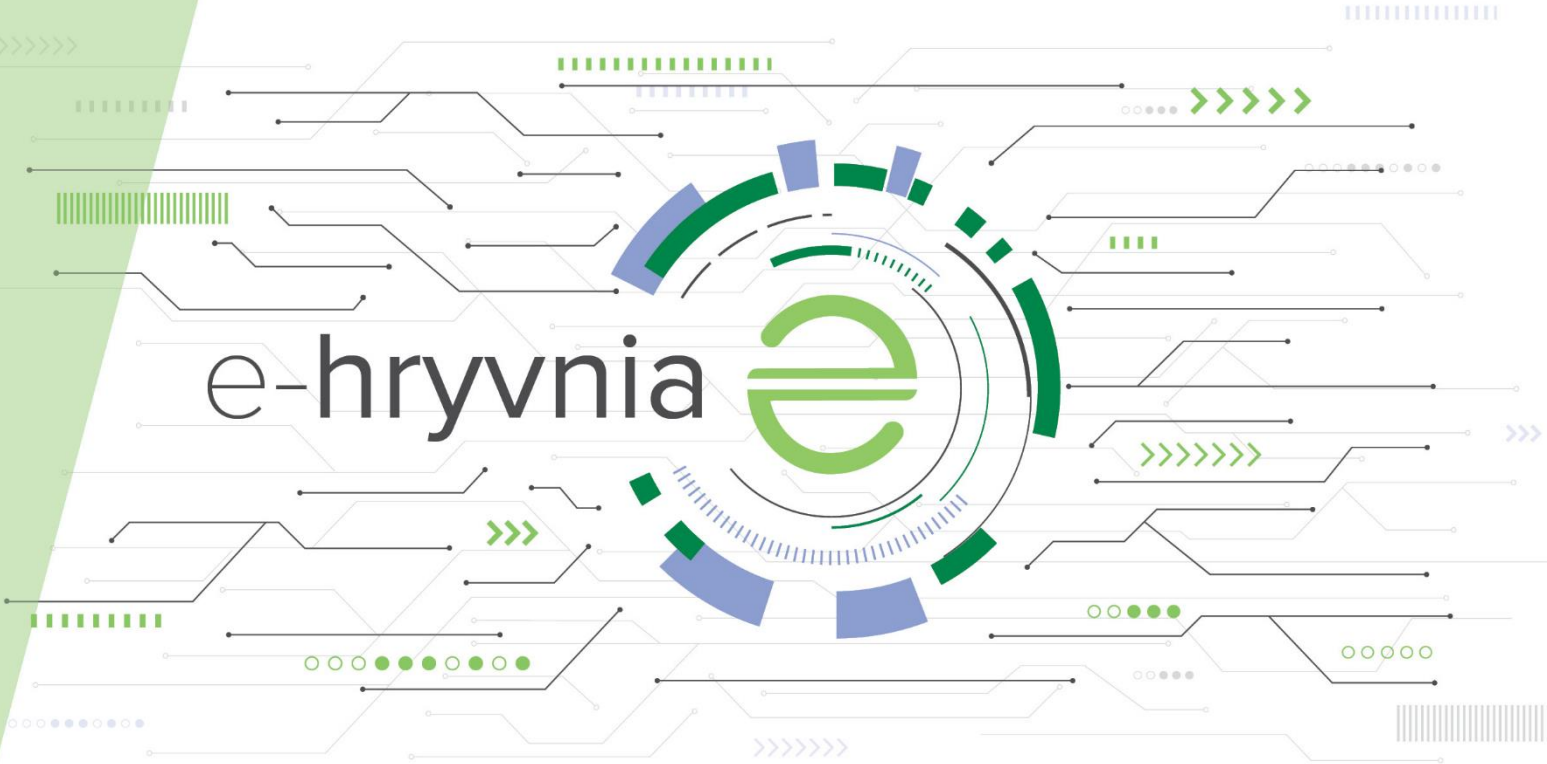
National Bank of Ukraine

Analytical Report

on the E-hryvnia Pilot Project



Kyiv 2019

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Introduction

Dear colleagues:

Recent years have witnessed a rapid growth of digital currencies issued and circulated on the basis of various models, using different technologies and within different legal frameworks. This relatively new phenomenon remains in the focus of attention of regulatory authorities across the globe, including central banks of European Union member states.

In this context, many central banks are pondering on the launch of their own digital currency (the so-called *central bank digital currency*, or CBDC) and the options of its use. CBDC forms and technologies differ depending on specific needs, but in any case, CBDC is regarded as a new, evolutionary form of central bank money.

In 2016, keeping up with the global trends of innovative development of payment instruments, the National Bank of Ukraine, whose vision includes integration into European community of central banks, started exploring the possibility of issuing an own CBDC, the e-hryvnia.

As part of the pilot project, we analyzed international experience, studied legal aspects and macroeconomic effect, and designed an optimal business model.

It is important to stress that along with theoretical studies of CBDC, our project also included the practical part. As part of the test of e-hryvnia blockchain platform technology, we have issued a limited amount of e-hryvnia currency and tested transactions using this currency in the live environment.

As a result, we drew useful conclusions as regards the issuance of our own CBDC and gained valuable practical experience that highlighted the NBU's capabilities and potential to implement projects of this kind.

Sergii Kholod
Deputy Governor
National Bank of Ukraine

The project team of the National Bank of Ukraine would like to thank our partner companies participating in this project: ATIK LAB LLC, UAPAY LLC, PAYCELL LLC AND DELOITTE & TOUCHE LLC, whose help and professionalism made this innovative project possible and gave us unique experience that we shall use in our further studies of digital currencies.

Summary

1. Central Bank Digital Currencies

In recent years, the idea of issuing an own digital currency by central banks has been in the focus of attention of regulatory authorities across the globe, including central banks of European Union member states. The reasons for this interest include, in particular, a surge in the significance of innovations in the financial sector, the advent of new payment technologies and services, and a trend and desire in many countries to decrease the share of cash in circulation in the economy.

Central bank digital currency (CBDC) means digital form of existing fiat currency issued by the central bank and having the status of legal tender [2].

Depending on combinations of CBDC features, researchers define the following schemes of using this currency:

- CBDC as a digital cash equivalent
- CBDC for interbank settlements
- CBDC as a monetary policy instrument
- CBDC as an equivalent of an account opened at the central bank.

To implement CBDC, central banks consider the use of the distributed ledger technology (DLT) or conventional databases.

Today, central banks are actively studying the risks inherent in CBDC. The following risks require especially thorough consideration: technology risk, cybersecurity risk, monetary policy implementation risk, risk of undermining financial stability, reputational risk for the central bank.

Countries of the world whose central banks are mulling the issuance of CBDC can be conditionally divided into three groups:

- countries studying CBDC (United Kingdom, Canada, China, Sweden and other)
- countries criticizing CBDC or discontinuing the research in this field for various reasons [Switzerland, Estonia, Ecuador, Japan/European Union (joint project by the Bank of Japan and ECB)]
- countries that have already taken practical steps toward the actual issuance of CBDC (Singapore, Tunisia, Senegal and, conditionally, Venezuela).

2. Preconditions for the issuance of CBDC by the National Bank of Ukraine

To increase the level of financial inclusion, reduce the share of cash transactions, and increase the speed, convenience and transparency of payment transactions in the country, the National Bank of Ukraine (NBU) is studying the possibility of launching an innovative, inexpensive, secure and functional instrument for retail payment transactions in small amounts by private individuals.

The currently existing retail payment instruments – cash, payment orders, payment cards and e-money – have their own upsides and downsides.

The NBU considers CBDC as an alternative instrument for instant payments in small amounts by private individuals. The advantages of CBDC may include the simplicity in use, security (as the repayment and settlement are guaranteed by the NBU), fast receipt of user status, speed of payment transaction.

At the same time, the implementation of CBDC would require a substantial investment in the creation and development of required retail payment infrastructure in Ukraine, including integration with infrastructure already existing in the country. This step must be preceded by the creation of a business model that would accommodate interests of all participants: individuals, merchants, distribution and settlement agents, banks, etc. and stimulate development and use of the instrument proposed to the market.

Another question that remains open is the need to popularize CBDC as a new instrument among the broad public in order to make sure that this instrument becomes a truly mass product, considering existing consumer habits.

In late 2016, the NBU started to explore the possibility of issuing its own CBDC, the electronic hryvnia or e-hryvnia, considering that:

- the e-hryvnia is regarded as a digital currency issued by the NBU
- the e-hryvnia may be characterized as a national digital currency representing a fiat currency
- the e-hryvnia must be convertible into cash or cashless money without limitations at the rate of 1:1
- the e-hryvnia is not a yield bearing instrument, and therefore, it works as a medium of exchange, not as a store of value.

The e-hryvnia could be either an anonymous CBDC or user-identifiable, since both options have their own advantages and disadvantages.

The e-hryvnia could be launched in Ukraine's payment market on the basis of one of the following two models (schemes) of interaction between participants: centralized or decentralized. If the decentralized model is chosen, the e-hryvnia may no longer fall under the definition of CBDC, because this digital currency will be issued not by the central bank, but by payment market participants under regulatory authority's supervision.

The implementation of the Pilot Project at a small scale (with a limited list of operations and users and a small number and volumes of transactions) did not enable us to analyze all pros and cons of the e-hryvnia. In particular, it is hard to forecast how many Ukrainian citizens will be using the e-hryvnia if it is decided to launch the nationwide circulation of this currency.

Still, Ukraine doubtlessly needs to move in the direction of European practice and continue to work on implementing innovative payment technologies.

3. Implementation of a pilot project of creating the platform and issuing the e-hryvnia

In 2018, the NBU implemented a pilot project that envisaged creation of the Electronic Hryvnia platform (the "Platform"), issuance of a limited amount of the e-hryvnia and testing of e-hryvnia transactions made by the NBU personnel and companies participating in this project (the "Pilot Project").

