The Perspectives of the Implementation of a CBDC-system
in the Republic of Belarus

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Introduction

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Introduction

A new round of technological revolution has changed the architecture of the payment system beyond recognition. The use of digital communication channels for the transfer of funds has ceased to be a privilege of banking institutions. International payment systems (hereinafter — IPS) and other information intermediaries have formed the image of today's value transfer model. For three decades, the foundation of the banking infrastructure has supported the positions of conventional players, which in turn made it possible to achieve relatively high efficiency of the settlement system while simultaneously creating dependencies that have not been overcome even by modern information technology giants.

The status quo was disrupted by the advent of blockchain technology, which conceptually changed the approach to the financial intermediation system[1]. It was no coincidence that the first practical implementation of the blockchain system found its application in the field of digital currency. The bitcoin protocol initially had a significant ideological content and was positioned by its creator, Satoshi Nakamoto, as a new alternative to the existing value transfer system[2]. Blockchain systems imply the construction of a collective management model of the accounting system, where participants' motivation to maintain the correctness of accounting will be provided by internal economic incentives implemented through the tools of the software protocol[3].
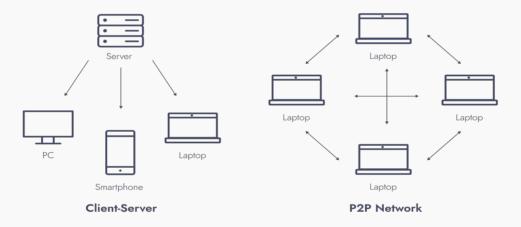

Figure 1 - Difference between Client-Server and P2P DLT networks

Consortium-type business models suppose a more rigid organizational consensus, which complements economic incentives with local regulatory rules. To meet the requests of numerous global and local consortia, distributed ledger system technologies have been actively developed since 2015 (hereinafter — DLT)[4].

1. How Blockchain Will Replace Banks and Intermediaries - URL: https://toplead.com.ua/ru/blog/id/kak-blockchain-zamenit-banki-i-torgovyh-posrednikov-140/ (accessed on 22.09.2021).
2. The idea of Bitcoin in 2008 and the results: why Bitcoin was not ready to become the new money - URL: https://habr.com/ru/company/moneypipe/blog/530952 / (accessed on 22.09.2021)
3."Consensus algorithms": Share confirmation and proof of work - URL: https://habr.com/ru/company/bitfury/blog/327468 (accessed on 22.09.2021).
4.History of blockchain technology - Chronology - URL: https://101blockchains.com/ru/история-технологии-блокчейн (accessed on 22.09.2021).

Introduction

DLT systems include key features of blockchain systems and can be considered a broader generic class of technologies compared to consensus systems.

Several DLT systems differ from classical blockchain systems in that they do not imply the construction of a pure economic consensus but are designed to be managed through administrative bodies guided by numerous organizational regulations.
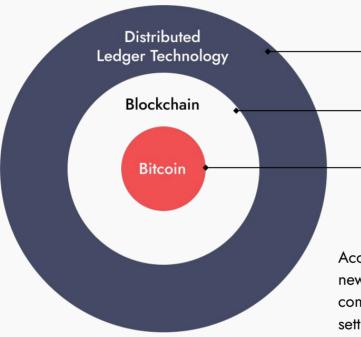
Figure 2 - Structure of DLT

Further development of blockchain systems has demonstrated the impossibility of completely replacing the system of national currencies accounted for in bank accounts. However, technological solutions in the field of collective consensus, as well as the practice of creating communities for protocol management, have pushed regulators to consider a new type of payment system - central bank digital currencies (hereinafter— CBDC).

According to several experts, CBDC is a new generation of value carriers that combines more effective control over the settlement system with the benefits of a cashless system[5]. There is currently no single commonly used definition of CBDC. As a rule, CBDC is an electronic unit of value issued by the monetary regulator in the form of the national currency that performs the role of a legal tender.

5.Central bank digital currency and the future of monetary policy. - URL: https://voxeu.org/article/benefits-central-bank-digital-currency (accessed on 22.09.2021).

Introduction

The institutional design of CBDC can be as close as possible to existing payment systems. CBDC, as a product, does not aim to significantly modify the concept of a mean of payment while retaining the bulk of the design characteristics of traditional non-cash payments.

The most notable difference between DLT-based CBDC and non-cash monetary assets is in software protocol management, which entails the existence of a single information system to which numerous interested financial firms have conditionally open access.

Table 1 - difference between DLT-based CBDC and non-cash monetary assets

	CBDC	**Cash**	Non-cash monetary assets	**Cryptocurrencies**
Objective form	Record in the DLT or record in the centralized database	**Banknote**	Record in the database	**Record in the DLT**
Personalization	Personalized or to bearer	**To bearer**	Personalized	**To bearer**
Issuer	Central Bank and (or) financial institutions organizations	**Central bank**	Financial organizations	**Protocol of issuance based on the consensus of various persons**
Management	Centralized or collegial management	**Centralized management**	Centralized management	**Collegial management**
Mandatory means of payment	Yes	**Yes**	Yes	**No**[6]
Form of payment	Online and offline	**Offline**	Online	**Online and offline**
Price stability	Yes	**Yes**	Yes	**No**
Value measure	Yes	**Yes**	Yes	**No**
Means of accumulation and savings	Yes. Accrual of interest is possible	**Yes. Without interest accrua**	Yes. Accrual of interest is possible	**Yes. Without interest accrual**

6.The exception is El Salvador, which has given a special status to the bitcoin cryptocurrency.

Introduction

While having a competitive and sophisticated banking infrastructure, the Republic of Belarus faced the fundamental issue of the necessity of integrating CBDC into the national payment system. Without a thorough examination of the possibilities of the CBDC phenomena, the answer to this issue will be incomplete. However, analyzing the practices that may emerge as a result of a full-fledged CBDC launch is challenging owing to the fact that no state can confidently announce the functioning of a CBDC system at the production stage as of mid-2021. Consequently, the research group faced the problem of studying foreign implementation scenarios that can serve as a basis for concluding the relevance of the Belarusian CBDC system.

This context required focusing on methodological issues that would allow responsible state bodies and, above all, the National Bank of the Republic of Belarus (hereinafter — NB of the Republic of Belarus) to make a qualitative and balanced decision.

As a consequence of the research, a set of theoretical tools capable of simulating CBDC [7] **implementation scenarios was offered in a report on research work.**
It is expected that different stakeholder groups would be able to customize the CBDC system idea to meet their aims and objectives.

This report, in turn, contains the primary research work's assumptions and results, as well as several conclusions about the prospects for CBDC models implementation in the Republic of Belarus or other countries with similar macroeconomic and sociopolitical features.

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7. The full version of the report is available on the Internet resource https://cbdc.by/

Features of DLT systems in the context of implementation of CBDC systems

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Features of DLT-systems in the context of CBDC systems implementation

Despite the apparent benefits of speed, bandwidth, and customizability, centralized information systems have several drawbacks.

To begin with, such systems need the presence of trusted institutionalized intermediaries.

Secondly, centralized systems are especially vulnerable to cybersecurity threats: information might be lost or destroyed in the case of a hacker attack or natural disaster.

