology accountable to human life and work rhythms
- AI and robotization displacing humans (with only high-technology or physical low-wage work remaining for humans)
- Symbiosis of AI and humanity

The review was prepared by the editor of the special issue of the Journal Alexey Aleksandrov, Professor of the Baltic International Academy

INFORMATION FOR AUTHORS

"Baltic Journal of Legal and Social Sciences" publishes articles in English. The theme of the article should be disclosed in a clear, logical and well reasoned way.

The requirements to the structure and the layout of articles are the following:

• The size of the submitted article, including the bibliography, should be within 20,000–70,000 characters with spaces. The article is presented in Microsoft Word, paper size – A4, margins along the edges of the page – 20 mm on each side.

• The text of the article: font Times New Roman; font size 12 pt; line spacing 1,5, the first line of each paragraph with indentation 1.5 mm.

• Components of the articles should be laid out as follows:

1. the title of the article is written in capital letters (font Times New Roman, font size 12 pt, Bold, Center);

2. Information about the author (font Times New Roman, font size 12 pt, Bold, Center): the name and surname of the author(s), their scientific and academic degree, position and place of work (for postgraduate and doctoral students the full name of the university, the name of departments not specified);

3. the abstract should be in the range of 6–7 sentences, and describe the main ideas of the article (font Times New Roman, font size 12 pt);

4. after the abstract the key words (5–6) follow, which are the most important concepts discussed in the article and related to the theme (font Times New Roman, font size 12 pt).

• The article should have the following basic structural parts consecutively emphasized in the text: the statement of the problem, its relevance / importance, the analysis of recent publications on the subject of the article, the purpose of the research conducted by the author, main findings, conclusions, and the list of references. The titles of the structural elements, as well as parts of the article, in the case of their designation by the author, should be marked in bold.

• The bibliographic list of regulations, normative acts and references to literary sources is placed at the end of the article with the use of the numbering arrangement starting with the first reference to the source of information in the main body of the text (font Times New Roman, font size 12 pt).

• Illustrations, tables, figures, created by means of MS Office and MS Visio should be located within the working area of a page. Figures created in other programs are inserted into the text at the appropriate place and attached to the article in separate files in .jpeg, .tiff, .pdf, or .psd. Figures in .jpeg and .tiff should have a resolution not less than 300 pixels / inch. All graphic materials inside the articles should be in black and white.

• *Sample for the design of articles in journals:*

Johnson A., Schwartz H. (2021) Comparative analysis of political participation in Latvia and Estonia. – Baltic Journal of Legal and Social Sciences. No 1(20). pp. 59–81.

• *Sample for the design of articles in collections of scientific articles and monographs:*

Tajfel H., Turner J. C. (1979) An integrative theory of intergroup conflict. – W. G. Austin, S. Worchel (eds.) The social psychology of intergroup relations. Monterey, CA: Brooks-Cole. pp. 33–48.

• *Sample for the design of a monograph:*

Rothschild J. (1981) Ethnopolitics. A Conceptual Framework. New York:
Columbia University Press.

• *Sample for the design of articles on the Internet:*

Petričušić A. (2005) The Rights of Minorities in International Law: Tracing Developments in Normative Arrangements of International Organizations. – Croatian International Relations Review. Vol. XI No. 38/39. http://bib.irb.hr/datoteka/421246.

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Articles for publication are e-mailed to the address: bjlss@cuesc.org.ua

All articles are subject to reviewing by the Editorial Board, which is entitled to perform a literary editing of submitted texts.

The Editorial Board has the right to reject articles submitted for publication in violation of these requirements.

NOTES

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