The Pilot Project continued from February to December 2018, in particular:

- February-August 2018: preparatory part
- September-December 2018: practical part
- November-December 2018: statistical data processing and analysis of results.

The NBU's e-hryvnia research had the following objectives:

- testing the distributed ledger technology (DLT) as the technological basis for the issuance and circulation of the e-hryvnia
- testing the NBU's capability to implement projects of this kind
- studying legal aspects of the e-hryvnia issuance by the NBU
- analyzing macroeconomic effect from the e-hryvnia issuance by the NBU
- working out an optimal business model advantageous for all participants of the e-hryvnia ecosystem
- analyzing international experience in the issuance of digital currencies by central banks.

Two working groups were established to implement the Pilot Project: the internal working group (comprised from representatives of the NBU's subdivisions) and the initiative group featuring volunteer representatives of companies – participants of Ukraine's payment market.

To create the Platform, the NBU selected the distributed ledger technology (DLT), in particular, its private type.

For the purposes of the Pilot Project, the centralized model of the e-hryvnia issuance was chosen as a simpler and more comprehensible and transparent model from the viewpoint of its regulation.

It was also decided that the Pilot Project shall be implemented within the existing legal framework regulating circulation of e-money in Ukraine (including transaction limits) deemed sufficient to study technology and perform transactions in the product environment.

The Pilot Project was implemented by the NBU's internal human resources and IT infrastructure and by members of the initiative group.

For the duration of the e-hryvnia's pilot testing, zero fee rates were set for all transactions using the e-hryvnia. The business model of e-hryvnia will be further worked out together with payment market participants.

4. Assessment of the outcomes of the pilot project for creation of the Platform and issuance of the e-hryvnia

During the Pilot Project's practical part (September-December 2018), the NBU issued a limited amount of the e-hryvnia (the equivalent of UAH 5,443) and the project's participants performed the following operations:

- creating their own e-wallet
- installing a mobile app for e-hryvnia wallet in their own devices running on Android or iOS
- refilling their e-wallet by a cashless method using a PROSTIR card via a specialized virtual terminal integrated with the Platform
- making P2P e-hryvnia transfers between e-wallet
- merchant transactions (topping-up LifeCell mobile phone account with the e-hryvnia)
- effecting charitable donations to help the Joint Forces Operation in the Donbas
- exchanging the e-hryvnia into cashless money using a PROSTIR card.

According to a general assessment of the basic technological solution used to implement the Platform, it can be considered suitable to perform the required tasks. At the same time, there are no fundamental advantages in using specifically the DLT technology to build a centralized e-hryvnia issuance system.

From the technical point of view, the Platform's functioning was regular. After certain improvement based on identified bugs and features, it could be used to service the issuance and circulation of the e-hryvnia, in case of proper monitoring and technical administration.

A detailed description and outcomes of the Pilot Project are provided in Sections 4 and 5 hereof.

1. Central Bank Digital Currencies

1.1. The Essence of Central Bank Digital Currency as the Next Evolutionary Form of Money

The issuance of digital currencies by central banks has been widely researched in recent years. The reasons for this interest include, in particular, a surge in the significance of innovations in the financial sector, the advent of new payment technologies and services, and the desire to increase the transparency, speed and convenience of settlement transactions and decrease the share of cash in circulation in the economies worldwide.

According to the definition of the European Central Bank, ***central bank digital currency*** means publicly-accessible digital form of fiat currency issued by the state and having legal tender status [16].

The Bank for International Settlements defines CBDC as a central bank liability, denominated in an existing unit of account, which serves both as a medium of exchange and a store of value [4].

The International Monetary Fund regards CBDC as a digital form of existing fiat money issued by the central bank that could be legal tender [2].

Turning back to classical functions of money, it should be noted that money performs the following major functions: a measure of value, a medium of exchange, a payment instrument, a store of value, and world money.

Depending on the scheme of use, CBDC should efficiently perform the functions of fiat money. In particular, CBDC in accounts can serve as a medium of exchange (CBDC accounts can be opened both at the central bank and at commercial banks in line with the public-private partnership). Yield bearing CBDC can provide a secure store of value with rate of return similar to the risk-free assets, such as short-term government securities.

Furthermore, CBDC can have additional benefits comparing to cash and cashless money. In particular, this covers the improved security, since all accounts are stored in the central bank.

For a better understanding of the essence of CBDC, let's take a closer look at the classification criteria of money based on the form of issuance. Money can be issued in physical (banknotes and coins) or electronic form (stored in electronic form).

In turn, money stored in electronic form can be divided by:

- payment technology (or type of verification): classical (centralized) and distributed ledger (decentralized) technologies
- value: either fixed or variable value of CBDC unit against fiat money unit
- accessibility: broad or limited access
- identifiability: identified or anonymous.

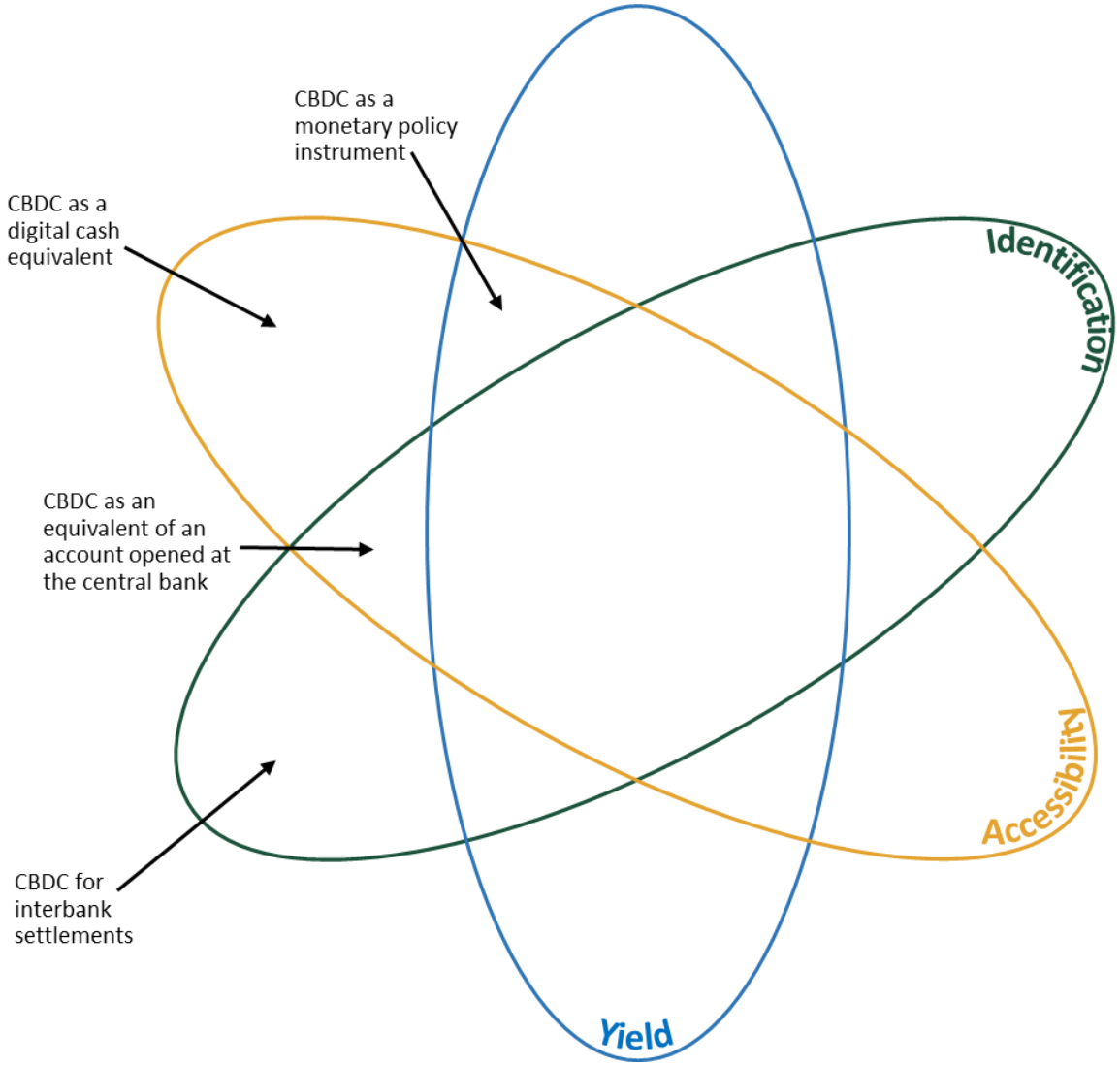
Due to rapid development of the financial sector and emerging market players using innovative solutions, the issuer criteria should be highlighted: either the central bank or another issuer.

According to the aforesaid criteria, CBDC in terms of the form of issue are money stored in electronic form, issued by the central bank with a decentralized verification type (almost always) and with a fixed value. The accessibility of CBDC depends on its issuance scheme (CBDC are accessible for specific market players or for all).

1.2. Description of approaches, schemes and types of CBDC

Most central banks use, according to their strategic goals, the architecture of own CBDC systems considering such criteria as accessibility, identification and yield bearing (ability to generate profit) [7]. Based on the Bank for International Settlements approach to Money Flower, we suggested CBDC Flower in line with the aforementioned criteria (Figure 1.1.).

Figure 1.1. CBDC schemes



According to combinations of CBDC criteria, researchers define the following schemes of using this currency:

- CBDC for interbank settlements
- CBDC as a digital cash equivalent
- CBDC as a monetary policy instrument
- CBDC as an equivalent of an account opened at the central bank.

Main features of each scheme are reviewed below.