Decentralized systems are an alternate notion in which there is no "central" node in the network that has incentives for opportunistic behavior or is vulnerable to external attacks (Figure 3).
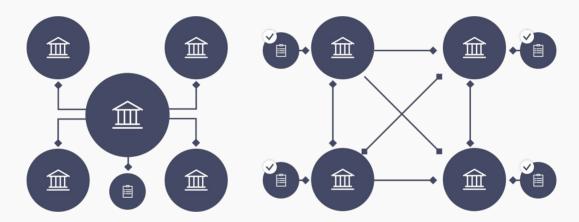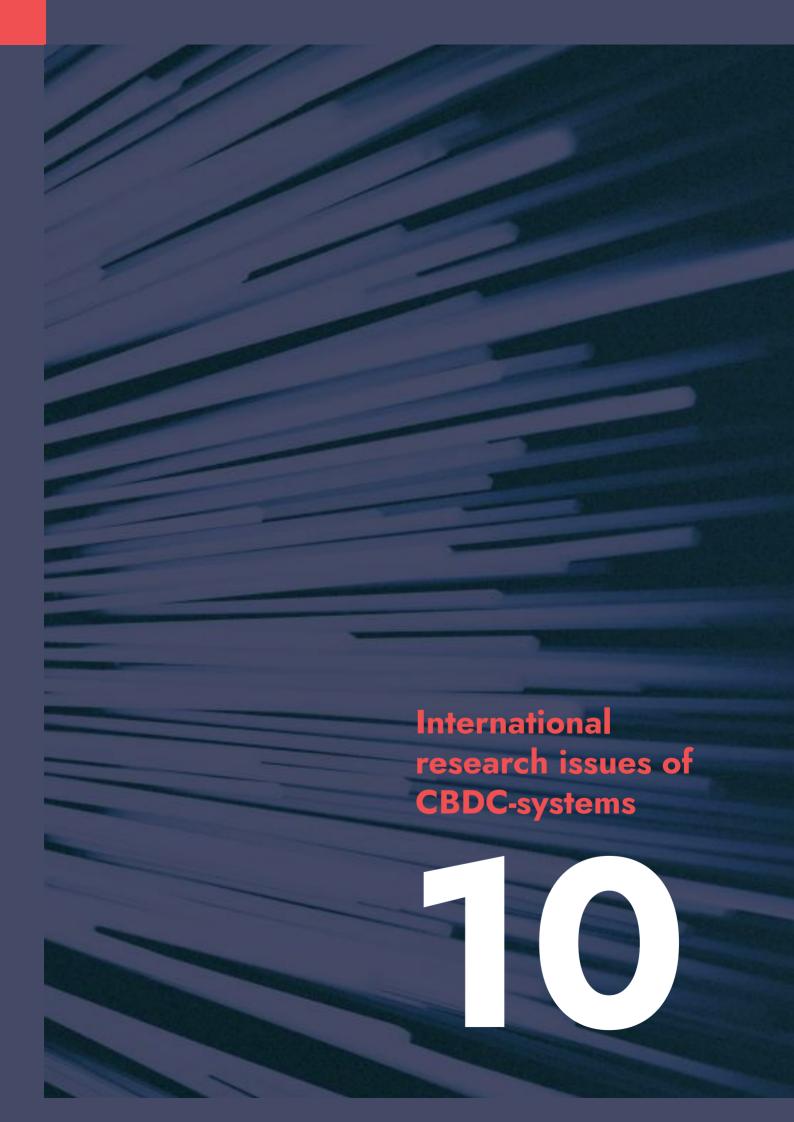

Figure 3 - Decentralized and centralized systems

The problem of the degree of centralization in the context of CBDC models implemented based on DLT is critical in the context of the management system. DLT protocols with varying degrees of centralization directly impact CBDC deployment scenario modeling.

In the context of establishing new institutions to manage a potential CBDC system, understanding the tools and models of DLT system management is critical. Because DLT systems have a unique technological architecture, their management models are constrained by the design. Collegial decision-making and the need for consensus validation of transactions presuppose the openness of the technological process[8]. The openness of the technological process can be expressed in open source code distributed under free licenses, procedures for accessing proposals for improving the ecosystem, etc.

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8. Atzori, M. Blockchain technology and decentralized governance: Is the state still necessary? // ResearchGate GmbH, 2008-2021.URL:https://www.researchgate.net/publication/315919685_Blockchain_technology_and_decentralized_governance_Is_the_state_still_necessary (accessed on:22.09.2021)

International research issues of CBDC-systems

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International research issues of CBDC-systems

For some years, central banks and research groups have been actively researching and developing experimental models of digital currencies. Since 2017, the concept of a digital national currency has gained traction. The reasons given were the need for national payment systems to be sovereignized, the introduction of more efficient transactional instruments in comparison to banking information systems, and the ability of central banks to manage monetary policy in real-time without the institutional mediation of banking organizations[9].

The central banks of many developed and developing countries, including the central banks of China, Europe, the USA, Canada, Russia, and Japan, are actively exploring the possibilities of introducing various design concepts of digital national currencies. At least 67 central banks have done or are undertaking their research and pilot studies to evaluate the feasibility of adopting or immediately establishing a CBDC by the beginning of 2021[10].

Despite the many different approaches to the implementation of CBDC, none of them can be interpreted as a universal model in relation to a specific payment system with a unique set of distinctive features. The adoption of foreign models to the framework of the Belarusian payment system has several issues:

1. Belarus' economy has a relatively low GDP and a limited range of external economic ties.
2. the Belarusian economy is marked by high inflation, high-interest rates, and a large share of foreign currency held in reserve[11]. This sets the National Bank of the Republic of Belarus's stance on inflation targeting and devaluation.
3. Third, most international studies ignore the backdrop of the banking market, which is highly concentrated[12].

Another significant flaw in the great majority of research is the absence of a qualitative portrayal of CBDC's full technological potential based on DLT. The adoption of smart contract technology is one of the most undervalued technological potentials.

9. Bech M., Garratt, R. Central bank cryptocurrencies. - URL: https://www.bis.org/publ/qtrpdf/r_qt1709f.htm (accessed on 27.01.2021).
10. Today's Central Bank Digital Currencies Status. - URL: https://cbdctracker.org/ (accessed on 27.01.2021).
11. The current monetary policy regime. — URL: http://www.nbrb.by/mp/target/current-mode (accessed on 25.02.2021).
12. Rating of banks in Belarus. - URL: https://myfin.by/banki/rating?Bank_sort=credit_amount.desc (accessed on 27.01.2021).

International research issues of CBDC-system

Many scenarios have become possible due to the introduction of smart contracts into the financial infrastructure. It allows digital currencies to gain the attribute of programmability, are not considered in existing research.

This is closely tied to the trend of using digital technology to automate financial procedures. The rise in the number of economic actors and scenarios of their interaction, as well as the necessity for more flexible sectoral economic management by state regulators, are among the major difficulties facing the modern economy. The financial system's ability to respond to these difficulties is put to the test. Solutions with great sensitivity and flexibility to multiple settings are required for operational support of these diverse types of economic activity.

To address these needs, the financial system must allow a wide range of vendors to participate in the development of financial applications while also maintaining overall management. Smart contracts, for example, are programmable components of a financial system that might assist solve scalability challenges. Still, they should be integrated into its architecture as first-class objects at the earliest design phases

The architecture of CBDC systems allows decision-makers to shift the paradigm of access to the digital money accounting layer. Banking institutions no longer have a natural monopoly on settlements that offer infrastructure for fintech services. The consortium supporting the DLT system provides organizational and technical assistance for fund accounting, while fintech businesses and banks enjoy conditionally open access to the infrastructure on equal terms.

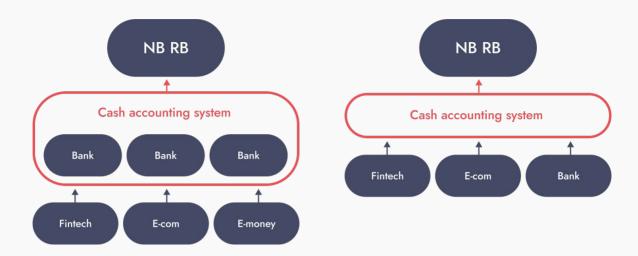## International research issues of CBDC-system

Figure 4 - Cash accounting system

Some studies draw attention to the risks associated with the expansion of the control of CBDC system owners over financial transactions, the downside of which is the narrowing of the zone for illegal financial transactions. This may be interpreted as an increase in public safety. In the future, detailed access to transactional data may enable greater legal analysis and administrative control in real-time. Furthermore, a greater economic effect can be achieved due to the increase in adaptability, addressability, and feedback reception speed of dititalized regulatory constraints.