CBDC for interbank settlements characterize with limited accessibility (only to banks and other potential participants of payment systems), full identification and no yield bearing. According to this scheme, therefore, CBDC represents an alternative to the existing settlement systems, in particular, interbank settlement systems (the SEP in Ukraine). The CBDC technology (probably of distributed ledgers or other) enables to carry out settlements 24/7/365 and check in real-time mode the transparency of capital flows, thus improving monitoring and management of systemic risks. This should result in costs reduction of interbank settlements support that are high now.

CBDC as a digital cash equivalent retains the inherent features of cash, such as transfer between individuals without intermediaries; it operates as a universal means (instrument) of payment, meaning that everyone has the right to possess, store and use it; and it is completely anonymous and not yield bearing. The complete anonymity may cause concerns that CBDC is practically impossible to restore if lost or stolen, but at the same time, CBDC is much more difficult to steal or lose than cash. A substantial benefit of using CBDC according to this scheme is increasing speed and lower transfer costs.

CBDC as a monetary policy instrument is universally accessible (any person has the right to store and use this type of CBDC), anonymous and, unlike the previous schemes, yield bearing. Therefore, this CBDC scheme enables to change the total value of CBDC by converting it into a profit-generating instrument. CBDC as a yield bearing instrument can cause revolutionary changes in the monetary policy.

However, the implementation of CBDC under this scheme is extremely complicated, in order to be suitable instrument for different conditions, CBDC interest rate must potentially be negative under certain conditions, thus ruling out the simultaneous existence of both CBDC and cash.

CBDC as an equivalent of an account opened at the central bank is universally accessible, identified and no yield bearing. The identification and storage at the central bank makes this CBDC scheme extremely secure comparing to cash and other CBDC schemes. This CBDC scheme is transparent, and it can be potentially used by the government in times of financial turmoil.

1.3. Approaches to Legal Regulation and Management of CBDC

Regulation of CBDC by the central bank depends on the selected CBDC scheme and its inherent settings. At the same time, some general points need to be addressed in certain CBDC schemes.

CBDC for interbank settlements requires definition of the criteria for participation of banks and definition of standard operating procedures.

CBDC as a cash equivalent requires mitigation of risks associated with anonymity of this currency [primarily, anti-money laundering (ALM) and Know Your Customer (KYC), setting limits on transactions, and resolving taxation issues]. At the same time, the division of responsibility regarding KYC between the central bank and commercial banks should be taken into consideration. Also, the possibility of increasing burden on the central bank due to shifting responsibility for KYC from commercial banks to the central bank should be studied, and if possible, this responsibility of the central bank should be offset or assumed and the appropriate regulatory framework should be created.

CBDC as a monetary policy instrument requires definition of the possibility and criteria for changing the interest rate.

CBDC as an equivalent of an account opened at the central bank requires definition of the confidentiality level.

In general, CBDC regulation should enable the coexistence of CBDC with conventional forms of money, also depending on the functions assigned to a specific type of CBDC.

1.4. Technological options behind CBDC

Most surveys of central banks on CBDC show that the distributed ledger technology (DLT) is regarded as a possible and even primary technology.

According to definition by the Bank for International Settlements, DLT refers to the protocols and supporting infrastructure that allow computers in different locations to propose and validate transactions and update records in a synchronized way across a network [19]. DLT do not have a centralized data warehouse or a centralized administrative function (unlike classical database), which means that the main feature of this technology is decentralization. Table 1.1 compares DLT and conventional databases.

Table 1.1. Comparative analysis of DLT and conventional databases

DLT	Conventional databases
Decentralization means no single center of trust and the means for any person to check any transaction, making the system transparent and reducing the time of transactions	Centralization means data storage is assigned to a limited number of participants – specifically designated administrators, which limits transparency comparing to DTL, improves security and increases transaction time
Sustainability/security means data cannot be changed and the system security ensured by a special infrastructure and firewalls become redundant. All data in the chain is already encrypted and cannot be manipulated. In other words, data stored in the block is stable and secure, which enables automatic payment transactions (confirmation is no longer needed)	Vulnerability means a mandatory infrastructure and firewalls for personal data protection and sustainability of the system
Accuracy means the longer information is stored in the registers (chains), the more secure it becomes, since more users confirm it. All stored data is subject to automatic verification	Risk-proneness means the longer information is stored, the more storage risks it becomes prone to

1.5. Expected Impact and Risks of Introducing CBDC

Depending on the scheme used, CBDC has certain inherent pros and cons. As for cons, they have potential negative effects for end consumers or for the banking system in general (Table 1.2).

Table 1.2. CBDC Impact in different CBDC schemes

CBDC scheme	Impact on the end consumer	Impact on the banking system
CBDC for interbank settlements	Banks = end consumers Positive	
CBDC as a digital cash equivalent	Positive: potential user-friendliness and speed of use; security (settlements guaranteed by the government)	Mixed: higher speed and convenience of payments; possible liquidity outflow from the banking sector to CBDC
CBDC as a monetary policy instrument	Mixed: security profitability or unprofitability depends monetary policy	Mostly positive: adaptability, flexibility
CBDC as an equivalent of an account opened at the central bank	Positive: security	Mixed: transparency; possible liquidity outflow from the banking sector to CBDC

In general, CBDC-inherent risks can be classified as follows:

- technology risk:
  - possible problems and disruptions with the CBDC platform
  - no access to technological solution (or technical resources), e.g. due to absence of Internet access
- cybersecurity risk:
  - low controllability of technologies (unauthorized access in case of DLT)
  - no setting to restore lost (stolen) money
- monetary policy implementation risk:
  transfer of liquidity from the banking system to the central bank (for certain CBDC schemes)
- risk of undermining financial stability:
  - negative impacts on liquidity and resilience of the banking system in case of outflows (especially, major outflows) from customer accounts to the central bank (for certain CBDC schemes)
  - anonymity of customers, which can aggravate the shadow economy and exploitation of resources for illegal purposes (violation of AML/KYC)
- reputational risks for the central bank:
  - if CBDC fails to become widely distributed and used, or if certain risks materialize during the use of CBDC, resulting in negative consequences
  - poor quality of introducing or implementing CBDC as a product
    reduced capacity for performing untypical functions

The central bank has the following options to mitigate the aforementioned risks:

- selecting of effective CBDC model adequately suitable to strategic goals of the central bank
- harmonizing CBDC with conventional forms of money (fiat money)
- cooperation between the central bank and players of the banking and financial markets in developing and introducing CBDC.

1.6. Central Banks are Considering the Possibility of Issuing CBDC

Countries of the world whose central banks are mulling the issuance of CBDC today can be conditionally divided into three groups:

- countries studying CBDC
- countries that have taken practical steps toward the issuance of CBDC
- countries criticizing CBDC or discontinuing the research in this field (Figure 1.2.).

The practice of implementing CBDC by various countries often proves that classification of CBDC based on the schemes of use mentioned in paragraph 1.2 is conditional. Depending on particular goals, certain countries may introduce an own CBDC based on “hybrid” schemes of use that simultaneously contain features of various schemes. There are also examples when a country started to study CBDC based on one scheme of use but later transformed it into the study of other schemes.

Detailed information with a breakdown by countries studying CBDC is provided in Annex 1, while some examples are briefly outlined below.

Thus, the Bank of England studies various models of yield bearing CBDC as a monetary policy instrument (CBDC is considered an equivalent of bank deposits). The central bank’s study is focused upon the impact of CBDC on the resilience of the banking system.

China has assigned a specialized laboratory to study the possible issuance of CBDC. Two types of CBDC are under consideration, including interbank settlements and cash equivalent. During the last year alone, the People’s Bank of China has registered over 40 patents associated with various aspects of creating a CBDC system (technologies, e-wallets, etc.). At present, pilot testing is under consideration.

The experience of Sweden is very interesting, where the use of cash is minimized today. Presently, Sveriges Riksbank is close to start issuing the e-krona, a digital equivalent of cash. Being easy and convenient to use, the e-krona must become more attractive than banknotes and coins, and therefore, it would allow cash not to disappear from circulation altogether but evolve into a new digital form. Sveriges Riksbank’s next steps in the e-krona project are further development of the technical solution suitable for supporting CBDC, amending laws in order to define the legal framework for CBDC, continued research of the monetary aspect of CBDC.

Countries actively researching the issuance of CBDC also include Australia, Denmark, New Zealand, and Norway.

At present, financial regulators in Estonia, Ecuador, and Japan (jointly with the European Central Bank) have declined the idea of issuing an own digital currency for various reasons. The central banks of Switzerland and South Korea are also skeptical about issuance of CBDC. Among the probable reasons is the unpredictable impact of CBDC on macroeconomic situation and financial stability.

On the other hand, there are pioneering states introducing CBDC for practical use. In Senegal and Tunisia, projects are

underway on the issuance of CBDC as an equivalent of accounts opened at the central bank.

The regulator in Singapore has launched Ubin, a project of using CBDC for interbank settlements. A similar project titled Jasper Project is being implemented by the Bank of Canada. As part of their partnership, the regulatory authorities of these two countries have performed the first cross-border transaction using CBDC. According to their joint statement, the purpose of these projects is to increase the speed and security and reduce the cost of these transactions.

In 2018, the government of Venezuela commenced the issuance of El Petro cryptocurrency, a publicly available, identifiable and profit-generating instrument. However, it cannot be considered CBDC, since its exchange rate is fixed not to the exchange rate of the domestic currency but rather to energy prices, and moreover, it is issued by the government and not the central bank.

The main reasons for considering the issuance of CBDC as a cash equivalent are shown in Table 1.3.

Figure 1.2. CBDC in the world

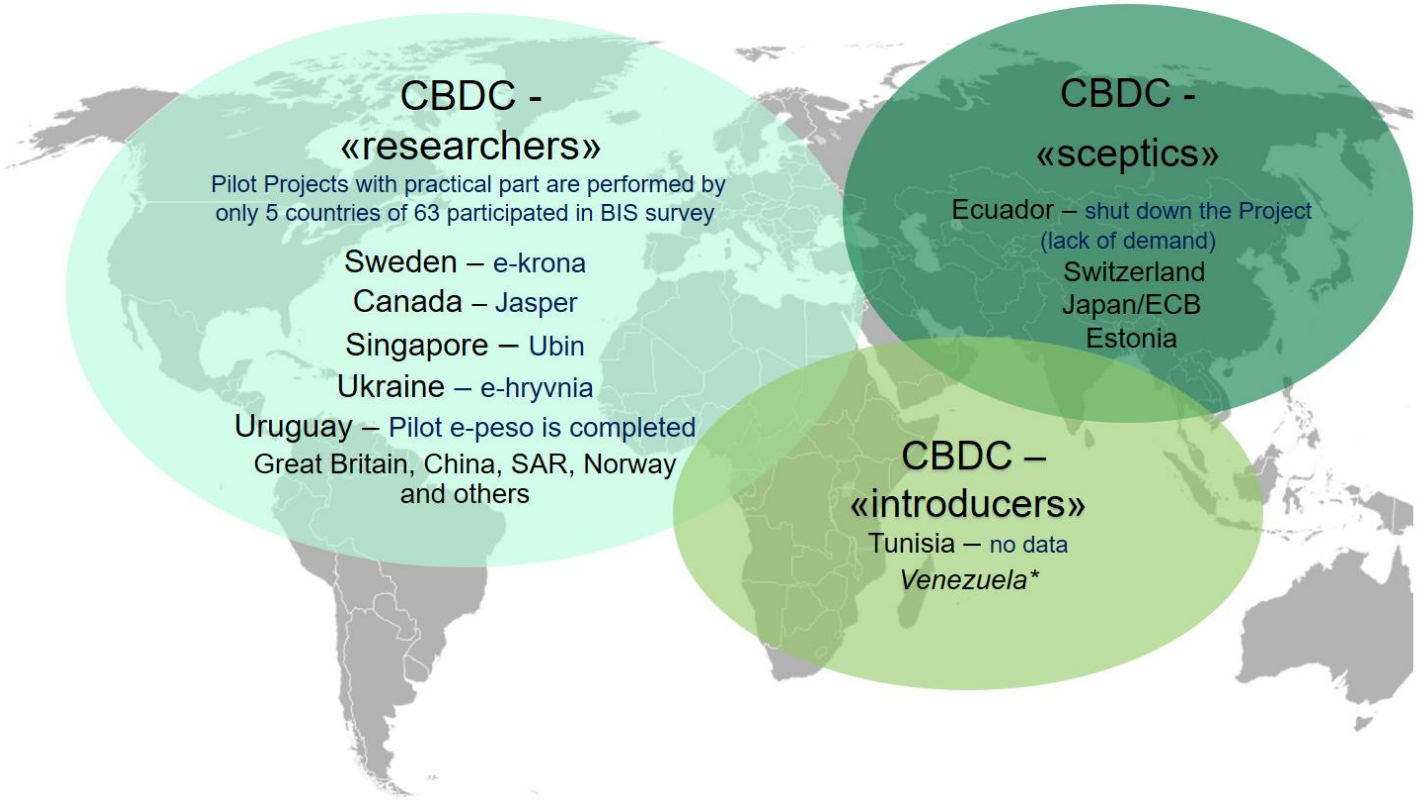


Table 1.3. Expected outcomes of introducing CBDC [2]

Country	Growing financial inclusion	Cost cutting	Decline of cash use
The Bahamas	✓		
Canada			✓
China	✓	✓	✓
Ecuador		✓	
Norway			✓
Senegal	✓		
Sweden			✓
Tunisia	✓		
Uruguay	✓	✓	

2. Prerequisites for Issuing CBDC by the NBU

2.1. Payment Landscape of Ukraine

Payment systems play a leading role in the economy of the country, ensuring transfer by the entities of funds and payments under obligations arising in the process of economic activity. The reliability and efficiency of payment systems is a guarantee of a stable functioning of the financial system and the economy of the country as a whole.

At the end of 2018, there were 42 domestic and international payment systems in Ukraine established by residents and nonresidents, as well as two systems established by the NBU. Among them, in particular: The System of Electronic Payments of the National Bank of Ukraine (SEP), payment card schemes (domestic NPS PROSTIR and international MasterCard, VISA and UnionPay International) and money remittance services (Figures 2.1, 2.2).

Figure 2.1. Number of payments and transfers within Ukraine, million pieces

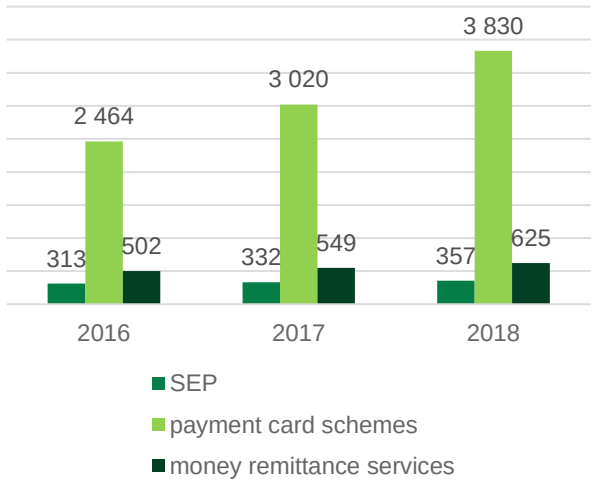
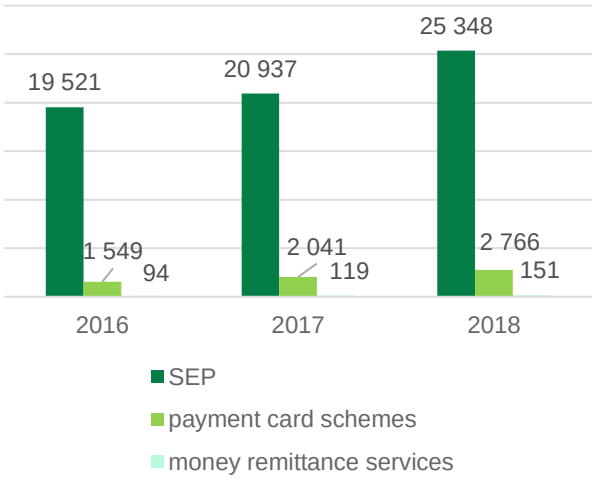


Figure 2.2. Volume of payments and transfers made within Ukraine, UAH billion



The only systemically important payment system in Ukraine is the NBU SEP, which:

- is the only system of interbank transfers in the country and provides more than 97% of interbank transfers in domestic currency within Ukraine (on average 1.4 million payments for UAH 101 billion are made per day)
- has a significant number of participants, including 77 banks of Ukraine and the bodies of the State Treasury
- is an infrastructure and technological basis for implementation of the monetary policy of the NBU, cash execution of the budget of Ukraine, and transactions with government securities.

At the same time, the largest number of operations within Ukraine is carried out in card payment systems with the use of payment cards, and therefore, their disruptions can negatively affect the public confidence in the banking system of the country and the national currency.

As of January 1, 2019, the number of payment cards issued by the Ukrainian banks amounted to 59.4 million pieces, of which 62% (or 36.9 million pieces) - active payment cards.

Each ninth active payment card in Ukraine is contactless - 4.0 million pieces (an increase by 44.3% compared with the beginning of 2018).

The key indicator of the development of the cashless economy is the share of cashless transactions within the total volume of transactions with payment cards, which following the results of 2018 amounted to 45.1% (according to the target indicators of the Cashless Economy project in 2020 it should be 55%).

Important factors for the stable development of cashless transactions are extensive payment infrastructure. In 2018, the network of trade payment terminals increased by 20.2% to 279,000.

The indicator of the ratio of the number of payment terminals and the number of the permanent population of Ukraine for

the year increased by 18% and as of 1 January 2019 amounted to 7,100 pieces per 1 million people.

At the same time, the uneven distribution of the terminal network in Ukraine and the insufficient level of its penetration are still there: the ratio of the number of payment terminals to 100,000 people today is lower than in neighbouring countries (in particular, Poland, Romania, Kazakhstan).

Contactless payment services using smartphones and other devices that support NFC technology become more and more popular in Ukraine. Tokenization services allow you to use the details of payment cards (including the magnetic stripe) for contactless settlements using this technology.

Also, over the past year, thanks to the popularization of innovative services such as Apple Pay and Google Pay, functioning in Ukraine, the number of contactless payment trading terminals has increased. Currently, 79.4% of POS-terminals in Ukraine provide an opportunity to make contactless payments (as of January 1, 2018 - 70.2%).

From the beginning of 2018, the number of ATMs (including deposit-taking ATMs) almost did not change, and as of January 1, 2019 it amounted to 20,000 pieces. The number of self-service kiosks (SSK) decreased by 3% as compared to the beginning of the last year and amounted to 16,600 pieces

In 2018, using of money remittances systems created both by residents and non-residents, were transferred the following amounts: within Ukraine – UAH 150.5 billion, or USD 5.5 billion (in equivalent); in Ukraine – USD 2,301 million (in equivalent); beyond Ukraine – USD 294 million (in equivalent).

The largest amount of transfers within Ukraine (USD 1.4 billion in equivalent, or 25.2%) was made using the Postal Transaction money transfer system (payment organization - Ukrposhta PJSC). At the same time, almost half of all transfers within Ukraine (46.5%, or USD 2.6 billion in equivalent) were made by POST FINANCE LLC.

An important part of the payment infrastructure are self-service kiosks (SSK) that satisfy the need of the population in making cash payments (refilling of accounts in banks, topping-up mobile accounts, payment for utilities, etc.) 24 hours a day, 7 days a week. Such SSK are installed by banks, their commercial agents and nonbank financial institutions that have received a license from the NBU for the transfer of funds.