These factors suggest that the digital transformation of the financial system of the Republic of Belarus requires a special research focus when taking into account the above features is put at the forefront. The creation of a single "optimal" solution for the implementation of the Belarusian CBDC would be a risky venture, given the vast number of sometimes conflicting needs and considerable uncertainty in this subject area. Scenario planning, which considers the diversity of the environment, goals, and means, is a more practical option.

Action-centric modeling - a tool for implementing CBDC scenarios

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Action-centric modelling - a tool for implementing CBDC scenarios

The Belarusian financial system's target transformation environment is made up of a variety of dynamic circumstances and activities. It is exceedingly time-intensive, if not impossible, to conduct a full examination of such a huge number of highly interconnected components. In such a setting, the applicability of classic decision-making approaches, such as linear programming appears to be exceedingly low. The authors of this research article present an approach that, in their opinion, strikes the optimal balance between application complexity and expense, as well as visibility and traceability of outcomes.

Action-centric modeling was created as a means to support decision-making in the conditions of:

1. a wide range of activities;

2. the uncertainty associated with it for interested parties;

3. the presence of strict resource constraints on the decision-making process.
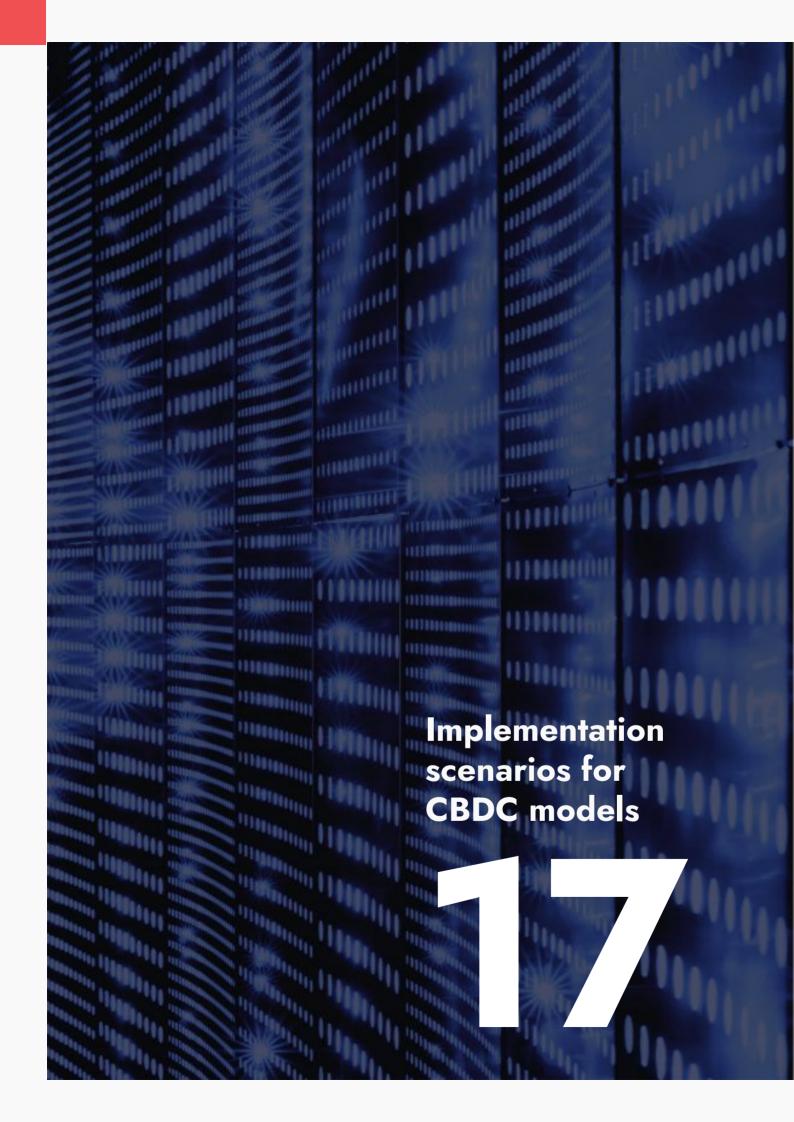
The purpose of the technique is to restrict the rise of the expense of researching topic areas and synthesizing solutions in response to the growing diversity and complexity of the operational environment, not to assure maximum simplicity of the approach or to reach some accuracy of results.

The method's unique feature is the production of regular representations that describe groups of practices that have been analytically chosen and specified. As a result, the description's fundamental aspect is practices and groupings of practices[13], rather than an object or entity represented through   characteristics and relationships. As far as the organisation of representations is concerned, both approaches can be interpreted as special cases of frame theory[14].

We can compare two perspectives as a simple example of the methodological differences between the approaches: 1) the concept of a "buyer" as a distributed object with a large number of complex interdependent properties that must be considered due to the large number of contexts where such a role is actualized, and 2) the concept of "buying and selling practice," which has a similar number of parameters, but in the model presented in simpler linear structures. In the second situation, a specific "Buyer" may be formed as an objectified set of practices with shared values (for example, an account number, passport, or some kind of marketing identifier).

13. As an example, we can consider one of the popular approaches, outlined in Chris Partridge's work "Business Objects: Re-Engineering for Re-Use"
14. Minsky M. Frames for Knowledge Representation (accessed on 27.01.2021).

In the end, the decision-making process should result in the implementation of a certain *action* because of the differences in descriptions, embedding a complicated *object* in such a process takes more time and effort than concluding that descriptions of practices may be conveyed as definitions in natural language with a specific structure. A set of "subject - action - object - circumstances" forms the heart of most stories. In the context of a certain set of definitions, it is possible to distinguish general and variable parts.

Elective components are called parametric places of definitions or "parameters". These places can receive their own identifiers. A structure (frame) with an ordered collection of parameters is represented by a separate formula. Frames with commonplaces of variability are defined as practices that have common parameters of the necessary action based on models of actual and possible activities.

Implementation scenarios for CBDC models

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Implementation scenarios for CBDC models

We cannot talk about any universal or unique scenario for CBDC implementation because there are no stated needs for product design from stakeholders at the research stage. Consequently, the proposed research methodology was used to create several theoretical implementation scenarios (Figure 5).
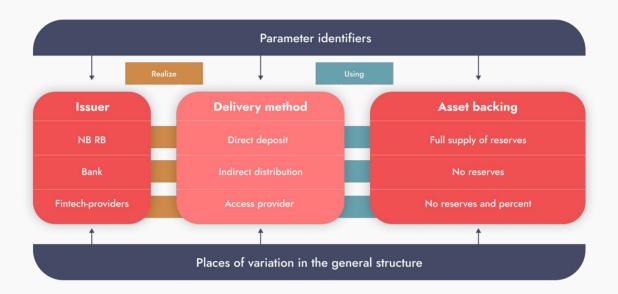
Figure 5 - Theoretical scenarios of CBDC implementation

In the process of formulating scenario hypotheses, the working group came to the conclusion that it was necessary to develop four test scenarios based on eleven Level 1 Parameters. The nature of the scenarios is determined by the degree of intervention of state bodies in the process of creating, functioning, and updating both of the payment system, understood in the narrow sense as a value accounting system (value), and in the process of managing monetary policy.