2.2. CBDC as Innovative Means (Instrument) for Retail Payments

Financial inclusion is one of the seven strategic objectives of the NBU in accordance with the Strategy of the NBU presented in March 2018.

According to the World Bank's calculations, in 2017, among the adult population of Ukraine, 37% did not have any bank accounts and did not use financial services, which indicates the still low level of financial services availability for Ukrainians.

In this aspect, projects "Improving the level of financial literacy of the population of Ukraine" and "Cashless economy" are the priority for the NBU.

For the Ukrainian payment market, the current issue is the introduction of an affordable, cheap, secure and functional instrument for retail payments for small amounts by individuals.

In the conditions of the existing payment landscape and infrastructure built by participants in the market, the most massive online instrument for making retail cashless payments is a payment card.

Innovative payment technologies and relevant infrastructure play a key role in the development of the cashless economy. Since today there is no possibility in Ukraine to make interbank instant payments in the format of 24/7 using bank accounts, and payment cards are the most common national settlement instrument with available relevant infrastructure, there is a tendency to increase the amount of funds transfer person-to-person (P2P) transactions. P2P transfers are gaining popularity, on the one hand due to the introduction of convenient and affordable services by both Ukrainian banks and nonbank payment organizations, on the other - in the absence of alternative technologies.

Due to the developed payment infrastructure, payment card holders have the opportunity to conveniently pay for goods and services in stores and the Internet. At the same time, payments using payment cards have their drawbacks.

In particular, card payment systems are characterized by the high cost of creating and operating a payment infrastructure for participants in these systems, which ultimately affects the value of card products for holders of payment cards, and may also affect the final value of a product or service due to a rather high level of penetration of cashless settlements.

For traders, a topical issue is a matter of high cost of servicing cashless transactions, which is the result of high rates of interbank commission (interchange) in Ukraine.

For the customers of the Ukrainian banks the cost of transfers between the cards (P2P) is relatively high.

Another instrument for retail payments in Ukraine is ***electronic money***. In accordance with the legislation of Ukraine, electronic money is used to pay for goods and services and P2P transfers made between users-individuals,

and partially close the need for quick settlements for small amounts.

At the same time, the amounts of operations using electronic money are limited by the limits established by the current regulatory legal acts of the NBU.

In 2018, compared with 2017, issuing banks increased: the volume of issued electronic money - from UAH 59.9 million to UAH 83.2 million (by UAH 23.3 million or by 40%); the volume of transactions with electronic money - from UAH 2,931 million to UAH 7,225 million (by UAH 4,294 million, or nearly 2.5 times); the number of "electronic wallets" - from 52.9 million pieces to 62.7 million pieces (by UAH 9.8 million, or by 19%).

Today, 23 banks of Ukraine have the right to issue electronic money. In accordance with the legislation of Ukraine, in order to ensure the issuance of electronic money and the implementation of operational and technological functions, the bank may, on the basis of the agreement, engage another legal entity, a payment infrastructure service provider, who will be entered into the Register of payment systems, settlement systems, participants of these systems and payment infrastructure service providers.

The legislation of Ukraine assigns control over the observance of the limits on operations with electronic money, the rules for the use of electronic money by all legal entities, as well as the functions of financial monitoring to issuing banks.

Electronic money issuance is also possible using prepaid cards (a relatively expensive instrument for participants) and electronic wallets systems (cheaper).

Electronic money of one issuer functions separately from electronic money of other issuers. However, the legislation of Ukraine provides for the exchange of electronic money issued by different issuers. The banks are entitled to carry out such transactions.

At the same time, despite the existing advantages, electronic money in the Ukrainian payment market did not become a massive instrument for retail payments for users - individuals. Instead, there is a demand for electronic money from market participants in order to optimize their operational activity.

In order to make cashless intrabank and interbank transfers in the national currency within Ukraine, ***payment orders*** are used.

At present, 97% of interbank transfers within Ukraine are made through the NBU SEP, while through correspondent accounts opened by banks in other banks, - 3% of such transfers.

Transfers within the same bank are carried out using ABS Bank.

As part of the modernization of the ***NBU SEP*** and the transfer of the Ukrainian payment infrastructure to the international standard ISO 20022, the NBU is considering the ***introduction of "instant" payments***, which will allow significant increase of their conduct speed.

By harmonizing Ukrainian legislation with the EU Directive PSD2, the NBU plans to implement the concept of ***Open Banking***, which should give impetus to the emergence of new instruments for retail payments in Ukraine.

Cash remains a popular settlement instrument in Ukraine. It is easy to use, available and widely distributed: as of 1 January 2019, cash totaling over UAH 400.1 billion was in circulation, the total number of banknotes per capita was 69 notes, and the small coins - 293 coins.

At the same time, the use of cash as an anonymous means of payment contributes to the growth of the shadow economy of the country. In addition, the state incurs high costs for manufacturing cash and servicing its circulation. In this regard, the NBU initiated the implementation of measures to narrow the scope of use of cash.

The digital currency, in particular, CBDC, is considered as an alternative means (instrument) for making instant payments for small amounts by individuals in the Ukrainian market.

The benefits of such CBDC for the user should be:

- optimal tariffs
- ease of use
- quick receipt of user status
- safety: repayment and settlements are guaranteed by the NBU
- protection of technologies
- settlement speed.

The introduction of such an innovative means (instrument) as CBDC will contribute to the achievement by the NBU of the following objectives:

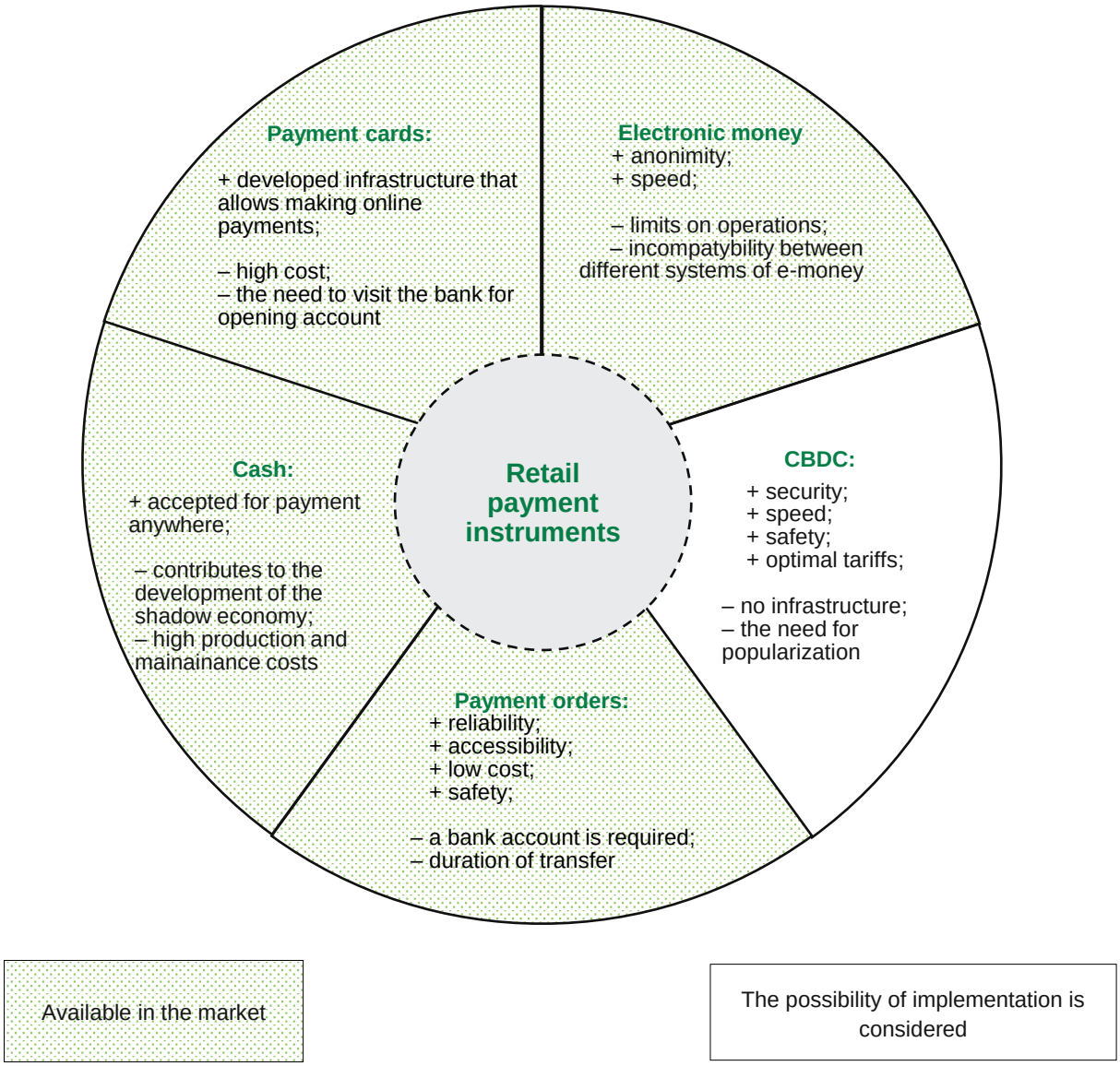
- increase of financial inclusion level
- reduction of the share of cash payments in circulation
- increase of the speed and convenience of cashless payments and the level of protection of financial services
- increase of the competitiveness of payment services
- increase of transparency of settlements in the state
- reduction of retail cashless payments value in Ukraine, comparing first of all with the cost of payments using payment cards.

At the same time, it is hard to find application in the current payment landscape for CBDC without significant investments in creating a retail payment infrastructure in Ukraine for servicing operations with CBDC.