Scenarios for implementing CBDC-models and their parameter values

In the suggested paradigm, the problem is decomposed into three layers (see Figure 6):

Figure 6 - Depth of decomposition of the problem in the proposed model

Scenarios

Scenarios are Level 0 Parameters reflecting various strategic options for solving the target problem (e.g., with more or less state involvement). The general task of the Level 0 Parameters is to give a generalized idea of the CBDC development strategy.
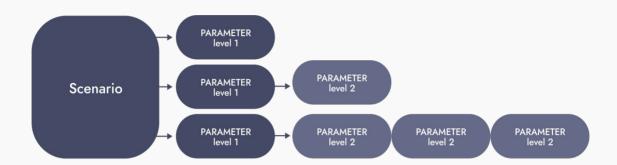
Level 1 Parameters

Variability of each Scenario in terms of combinations of social, administrative, and economic practices (e.g. "Issue Protocol", "Transaction control"). Level 1 parameters are grouped considering the subject areas formed due to the functioning of conventional payment systems and existing public and (or) DLT consortium systems.

Level 2 Parameters

Configurations of the main practices are the variations of Level 1 Parameters. Level 2 Parameters perform the function of detailing Level 1 Parameters and allow one to define specific details of business models (business rules) and even to promise functional and non-functional business requirements for CBDC protocol solutions.

Scenarios for implementing CBDC-models and their parameter values

The Level 1 parameters (Table 2) are described here, with their values varying from scenario to scenario. The links in this table lead to more detailed tabular scans available in Google Sheets formats https://cbdc.by/2021-report-gt and Excel Online https://cbdc.by/2021-report-xt .

Table 2 - Characteristics of Level 1 Parameters

Title of the parameter	Description of the parameter. Justification for its inclusion in the model, Level 2 parameters
Issuance protocol	Under the issuance protocol, it is necessary to understand the procedure for creating and delivering secured or unsecured funds to end-users. The protocol specifies the kind of entities involved in the issuance process, their roles, the type of collateral used, and a variety of other details. The CBDC protocol separates the accounting of digital currencies from bank information systems, raising the challenge of how to manage the money supply under new circumstances. **The parameters of the second level are** 1.Issuer [NBR; Banks; Fintech providers]; 2.Delivery Method [Direct Enrollment; Indirect Distribution; Access Provider]; 3.Security [Full provision of reserves; Lack of provision of reserves; Lack of provision of reserves and interest]
Restrictions on the use of CBDC by certain categories of subjects	The CBDC system imposes a variety of limitations based on the actors' status. The CBDC system can be limited in use by certain categories of subjects both at the piloting stage and as a result of a full-fledged launch. Other characteristics (such as transaction privacy) may cause legal entities to employ an anonymized CBDC, which violates international standards AML/CFT principles. **The parameters of the second level are:** 1.Agents [Individuals; Legal entities]; 2.Restrictions on transactions [Quantitative restrictions; 3.Restrictions on regulatory purposes].
Variability of payment instruments	Variability in payment instruments refers to the capacity to conduct transactions using a variety of hardware and software systems. Payment instruments can acquire both tangible and intangible forms. **The parameters of the second level are:** 1.Types of access devices [Physical Tokens; Software Tokens; Plastic Cards]; 2.The degree localization of device production [High degree of localization; 3.Low degree of localization].

Scenarios for implementing CBDC-models and their parameter values

Title of the parameter	Description of the parameter. Justification for its inclusion in the model, Level 2 parameters
Dynamic, context-dependent manner of regulation of CBDC transaction costs	System administrators have the technological capacity to adjust the cost of a transaction in real-time by having precise access to qualitative and quantitative features of transactions carried out using the CBDC protocol. **The parameters of the second level are:** 1.Agents participating in the consensus to establish the rule [Government agencies; Government Agencies+Banks+Fintech providers]; 2.Transaction Class, Context [Any context]; 3.Amount of fee[Any fee]; 4.Type of rule [Regulatory rule; Operational rule].
Infrastructure management and definition of CBDC (governance) software protocol management policy	The nature of the general management of the project development plan, as well as the decision-making mechanism for managing the CBDC information system. Government entities exert tremendous power over low-symmetric consensus variants. The active engagement of other stakeholders in the decision-making process is required for a highly symmetric consensus. **The parameters of the second level are:** 1.Composition of the committee that determines technological and organizational policy [State bodies; State bodies+Banks+Fintech providers]; 2.Symmetry of consensus [Low-symmetric consensus; Medium-symmetric consensus;High-symmetric consensus].
The openness of the program code of the basic CBDC protocol	The disclosure of entire or partial technical documentation outlining both the principles of system functioning and containing the source code of the system modules is referred to as openness of the fundamental CBDC protocol program code. The openness of the program code is important in cases where the system is managed collectively, and participants have equal or nearly equal rights to audit and alter the information system's program code. **The parameters of the second level are:** 1.Actors [Key Developers and state audit; Consortium developers Public Developers]; 2.Components [Core, Platform; Application Programming Interface (hereinafter — API), Software Development Kit (hereinafter — SDK); Application Components]; 3. License [Without access; License to use; Free License].
Programmatic access to the protocol	The set of permissions for interested parties to access the software protocol is defined by this option. Access refers not only to the technical ability to connect external software modules (analyzer programs; client software) but also to the ability to understand the CBDC information system's principles. **The second level parameter is the following:** 1.The cast of actors with access [Government agencies; Consortium; Legal entities].

Scenarios for implementing CBDC-models and their parameter values

Title of the parameter	Description of the parameter. Justification for its inclusion in the model, Level 2 parameters
Interaction with external payment systems	The capacity of the national currency, which is based on the CBDC software protocol, to link to payment and settlement systems' information systems. The parameter presupposes the availability of several organizational measures for the execution of information exchanges from the CBDC system to traditional payment systems, in addition to the technological potential of interaction. **The parameters of the second level are:** 1.Protocol [No technical protocol; Technical Protocol]; 2.Agents [Individuals; Legal entities; All economic agents].
The ability to ensure consistency of transactions during interaction with other DLT systems (interoperability)	The system's interoperability refers to the system's capacity to broadcast the status of specific accounts to other DLT systems without the requirement for a relying entity. **The parameters of the second level are:** 1.Protocol [Direct access; No interaction]; 2.Agents [Individuals; Legal entities; All economic agents].
Access to transaction information	The possibility of full or partial concealing of the information about senders, receivers, and transaction content from a certain circle of people determines privacy. This parameter is crucial since it has a direct impact on the basic incentives that customers have while utilizing a CBDC system. **The parameters of the second level are:** 1.Access subject [State bodies; Banks; Holders of certifying nodes; Fintech providers]; 2.Information Group [All information about all transactions; A group of information limited by the sanction; Aggregates for all information of all transactions; Aggregates for groups of information limited by the sanction]; 3.Sanctioning [Org sanction of one of the counterparties; Org sanction of both counterparties; Org sanction of the regulator; Regulatory sanction with access].
Transaction control	Control entails the imposition of a variety of constraints on the execution of financial transactions by entities by a small group of authorized individuals. **The parameters of the second level are:** 1.Regulatory body [Government agencies; Banks; Holders of certifying nodes; Fintech providers] 2.An agent whose transactions are subject to regulation [Economic Agent] 3.Operation [Impersonation of Transaction Execution;Restriction on Transaction execution] 4.Sanctioning [Org sanction of the regulator; Regulatory sanction with access; Contractual sanction]

Scenarios for implementing CBDC-models and their parameter values

To simulate any situation, specific values of Level 2 parameters must be chosen, which, according to the hierarchy, will result in particular Level 1 parameter values.

For example, the value of the Level 1 Parameter "Transaction Control" can be: <Government agencies> and <Holders of certifying nodes> <Restrict the execution of transactions> <Economic agents> based on <Regulatory authorization with access>.

In practice, this means blocking transactions of any entities without changing their characteristics based on legislation without additional sanctions from regulators.

As a result of combining the Parameters of level 2, the user of the model will be able to get a text description of the implementation scenario, simultaneously excluding unacceptable implementation options.

The study team presented four implementation choices that may be placed on a scale of "Conservative-Progressive" as examples of modelling scenarios for CBDC implementation. The degree of engagement of government entities in the CBDC operating process, the degree of freedom of end-users, the decentralization of administration of the CBDC software system, and other criteria define the relevance within the context of this school. The number of scenarios is due to the need to analyze a fairly wide range of parameter variations, provided that the volumes of research work that are convenient for studying are preserved. A detailed tabular scan is given at the link https://cbdc.by/2021-report-gt-scenarios .

Scenarios for implementing CBDC-models and their parameter values

Scenario 1
''**Conservative scenario**''

A cautious implementation scenario for CBDC, assuming a high level of supervision by government agencies and other authorized individuals. There is no organizational consensus. Low transaction privacy. Closed source code. Centralized management. Active use of the electronic money model. The National Bank of the Republic of Belarus carries out direct transfer of funds with full provision of reserves. Banks and fintech providers carry out indirect distribution with full provision of reserves.

Scenario 2
''**Moderate-conservative scenario**''

A moderate scenario of CBDC implementation. Balanced control. Special protocols for the disclosure of private transactions for a wide range of government agencies. Free movement within the economy among legal entities and individuals.

Scenario 3
''**Moderate-progressive scenario**''
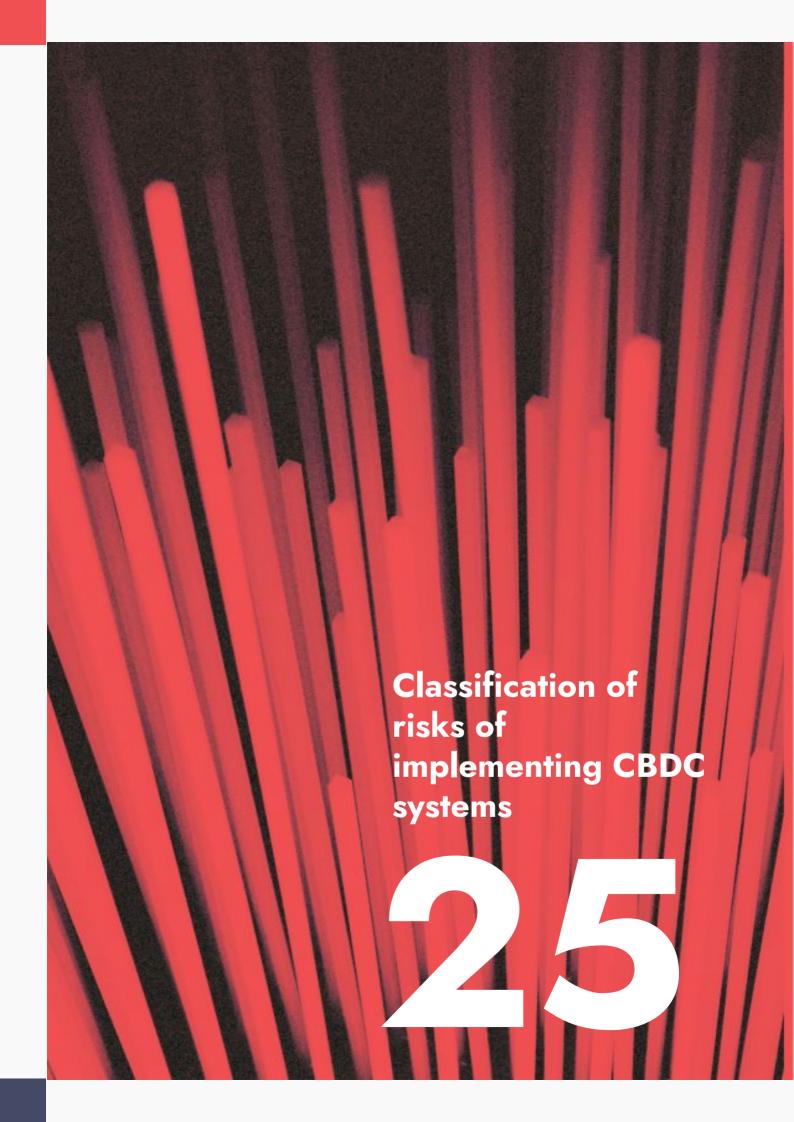
A moderately optimistic scenario for the implementation of BSC. Transition to consortium management and desk control by government agencies. Disclosure of the content of transactions to a narrow circle of government agencies under a special procedure. Free movement within the economy among legal entities and individuals. Banks are agents of the National Bank of the Republic of Belarus.

Scenario 4
''**Progressive scenario**''

A liberal scenario. The system is largely controlled by a commercial consortium, but the volume of emissions is coordinated with the National Bank of the Republic of Belarus. The entry criteria to the payment sector are quite low. The high degree of privacy. Open source code. CBDC can freely circulate within the economy between legal companies and individuals.

Classification of risks of implementing CBDC systems

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Classification of risks of implementing CBDC systems

The examination of current risks and advantages should be used to evaluate options for the deployment of such complex systems as DLT-based CBDC. Because the CBDC-system has such a broad impact on numerous aspects of the country's economy, the analysis of the possibility of unfavourable occurrences should include not only technology risks but also economic and legal impacts. Stakeholders should consider the impact of each risk outlined below and take steps to reduce the chance of negative outcomes.

It's necessary to keep in mind that the level of risk is determined by the CBDC implementation scenario. The risk values for test scenarios can be found in section 4.2 of the main research.

The Risk Management Strategy in the Payment System of the Republic of Belarus, adopted by Resolution of the Board of the National Bank of the Republic of Belarus No.155 dated 29.04.2017[15], as well as the International Monetary Fund research on CBDC[16] and other scientific studies, were used to determine risk categories[17].

Credit risk

Credit risk is the possibility that a monetary obligation will not be fully met, either on the payment due date or throughout the course of the following period of time. Credit risk is a feature of financial systems that use received liquidity to fund additional investments in order to generate a multiplier effect from the loan. The higher the risk, the less the proportion of reserving commitments in the system. Except in cases when the issuer creates a money supply backed by assets with their own risk criteria, credit risk is atypical of CBDC(see the Libra stablecoin case[18]). When the National Bank of the Republic of Belarus issues digital money with the properties of currency without a payback requirement, there is no credit risk[19].

15. Risk management strategy in the payment system of the Republic of Belarus: approved Resolution of the Board of the National Bank of the Republic of Belarus No.155 dated 29.04.2017. - URL: https://www.nbrb.by/payment/supervision/regulation (date of access 07.04.2021).

16. Kiff J., Alwazir J., Davidovic S. A Survey of Research on Retail Central Bank Digital Currency // IMF WORKING PAPERS, 2021.URL:https://www.imf.org/en/Publications/WP/Issues/2020/06/26/A-Survey-of-Research-on-Retail-Central-Bank-Digital-Currency-49517 (date of access 07.04.2021).

17. Zachosova N. Risks and possibilities of the effect of financial inclusion on managing the financial security at the macro level //ResearchGateGmbH,2008-2021.URL:https://www.researchgate.net/publication/329548744_Risks_and_possibilities_of_the_effect_of_financial_inclusion_on_managing_the_financial_security_at_the_macro_level (date of access 07.04.2021).