Another open question is the need to popularize CBDC as a new instrument among the population.

The comparison of CBDC with other forms of money, as well as existing instruments and means of payment in the Ukrainian market, is presented in Annexes 2-4.

Figure. 2.3. Instruments and means for retail cashless payments in Ukraine



2.3. E-Hryvnia – CBDC as Cash Replacement

At the end of 2016, the NBU began studying the possibility of issuing its own CBDC – "electronic hryvnia" (hereinafter – "e-hryvnia") and finding an alternative instrument for making instant and cheap payments in line with current trends in central bank activities.

For the study, the model of CBDC as the equivalent of cash was selected, which assumes that e-hryvnia:

- is considered as a digital form of money issued by the NBU

- is characterized as a national currency, which is fiat money
- must be exchanged without limitation for cash or cashless funds in the ratio of 1:1
- is not a profit-generating instrument, therefore it is considered a means of payment, not accumulation.

Today, the NBU is considering the possibility of issuing an anonymous and identified CBDC, as each option has its advantages and disadvantages. At the same time, the option of an anonymous CBDC for the NBU is not a priority.

2.4. Possible Models of E-Hryvnia Issuance

The NBU is considering introducing e-hryvnia on the Ukrainian payment market under two alternative models (schemes) of interaction of participants: ***centralized*** or ***decentralized***. Below, the figures show the features of the structure and functional distribution in the models.

1) The centralized model (Figure 2.4) implies that the issuer of e-hryvnia is the NBU. E-wallets are accounted for in the single centralized registry of the Platform, the owner and operator of which is solely the NBU. The decision to include any transaction in the register (validation of the transaction) is taken solely on the information resources of the NBU.

Other banks and non-bank financial institutions in accordance with this scheme are agents for the settlements and distribution of e-hryvnia, provide users with access to the Platform through their Internet resources, provide customers with other services: secure key storage, applications for mobile devices, user-friendly presentation of information on customer transactions, etc.

Individual users can receive an innovative instrument for quick payments for small amounts, which has a number of advantages over payment cards and electronic money.

Repayments and settlements are guaranteed by the NBU, which makes e-hryvnia the most protected payment instrument.

E-hryvnia wallets can be both identified and anonymous, which may affect the size of the limits for transactions with e-hryvnia compared to limits on transactions using electronic money.

Figure 2.4. Centralized model of issuance and circulation of e-hryvnia

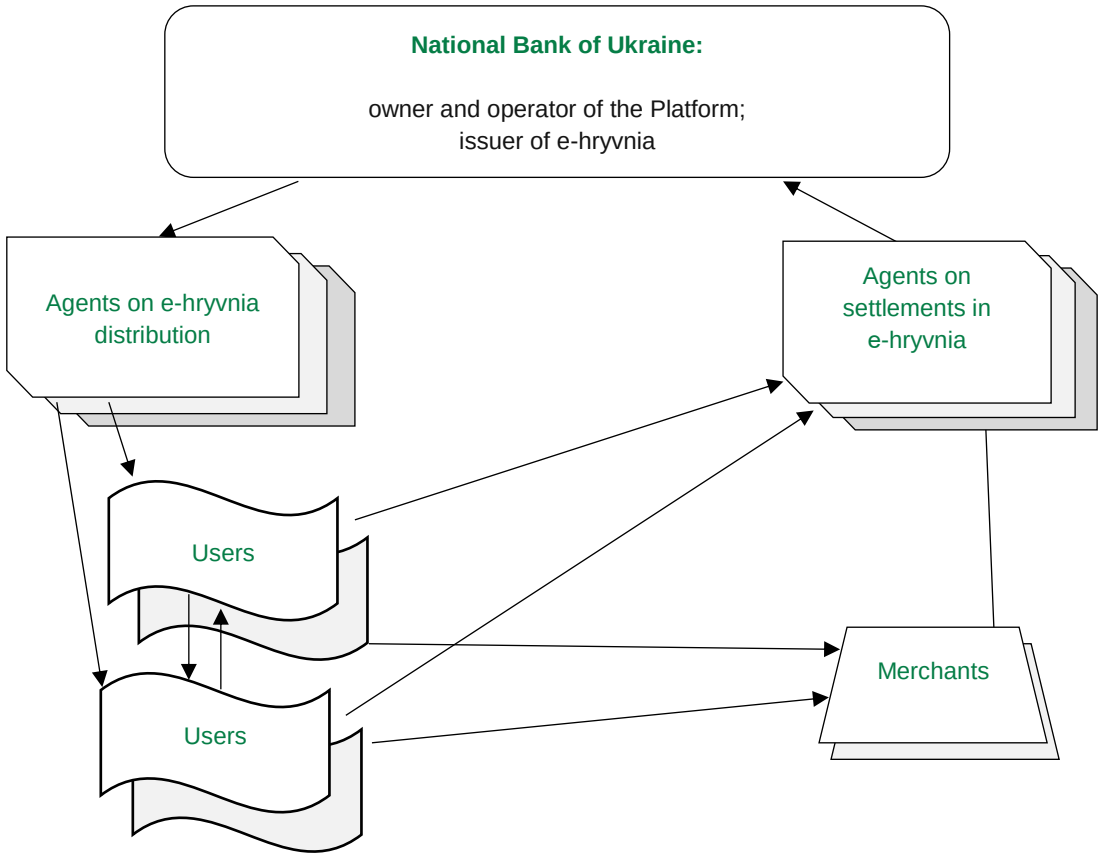


Table 2.1. Advantages and disadvantages of the centralized model of issuance and circulation of e-hryvnia

− Disadvantages (open issues)	0	Advantages +
NBU		
• Servicing individuals, the NBU will perform a noncore function (including dispute resolution). • The NBU will need to allocate resources for creating and maintaining the Platform, as well as for the promotion of this instrument. • Legal framework is needed.		• The scheme is transparent in terms of its control and regulation. • The share of cash in circulation will decrease.
Users		
• If wallets are anonymous, the limits will be applied.		• The central bank will provide a guaranteed payment instrument. • If wallets are anonymous, the bank identification is not needed.
Banks and nonbank financial institutions		
• There is a risk that liquidity will be flowing to the central bank rather than staying with participants of the banking system. • The attractiveness of the business model is questionable.		• When using the blockchain platform, the cost of the required infrastructure is potentially lower compared with the card payment schemes.

2) The decentralized model (Figure 2.5) provides that banks and non-bank financial institutions (hereinafter – Issuers) are entitled to issue e-hryvnia under the control of the NBU. E-wallets of customers, traders, agents are being decentralized

- separately in the information systems of each of the Issuers. The NBU provides for the possibility of using the e-hryvnia of one Issuer in the networks of traders and/or agents on settlements of other Issuers and the settlements under transactions in e-hryvnias between the Issuers. Issuers in their e-hryvnia service systems can maintain both model without identifying users of e-hryvnia, and with partial/complete user identification.

In this case, e-hryvnia will no longer meet the criteria of the CBDC, since the issue of this digital currency will be carried out not by the central bank, but by other institutions.

Such a model may be attractive for participants in the payment market, primarily for non-bank financial institutions. With the use of identified e-wallets, they could become a kind of "analogue of current accounts" that would open and run non-bank financial institutions under the control of the NBU, and become a competitive alternative to electronic money systems that are currently operating on the Ukrainian market.

Figure 2.5. Decentralized model of issuance and circulation of e-hryvnia

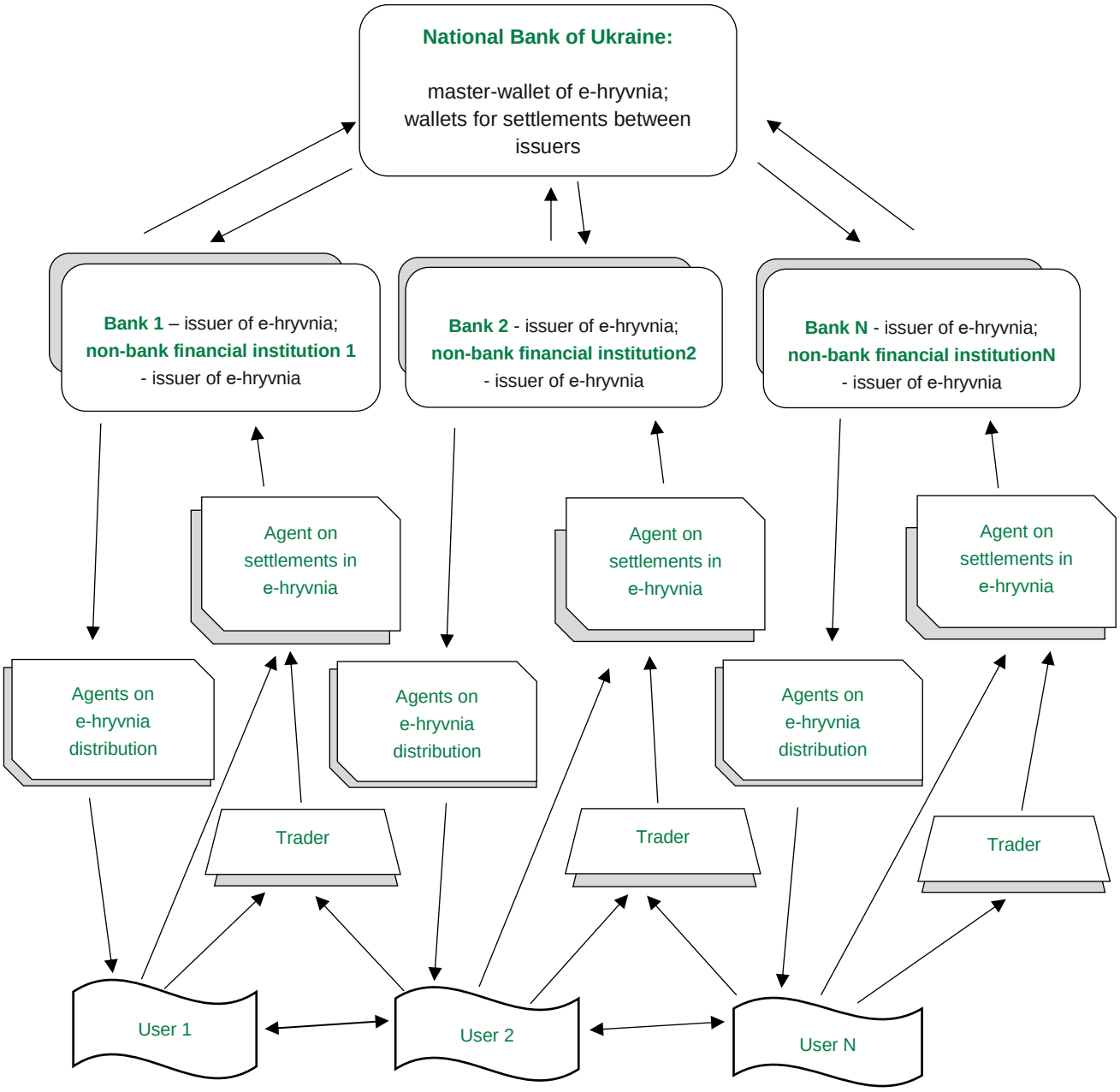


Table 2.2. Advantages and disadvantages of the Decentralized model of issuance and circulation of e-hryvnia

− Disadvantages (open issues)	0	Advantages +
NBU		
To put the issued e-hryvnia in circulation, the NBU will need • to resolve a number of issues, including building up guarantee deposits and establishing an institution similar to the DGF. • to draft admission criteria and a permit/licensing procedure for banks and nonbank financial institutions that wish to issue e-hryvnia.		• fee and commissions income for servicing operations of various issuers. • reduced share of cash.
Users		
• If wallets are anonymous, the limits will be applied.		• If wallets are anonymous, the bank identification is not needed.
Bank		
• The Platform, if joined by the bank, can absorb existing electronic money services of the bank. • Significant investments have already been made to build banks' own customer services.		• The model eliminates the risk of liquidity flowing from in the banking system participants to the central bank.
Nonbank financial institutions		
• The Platform, if joined by the NBFI, can absorb existing electronic money services of the NBFI. • New investments are needed for building a new payment infrastructure (significant investments have already been spent on building NBFIs' own customer services).		• The model provides an opportunity to loosen limits for operations with e-hryvnia in comparison with the limits on operations using electronic money, established by the current NBU's regulations, provided identification is done of users of e-hryvnia. • The model provides interoperability of different issuers (as opposed to the incompatible systems of electronic money that operate today in the payment market of Ukraine).

2.5. Business Model of E-Hryvnia Transactions

In order to scale e-hryvnia in the real life and business conditions, it is necessary to develop a full tariff/commission model that will take into account the interests of all participants: individuals, traders, banks and non-bank financial institutions.

The basic requirements for such a tariff model:

first, it should create a real motivation for all participants in switching to payments using e-hryvnia

second, it should take into account different interests and maintain a balance of motivations for all participants in the ecosystem

third, a tariff model should provide the most affordable payments for users.

In particular, for the centralized model of issuance and circulation of e-hryvnia, fees for refilling of e-wallets and the repayment of e-hryvnia may be established, which should render e-hryvnia operations cost-effective for distribution and settlement agents.

Transfers of e-hryvnia between users can be free of charge, and the cost of accepting e-hryvnia for traders as payment for goods and services provided should not exceed 1% of the transaction amount, create an advantage for e-hryvnia over other existing payment instruments, payment cards.

Table 2.3. Examples of commission rates for e-hryvnia transactions (for the centralized model of issuance and circulation of e-hryvnia)

Current situation in the market:	E-hryvnia:
For merchants:	
▪ ~ 1.8-2.1% + UAH 250 - the cost of cashless transactions (payment for goods and services) ▪ ~ 0,1-0,5% - the cost of storage and transportation of cash.	▪ up to 1.0% – cost of transactions with e-hryvnia (payment for goods and services).
For individuals:	
▪ ~ 1% + UAH 5 – person-to-person transfers (P2P) ▪ 1% + UAH 19 – postal transfer by Ukrposhta to the address of the recipient ▪ ~ 0.3-2% – transfer using Internet banking ▪ 1% (minimum UAH 10) – transfer using a payment order ▪ ~ 1.5% + UAH 5 – withdrawal of cash at ATMs of other banks.	▪ 0% – transfers between e-wallets ▪ 0.5% – purchase of e-hryvnia (of them 0.05-0.1% system fee, 0.4% – agent's fee) ▪ 0.5% – repayment of e-hryvnia (of them 0,05-0,1% – system's fee, 0.4% – agent's fee).

3. Pilot Project on Establishing Platform and Issuing E-Hryvnia

3.1. General Information on Pilot Project

In 2018, the NBU implemented the project titled Implementation of the Electronic Hryvnia Platform and Electronic Money of the National Bank of Ukraine (E-Hryvnia). Stage 1: Pilot Project approved by the decision of the Change Management Committee dated 26 February 2018.

Pursuant to the NBU Board Decision No. 602-D On Carrying Out the Pilot Project on Implementation of the Electronic Hryvnia Platform and Electronic Money of the National Bank of Ukraine dated 6 September 2018, the NBU initiated the active phase of the project in production environment using cashless hryvnia and involving a broad range of users.

3.2. Pilot Project Goals

Under the Pilot Project, the NBU was pursuing the following goals:

- to test the distributed ledger technology (DLT) as a technological framework for e-hryvnia issuance and circulation
- to test the NBU's capacity to implement similar projects
- to study the legal aspects of e-hryvnia issuance by the NBU
- to analyze the macroeconomic effect of e-hryvnia issuance by the NBU
- to design a business model that would be beneficial for all members of the e-hryvnia ecosystem
- to analyze international experience in issuance of digital currencies by central banks.

3.3. Organizational Support to Pilot Project

Two working groups were established to implement the pilot project, namely:

The internal working group made of representatives of NBU structural units:

- Payment Systems and Innovative Development Department
- Strategy and Reforming Department
- Information Technologies Department
- Security Department
- Accounting Department
- Operational Department
- Legal Department
- Monetary Policy and Economic Analysis Department.

The initiative group made of representatives of the companies participating in Ukraine's payment market who volunteered with the intentions established by the Memorandum of Understanding, including:

- ATTIC LAB LLC responsible for creating the system's core, load testing, financial applications development, integration with involved participants, and technical consulting as part of further technical support to the Platform
- UAPAY LLC as a settlement agent servicing e-hryvnia payments at https://uapay.ua
- FINANCE COMPANY OMP 2013 LLC as a distribution agent providing a network of self-service devices for purchasing e-hryvnia. The company took no part in the Pilot Project due to the revocation of license from the TYME payment system.

Deloitte & Touche LLP providing consulting and expert support to the Pilot Project.

3.4. Key Actions and Timeframe of Pilot Project

The Pilot Project was implemented in February–December 2018 as follows:

- **February–August 2018:** the preparation phase that comprised drafting and approving regulatory and technological documents, taking measures to install and configure system and application software at

main servers (the Platform's core), configuring technological processes, settling information security and organizational issues, configuring the systems and software of the NBU and other participants of the Pilot Project, as well as considering matters of accounting and financial interaction with external participants of the Pilot Project

- **September–December 2018:** the practical phase that comprised e-hryvnia issuance, opening of e-wallets, and execution of e-hryvnia transactions by users in accordance with the project's target KPIs. Please see Annex 5 for the list of transactions executed through the Platform participants interaction and their short descriptions.

- **November–December 2018:** statistics processing and day-to-day analysis of the Pilot Project's results.

3.5. Business Model for E-Hryvnia Transactions

Technologically, it is possible to charge a commission fee in e-hryvnia for any transaction in line with the relevant tariffs and calculate it as a fixed amount plus interest on the transaction.

Each credit of the commission fee for an e-hryvnia transaction increases the balance of the Issuer's commission fee e-wallet. All commission fees at a commission fee e-wallet are repaid to the Issuer's e-wallet and, in line with the Issuer's current procedures, transferred to the Issuer's income accounts.

Agents servicing e-hryvnia transactions may receive commission for distribution/repayment of e-hryvnia as a fixed amount plus a percentage of the transaction amount without using the Platform.

Since project participants and the NBU had not agreed on e-hryvnia tariff/commission model in the course of respective consultations, ***zero commission fees*** were set for all e-hryvnia transactions for the period of pilot testing.

3.6 Legal Grounds for E-Hryvnia Implementation and Pilot Project Methodology

As the full-scale implementation of e-hryvnia in Ukraine's payment market would require amendments to both current laws of Ukraine and NBU regulations, a decision was made for the period of the Pilot Project to act under the framework regulating the circulation of electronic money in Ukraine as a sufficient one for studying technologies and opportunities for the NBU to implement similar solutions.

The Pilot Project was implemented in line with the Laws of Ukraine On the National Bank of Ukraine, On Payment Systems and Money Transfer in Ukraine, On Banks and Banking and the Regulation On Electronic Money in Ukraine approved by NBU Board Resolution No. 481 dated 4 November 2010 (as amended), as well as other laws of Ukraine and NBU regulations.