18. Lopatto E. LIBRA, explained: Move fast and bank things. - URL: https://www.theverge.com/2019/6/26/18716326/facebook-libra-cryptocurrency-blockchain-irs-starbucks (date of access 22.09.2021).

19. Carstens A. Central bank digital currencies: putting a big idea into practice. - URL: https://www.bis.org/speeches/sp210331.pdf (date of access 22.09.2021).

Classification of risks of implementing CBDC systems

Financial accessibility risk

The risk of unavailability of financial services is understood as the probability of a situation in which financial services become unavailable to certain population categories. A situation comparable to this might occur if new technologies that provide access to financial services are inaccessible to certain groups of people for various reasons. The requirement for a mobile device or a physical token on which to execute a client software, the necessity for a reliable Internet connection, the need to adjust user experience and form user habits, and the availability of payment acceptance tools are the main factors impacting CBDC availability. CBDC is less financially accessible to the elderly and rural communities due to these reasons.

Compliance risk

Compliance risk is the probability of losses or loss of reputation as a result of non-compliance with the activities of a participant in the payment system with regulatory legal acts and standards governing the provision of payment services. The financial regulator's action is a risk control factor. The lower the risk, the greater the function of the financial regulator is in the system and the more authority it has to manage it. The risk value may be reduced in CBDC deployment scenarios with a higher degree of system management concentration in the public domain. However, as the management of the CBDC system becomes more decentralized, this danger becomes greater.

Technological risks

The degree of exposure of the CBDC system to technological risks depends on the implementation scenario. Varying risks, or their various exposure, or the different cost of actual risk in different situations are presupposed by the features of each scenario. It is feasible to determine an aggregate degree of riskiness and compare these levels to scenarios. However, it appears to be very speculative and irrelevant. None of the chosen scenarios have any severe events that set them apart from the others in terms of real danger. The reason for this is that certain systems are vulnerable to one sort of danger while having a high level of resilience to other threats. Scenario 1 total danger of IT infrastructure hazards and information security breaches as a consequence of "denial of service" attacks (hereinafter — DDoS attacks) appears to be higher due to the technological solution's high level of centralization, which also includes a higher cyber risk. However, when the system's spread grows, the possibility of additional engineering and organizational attacks, such as "man in the middle," may increase.

Classification of risks of implementing CBDC systems

Depending on the functional position in the CBDC architecture, the physical location of the service, and its place in the IT topology, the risks of loss of access to CBDC financial services, violation of confidentiality, or illegal interference may have different implementation alternatives. Due to higher technical, technological, and/or organizational localization, more centralized CBDC systems may be more vulnerable to DDoS attacks and failures linked with issues such as the universality of technological policies, difficulties in the developer organization, etc.

The availability and integrity of private information are heavily reliant on encryption and backup technology. We can see a minimal degree of this risk in the designs of centralized CBDC systems since the information will be contained and controlled by a small group of stakeholders. The risk gradually increases as decentralization increases. The inevitable dispersal of user information over the network, as well as a larger number of agents with different levels of access, will result in a greater number of privacy threats: both local — due to the larger number of data locations — and non-local — when data from one private service jeopardize many other services. However, maximum decentralization, like cryptocurrency, will have the opposite effect: risk is minimized as individual transactions become more private and institutional players are unable to acquire access to money management.

The immediate cost of hazards may be significant in centralized circumstances, but the time required to resolve the issue is decreased. The opposite is true in situations with more decentralization when good individual security is mixed with a high overall degree of cyber risk due to the lack of a single vendor capable of quickly correcting significant protocol issues. It is worth noting that the consortium of participants may appoint a similar organization to handle crucial responses to unfavorable situations, but the consortium's job will be hampered by the wide range of technology options available.

Classification of risks of implementing CBDC systems

General commercial and investment risks

The risk of the payment system's financial situation deteriorating due to a decrease in its income or loss, which may be due to incorrect decisions, unforeseen or excessively high operating costs, or as a result of the implementation of other risks, is referred to as the general commercial risk. The degree of this risk is directly proportional to the level of government and bank engagement, the commercial appeal of adopting CBDC, and the cost of developing software and operating a payment system. The level of risk is defined by the system's functionality, which determines capital expenses and operational maintenance costs. The practice of implementing cryptocurrencies has shown that decentralized systems have reduced costs for ensuring payment information reliability and integrity. However, the application of a number of additional hazards may result in system-wide losses, resulting in the emergence of general commercial risk.

Risk of no exit strategy

The risk of not having an exit strategy is determined by the degree of impossibility of resuming activities in the previous model or incurring large costs for its resumption in the event of project closure. To reduce this risk, methods for resuming operations in the previous mode must be developed ahead of time. However, it may become clear during the planning stage that reverting to the status quo without major material expenses is unfeasible. CBDC systems will almost certainly be used in combination with traditional non-cash and cash payments. As a result, one of the most important criteria for measuring the degree of this risk is the ease and simplicity with which the economic condition of agents may be transferred back. The degree to which the banking sector is involved in the management, accounting, and distribution of CBDC determines the transfer's complexity. One will be able to convert CBDC into bank obligations with ease if you have a high level of engagement. The banking sector's low involvement, combined with the realization of the risk of liquidity loss, increases the risk of a lack of an exit strategy because the regulator will have to deal with not only the technical procedure for offsetting liabilities but also macroeconomic factors such as money flow back into the banking system and foreign currency.

Classification of risks of implementing CBDC systems

The risk of liquidity outflow in the banking system

The possibility of funds leaving the banking system, which might lead to low regulatory reserve levels, is known as the risk of outflow of liquidity in the banking system. The risk of loss of liquidity in the banking system as a result of the implementation of the CBDC model is one of the most significant threats to the banking system of the Republic of Belarus. As indicated by the high rates of the interbank lending market, the Belarusian banking sector is frequently short of accessible cash. The establishment of an additional payment system, which in certain scenarios entails the abolition of the idea of a current account, results in the outflow of non-cash money into "digital cash." CBDC systems, according to the literature, are possible to speed up so-called "bank runs" since CBDC can operate as a full-fledged replacement for bank deposits, which is typical of CBDC with an interest rate [20] [21].

20.Barrdear J., Kumhof M. The macroeconomics of central bank issued digital currencies: Staff Working Paper No. 605. - URL: HYPERLINK "https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2016/the-macroeconomics-of-central-bank-issued-digital-currencies.pdf"https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2016/the-macroeconomics-of-central-bank-issued-digital-currencies.pdf (date of access 22.09.2021).
21. Purnawan M. E., Retno R. "Significant Effect of the Central Bank Digital Currency on the Design of Monetary Policy". (date of access: 22.09.2021).
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Characteristics of the benefits resulting from the implementation of CBDC

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Characteristics of the benefits resulting from the implementation of CBDC

In the current circumstances, the rewards and risks associated with CBDC implementation might be weighted differently based on the priorities of the position under review. However, such analysis must take into consideration the strategic aspect of the financial infrastructure's digital transition. Many valuable or harmful aspects of these new technical infrastructures exist beyond the first horizon of deployment and operation. The present payment system's architecture assumes the function of banks as institutional intermediaries, with one of their responsibilities being to account for non-cash money and undertake operations for their transfer.

Reduction of transaction costs

The present payment system's architecture assumes the function of banks as institutional intermediaries, with one of their responsibilities being to account for non-cash money and undertake operations for their transfer. Payment market authorities are building extra organizations that can provide clearing and (or) settlement functions to assure the payment's finality because even banks cannot trust each other's information systems[22]. DLT-based settlement systems have key characteristics that allow for abandoning the functional role of an intermediary in accounting for a digital asset and its transfer. The absence of costs for institutional intermediary maintenance and control can have a favorable influence on the overall income and expense balance of the Republic of Belarus' payment system.

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22. Latysheva N.V. Interbank settlement relations as one of the directions of development of the payment system // Finance and credit.2008.
№41(329).-URL:https://cyberleninka.ru/article/n/mezhbankovskie-raschetnye-otnosheniya-kak-odno-iz-napravleniy-razvitiya-platezhnoy-sistemy (date of access: 12.04.2021).04.2021)

Characteristics of the benefits resulting from the implementation of CBDC

Improving the efficiency of the economy through the introduction of dynamic context-dependent regulation of transactions

In certain conditions of economic interaction, dynamic context-dependent transaction regulation entails the establishment of monetary barriers or incentives. The result of the implementation of this function is the awarding of individual classes of transactions[23]. It is also feasible to channel the money supply in very specific directions, allowing for better control over the targeted use of public funds[24]. One example is the ability to use social benefits alone to purchase a limited number of products and services.

Open access to the payment protocol

The existing paradigm of the financial system assumes the key role of the banking system as a holder of true information about the state of the bank account of an economic agent. The introduction of new modes of payment, such as electronic money, payment initiation systems, and card payment systems, did not diminish the role of banks but rather boosted it. Instead of replacing "banks for banking," as experts feared, banks began to focus on related services, building new ecosystems and strengthening their own market position with the implementation of PSD 2 (Payment Service Directive 2)[25]. Experiencing difficulties in creating high-quality added value and being dependent on the banking infrastructure, fintech providers demonstrate weak financial indicators and force experts to discuss the decline of neobanking[26]. The solution to this problem can be conditionally open access to the payment–infrastructure, which will be carried out according to uniform rules. DLT enables you to assign the level of financial accounts to a distributed infrastructure, resulting in a high degree of model flexibility at various levels of centralization.

23. Report on a digital euro // European Central Bank, 2020. - URL: https://www.ecb.europa.eu/pub/pdf/other/Report_on_a_digital_euro~4d7268b458.en.pdf (date of access: 12.04.2021).
24..The concept of the digital Ruble // Central Bank of the Russian Federation,2021. - URL: https://www.google.com/url?q=http://www.cbr.ru/Content/Document/File/120075/concept_08042021.pdf&sa=D&source=editors&ust=1618170691439000&usg=AOvVaw0bpqajPehKoo-ShRzyrB_c (date of access: 12.04.2021).
25. A New Digital Age for Banking Ecosystems // FinTech, 2021. - URL: https://www.fintechmagazine.com/banking/new-digital-age-banking-ecosystems (date of access: 12.04.2021).
26. Dawkins D. The Sad Demise Of Europe's Neobanks // Forbes, 2021. - URL: https://www.forbes.com/sites/daviddawkins/2020/08/24/the-sad-demise-of-europes-neobanks/?sh=260b1cf6223a (date of access: 12.04.2021).

Characteristics of the benefits resulting from the implementation of CBDC

Overall cost reduction of the payment system

It is a generally recognized fact of economics that the costs of any goods and services exceeding the revenue part must be transferred to the end-user or reflected in the form of losses in one of the links of the industry chain. The overall cost reduction in the operation of the CBDC protocol is possible for the following reasons:

1. Reducing the cost of fee payments in favour of IPS. The retail payments market in the Republic of Belarus is influenced by the duet of IPS of Visa and MasterCard companies. It seems difficult to determine the amount of transaction fees in favour of an international payment system, but experts note that these figures exceed $ 50 million per year. The national CBDC system reduces the amount of fees paid within the national ecosystem.

2. Replacement of the settlement fee of Joint-stock Company "Belarusian Interbank Settlement Center" with the fee of the DLT protocol. At this stage, it seems difficult to determine the cost of a transaction in the DLT protocol. It might be determined by capital expenditures, new add-ons, and consortium members' estimated rate of return. However, some studies have found that using CBDC in international transfers reduces transaction costs[27]. However, the hypothesis of lower costs compared to Real Time Gross Settlement requires requires additional validation.

3. Financial institutions' infrastructure expenses are reduced. Banks' operating expenses will rise once CBDC protocols are implemented, as they will have to support both old cashless systems and the new CBDC system. However, because no fixed assets or expensive software are required, the cost of entry for new participants, even those linked with the bank, will be substantially cheaper.

4. Reducing the cost of integrating management systems. The ability to create accounting systems for diverse asset classes and other sorts of entities that may interact successfully owing to smart contract technology is demonstrated by the experience of employing DLT systems. Standardization of API DLT-systems also reduces barriers to connecting external information systems, and the use of the concept of Self-Sovereign Identity can become a key point in the formation of a more effective electronic state.

27. Ginneken C.L. van Settlement of cross-border transactions through Central Bank Digital Currency (CBDC): analysis from a risk management perspective // The University of Twente Repository, 2021. - URL: https://essay.utwente.nl/78027/ (date of access: 12.04.2021).

Characteristics of the benefits resulting from the implementation of CBDC

New tools for financial incentives

It seems possible to consider CBDC not just as a means of payment but also as a fundamentally new instrument of monetary policy. The CBDC allows the central bank to interact directly with the population, influence some economic indicators, and also provides a deeper understanding of financial flows in the country's economy. CBDC is a more effective instrument since the transmission mechanism is simplified and the transmission lag is reduced. CBDC is issued by direct crediting money to the end-user, removing commercial banks from the transmission process, and removing the difficulty of anticipating the effect of the bank multiplier. The CBDC model, which implies that transaction costs may be dynamically regulated, is a mechanism that allows the National Bank of the Republic of Belarus to control the pace of money circulation directly. A rise in transaction value can slow money circulation, whereas a drop in value might speed it up.

Increasing the prestige of Belarusian statehood and consolidating the country's sovereignty

The adoption of a national payment system based on CBDC will considerably enhance the Republic of Belarus's position as a leader in the field of digital economy development. The Republic of Belarus has already achieved success in this field during the "cryptocurrency boom". CBDC is the most significant topic that combines an interest in blockchain technologies with the notion of an electronic state. At the moment, there isn't a single full-fledged CBDC model in the world that can claim to be a fully functional version. The Republic of Belarus will be able to capture the attention of the international community by establishing such a system, as well as define industry standards and export its organizational and technological solutions.

Strengthening the sovereignty of the Belarusian state

Currently, a considerable number of non-cash payments in the Republic of Belarus are done using bank cards, with the involvement of IPS (Visa; Mastercard). The infrastructure of today's financial institutions is heavily reliant on the card account system. The payment market may confront substantial challenges before moving to Russian and Chinese payment systems if IPS cease to operate within the territory of the Republic of Belarus. The establishment of an alternative settlement system to payment systems based on bank cards will lessen the Republic of Belarus' reliance on IPS, therefore increasing state sovereignty.

Forecasts and recommendations for the implementation of CBDC system in Republic of Belarus

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Forecasts and recommendations for the implementation of CBDC system in Republic of Belarus

The choice to implement the CBDC system in the Republic of Belarus' economy should be based on a balance of risks and potential rewards. It should be noted that for most regulators, including the National Bank of the Republic of Belarus, there is no alternative to "abandoning CBDC - creating a CBDC system". The other option is to "abandon CBDC - create a CBDC system with a specific design." This fact is predetermined by the variability in the design of CBDC systems, which was demonstrated in our main study.
The subject of the feasibility of implementing a somewhat conservative CBDC system scenario in the Republic of Belarus was not addressed in the primary research, but it can be addressed within the scope of this paper. To solve this problem, it is necessary to pay attention to several key factors:

1. High level of digitalization of the payment system.

In terms of digital channels of service provision, the banking industry of the Republic of Belarus may be regarded as "advanced" in 2021. Belarusian banks provide a wide variety of services in the areas of loans, deposits, trust administration, and so on, in addition to standard Internet apps with account access. Belarusian banks are actively developing the payment infrastructure, providing access to money transfers through unified automated information system "Settlement" and IPS, including payment instruments from popular device suppliers (Apple, Samsung, Garmin, etc.). The ability to make quick and inexpensive transfers, as well as payments that are actively accepted by businesses, is becoming a factor in the Republic of Belarus' population's active usage of non-cash payments. The banking sector did not stop at innovations for consumers. By developing software and hardware solutions for merging commodities and payment registers, the electronic cash register industry increasingly streamlines the process of receiving payments by enterprises. Such conditions for the start of CBDC are not optimal. Except for the reduction in the acquisition charge, which will be free of international payment systems fees, users and companies would hardly notice the changes. CBDC will certainly have to find a new distinctive competitive offer in the open market, such as accrual of interest on balances, direct crediting of monetized perks, partner discounts, anonymity, and so on.

Forecasts and recommendations for the Republic of Belarus' deployment of the CBDC system

2. A high degree of disunity in the banking sector.

Managing the CBDC ecosystem using the DLT protocol necessitates close collaboration among all parties, including banks, technology providers, regulators, and their subsidiaries. The Republic of Belarus's historical experience with the growth of the financial industry reveals that key players prefer to construct their own ecosystems by limiting partnerships to specific types of services. This has a favourable influence on overall levels of competition, but it does not help to quickly build a system of evident and transparent incentives for all stages of the value chain. Consortium participants should be ready to cannibalize their branch of payment business with a clear understanding of the long-term benefits that can be obtained as a result of the implementation of a particular CBDC model. The significant concentration in the consumer services market, as well as the strategic development of electronic money (Open joint-stock company Belinvestbank and the Pay system) and International Bank Account Number (IBAN) settlements (Open joint-stock company Belarusbank), appear to be preventing the banking industry from gaining widespread excitement.

3. CBDC is a non-core activity of the National Bank of the Republic of Belarus.

Most CBDC implementation scenarios assume a significant degree of involvement from the National Bank of the Republic of Belarus. The assessment and control of monetary consequences are not the only aspects of CBDC system management. It seems that the CBDC system opens up two new directions for development: strategic and product. The strategic direction is determined by the parameters related to the regulation of the cost and quality of transactions, the privacy and anonymity of transaction data. The National Bank of the Republic of Belarus is permitted to make decisions on these matters at the present time; nevertheless, the absence of public participation by other state authorities in the process of establishing the CBDC system's concept and vision is a concern. Modelling the real economic impact of the system's introduction purely based on the monetary regulator's forces and abilities might lead to a misleading view of the system's possibilities. In the case of a conservative single-level CBDC system, the product line might become a burden for the regulator. The necessity to design incentives for utilizing the software product should be entrusted to a third party; otherwise, the National Bank of the Republic of Belarus will confront a conflict of interest within its own divisions. The National Bank of the Republic of Belarus's previous experience with the split of its own divisions into distinct legal organizations (Joint-stock company "Belarusian Interbank Settlement Center") and the formulation of autonomous aims and objectives for these individuals might be applied here.

Forecasts and recommendations for the Republic of Belarus' deployment of the CBDC system

4. The necessity to enhance international prestige

Belarus has the capacity to develop its brand centred on the development of a digital state. Many individuals and enterprises will be able to assess the benefits of the national payment system thanks to the launch of its own CBDC and active popularization of payment availability, as well as the convenience of generating experimental financial products. It is obvious that the effect of the adoption of the Decree of the President of the Republic of Belarus dated December 21, 2017 No. 8 "On the development of the digital economy" continues to evaporate. Residents' tax advantages are transformed into market advantages on overseas marketplaces. In a distributed architecture, a CBDC system can send a clear signal to international participants about the local market's readiness for specific risks.

5. The need for digitalization and automation of the administration of economic transactions.

The present strategic regulatory legal acts in the sphere of economic digitization are primarily concerned with improving the digital accessibility of public services and improving the efficiency of government administration[28]. The concept of "colored money", which can be implemented in the event of the launch of the CBDC system, assumes a qualitatively different analysis of the nature of the cash flow than the one available to the National Bank of the Republic of Belarus today. The technological possibility of adding additional qualitative attributes to a financial message means the traceability of the accounting unit in the cash flow. The regulator will be able to stimulate cost-effective behaviour in real-time. Controlling the expenditure of budget allowances and subsidies may also be a significant component of enhancing the quality of public finance administration. The system of tax deductions might be replaced by a system of personal wallet control, in which the end-user receives the appropriate incentives or incurs certain expenditures in line with legal requirements.

28. Resolution of the Council of Ministers of the Republic of Belarus No. 66 dated 02.02.2021 (ed. dated 24.02.2021) "On the State Program "Digital Development of Belarus" for 2021-2025". - URL: https://minprom.gov.by/postanovlenie-soveta-ministrov-respubliki-belarus-2-fevralya-2021-g-n-66-o-gosudarstvennoj-programme-cifrovoe-razvitie-belarusi-na-2021-2025-gody_/ (accessed 01.11.2021).

Forecasts and recommendations for the Republic of Belarus'
deployment of the CBDC system

6. Integration processes of the Republic of Belarus and the Russian Federation.

The integration processes between the Republic of Belarus and the Russian Federation, which have gained momentum in the last two years, imply a significant degree of harmonization of legislation, as well as the principles of building the economy. The financial industry will not be spared from mutual integration. This fact should be considered while constructing the CBDC model since the Russian Federation likewise plans to advertise and promote the notion of the "digital ruble." Gaining access to the Belarusian financial market by Russian banks might result in the growth of the Russian CBDC's influence in the sphere of retail payments in Belarus. It should be highlighted that regardless of how interested parties decide to implement the CBDC system in Belarus, this aspect will influence the Belarusian market. We should also keep in mind the predicted convergence of macroeconomic policy and monetary policy harmonization, which might be a key element in CBDC growth. The National Bank of the Republic of Belarus, while using the CBDC to regulate the money supply, may run across external obstacles that prevent the system from fully realizing its potential.

7. Global integration processes in the payment space.

The interest of foreign research groups and regulators in CBDC can be converted into pilot projects and industrial implementations. The advent of a new level of cash accounting, which in some countries may be outside the banking sector's control, may provide the groundwork for a new organizational and technical framework for interaction. Existing DLT interoperability solutions enable the creation of technical bridges without the need for centralized clearance processes. The Belarusian market will be impacted by this shift in the payment environment, as it will need to find new ways of integration with foreign currency flows.

Forecasts and recommendations for the Republic of Belarus' deployment of the CBDC system
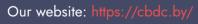
Because practically each breakthrough technology or institution encounters a significant number of counterarguments and insufficient risk assessment, the preceding reasons should not be measured. Nevertheless, it seems difficult to assert that the introduction of CBDC is an urgent need for the Belarusian economy and is able to solve many pressing problems.

The phase of identifying stakeholders, searching for an internal customer, fixing the requirements of stakeholders, defining the boundaries and vision of a technological solution, software development, testing, and acceptance of an ideal concept can take at least 2-3 years and require significant amounts of organizational and financial resources. At present, the existing regulatory aims are being achieved via conventional mechanisms that have previously found use among sophisticated digital powers. CBDC, based on DLT, is a completely new project with its value and the ability to define new goals for society and the state. If the system's design and management are limited to a small group of people, there's a good chance you'll end up with a trendy but essentially worthless initiative that duplicates the tasks of current payment system agents.

It appears that interested parties, particularly the National Bank of the Republic of Belarus, should avoid following a popular trend and instead concentrate on the form. The most important task should be to choose the correct goals that can only be achieved by a distributed CBDC system.

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