The NBU's legal grounds for the Pilot Project on implementation of the Platform and e-hryvnia

Pursuant to Article 7 of the Law of Ukraine On the National Bank of Ukraine, the NBU shapes the development of modern electronic banking technologies, establishes payment and accounting systems, promotes their smooth and efficient operation, ensures their development, and controls the creation of payment instruments, banking automation systems, and banking data protection systems. Thus, the Pilot Project falls under the NBU's functions as prescribed by the current laws of Ukraine. The following documents have been prepared and approved as methodological support to the project:

Methodological documents

- Concept on Implementation of the Electronic Hryvnia Platform and Electronic Money of the National Bank of Ukraine agreed by the Governor of the National Bank of Ukraine on 26 April 2018

- Provisional Regulation On Operation of the Electronic Hryvnia Platform and Electronic Money of the National Bank of Ukraine approved by NBU Board Decision No. 470-D On Approval of the Provisional Regulation On Operation of the Electronic Hryvnia Platform and Electronic Money of the National Bank of Ukraine dated 20 July 2018

- Technical requirements to the software and hardware solution "Electronic Hryvnia Platform", as agreed by the Director of the Information Technologies Department on 11 June 2018 and the Director of the Security Department on 27 June 2018 and approved by the Director of the Payment Systems and Innovations Department on 5 May 2018

- Provisional Rules for Recordkeeping of E-Hryvnia Transactions at the National Bank of Ukraine approved by NBU Board Decision No. 541-D On Approval of the Provisional Rules for Recordkeeping of E-Hryvnia Transactions at the National Bank of Ukraine dated 14 August 2018

Orders and instructions

- NBU Board Decision No. 564-D On Implementation of the Electronic Hryvnia Platform and Electronic Money of the National Bank of Ukraine dated 30 December 2016
- NBU Board Decision No. 602-D On Pilot Project on Implementation of the Electronic Hryvnia Platform and Electronic Money of the National Bank of Ukraine dated 6 September 2018
- User Guide to Creating and Using E-Wallets
- Guide to Setting the Maximum Amount of E-Hryvnia in Circulation at the Electronic Hryvnia Platform
- Guide to Generating Basic Key Data via the Electronic Hryvnia Platform.

3.7. Monetary Policy Aspects of E-Hryvnia Implementation

The Pilot Project had no macroeconomic impact, as the volume of e-hryvnia transactions was minor.

The banking system as a financial intermediary may be completely altered only if the majority of population and businesses start using e-hryvnia instead of cash and bank accounts. For now, we cannot be certain about the future of a new ecosystem.

We consider the risk of influencing inflation to be improbable, as the full-scale implementation of the domestic digital currency foresees no uncontrollable issuance of hryvnia. Over the long-term horizon, there is still a risk of the central bank losing its ability to effectively influence the macroeconomic, primarily inflation, processes if the role of banks as financial intermediaries changes, banks lose their money creation function, and thus efficiency of monetary transmission channels goes down.

The NBU will store any liquidity transferred from the banking system. However, if such flows become significant, especially during crises, the transfer of funds into e-hryvnia from customer accounts with banks may create or deepen a liquidity crisis for some banks or the banking system as a whole. This will adversely affect resilience and financial stability of banks. To prevent the banking system's liquidity crises, limits may be introduced to restrict the exchange of noncash funds for e-hryvnia.

Table 3.1. Possible impact by e-hryvnia

Scenario	Amount	Percentage
Replacement of payment cards (M1)	UAH (-25) billion	(-20%)
Replacement of cash (M0)	UAH (-52) billion	(-15%)

The e-hryvnia's impact on monetary indicators depends on what it will compete with (cash or noncash transactions) and the shares of P2P transfers and payments for goods and services in the expected volume of e-hryvnia transactions.

Such impact can be predicted based on the assumption that e-hryvnia will be mostly used for purchases of goods and services, while the volume of e-hryvnia transactions will reach 20% of the total volume of cashless transactions using payment cards (which amounted to UAH 259 billion in 2018).

Let us consider two possible scenarios:

1. E-hryvnia replaces card transactions.

According to the data for 2018, the ratio of balances of retail current accounts to card cashless settlements accounted for 10%. Therefore, if the ratio of cashless payments using e-hryvnia to the volume of payment card transactions accounts for 20%, total balances of current accounts may decrease by 20% amounting to UAH 25 billion. In such a case, banks' liquidity will also decrease.

2. E-hryvnia replaces cash payments.

According to the data for 2003–2007, when cash prevailed in household consumption, the ratio of cash to the final consumption expenditure was 20%. Therefore, if e-hryvnia replaces cash settlements, the M0 monetary aggregate may reach UAH 52 million (15%). However, banks' liquidity will not change (Table 3.1).

Such impact will be quite significant both for banks' liquidity and cash. At the same time, the actual impact will depend on the e-hryvnia's turnover rate and areas of use.

Potential risks that may arise as a result of the full-scale implementation of e-hryvnia include the following:

- uncertainty of impact on the transmission mechanism due to a decline in commercial banks' ability to create loan funds and remain mere intermediaries in terms of loan funds
- the outflow of funds from commercial deposit institutions to the central bank, especially in the periods of financial turmoil
- the loss of the credit money function by commercial banks
- the threat that the system of long-term insurance of deposits collapses if deposits with banks will be deemed as high-income and risky assets (in comparison with digital currency)
- nationalization of the wholesale money market (due to the outflow of retail deposits to the central bank and lending of such funds to commercial banks).

E-hryvnia should be considered solely as the third form of the hryvnia. Otherwise, we would get a domestic cryptocurrency, a financial instrument with its own value, instead of CBDC as an equivalent to the domestic money. The NBU's duties as provided for by legislation do not include issuance of new financial instruments.

Since e-hryvnia is deemed to be the third form of the hryvnia, it should be exchanged for cash and noncash domestic currency without any restrictions. In theory, the maximum volume of e-hryvnia issuance may not exceed the M1 aggregate.

3.8. Procedure for Operation of Platform

The NBU operates the Platform.

The Platform processes all transactions in real time 24 hours a day, which enables entities to conduct e-hryvnia transactions via the Platform on a 24/7/365 basis.

The Platform is based on open algorithms and libraries used in modern international information systems.

The Platform ensures the following:

1) permanence of the data stored in the distributed general ledger

2) maintaining of secured logs of the Platform's operation

3) encryption of information exchanged by Platform participants

4) administrating of distribution and settlement agents in terms of registration, blocking, setting restrictions, etc.

5) storage of information messages in the distributed general ledger

6) backups and secure storage of keys to e-wallets

7) calculation of commission fees for Platform participants

8) implementation of a consensus mechanism for all e-hryvnia transactions between Platform participants

9) verification of electronic signatures for transactions

10) issuance, distribution, transfer between e-wallets, payment (refund), exchange of e-hryvnia for cash/noncash funds, and repayment

11) storage of personal keys of Platform participants (if necessary)

12) administrating of merchants.

All e-hryvnia transactions within the Platform are arranged and permanent.

An e-hryvnia transaction cannot be cancelled once executed and confirmed by the Platform's core.

The Platform stores the full history of changes in all account balances of Platform participants.

3.9. The NBU's Roles in Operation, Use, and Management of the Platform

The NBU registered e-wallets of all Platform participants by making an actual entry about an e-wallet to the distributed general ledger.

The NBU executed E-Hryvnia Issuance and E-Hryvnia Repayment transactions.

Special roles were assigned to administrate the Platform: master and administrator.

The Platform's master and administrator were selected from NBU employees.

The NBU being the Platform's operator fully controlled (verified) the maximum amount of e-hryvnia in circulation, e-hryvnia issuance, and all transactions before they were stored to the distributed general ledger.

E-hryvnia issuance and distribution were performed either by the NBU through distribution agents who purchased e-hryvnia from the NBU and distributed it among Platform users or directly by the NBU conducting e-hryvnia transactions via its virtual terminal and NPS PROSTIR payment cards.

The NBU had the right to issue e-hryvnia in return for noncash hryvnia to be used within Ukraine.

The NBU controlled the amount of e-hryvnia issued, which had to correspond to the amount of noncash funds received by the NBU from distribution agents and users.

3.10. Limits on E-Hryvnia Transactions

The NBU controlled e-hryvnia balances on Platform users' e-wallets and the volumes of e-hryvnia transactions in accordance with the limits set by the Regulation On Electronic Money in Ukraine approved by NBU Board Resolution No. 481 dated 4 November 2010, which was used in the Pilot Project, as follows:

- the amount of e-hryvnia available to a user on an e-wallet must not exceed UAH 14,000
- users may use e-hryvnia for settlements below UAH 62,000 throughout a calendar year. The said amount does not include e-hryvnia repaid at a user's request throughout a calendar year.

Users have the right to:

- transfer e-hryvnia to other users in the amount of no higher than UAH 500 per day and no higher than UAH 4,000 per month
- exchange e-hryvnia for cash in the amount of no higher than UAH 500 per day and no higher than UAH 4,000 per month.

3.11. Roles of Platform Participants

The following participants were interacting through the Platform:

- E-hryvnia issuer
- distribution agents
- settlement agents
- merchants
- users.

Each participants according to its role could perform actions set out for its e-wallet.

3.12. Recordkeeping of E-Hryvnia Transactions

Recordkeeping of e-hryvnia transactions and e-hryvnia settlements are regulated by Temporary Rules for Recordkeeping of E-Hryvnia Transactions at the National Bank of Ukraine.

The Platform ensured analytical recordkeeping of e-hryvnia transactions using the distributed ledger technology.

Synthetic recordkeeping of e-hryvnia transactions on the issuer's accounts was performed via the NBU's banking automation system solely in hryvnia. The issuer's liabilities under the issued e-hryvnia were recorded on a separate consolidated account. Depending on the essence of accounting entries, the files with such accounting entries were prepared by different systems of the NBU: the Platform, the Central Switching Center and the Settlement and Clearing Center, or the Processing Center.

3.13. Financial Support to Pilot Project

The Pilot Project implementation was supported by internal personnel and IT infrastructure of the NBU and participants of the initiative group.

3.14. Technical Assistance and International Communication

As part of experience exchange and international technical assistance to the NBU, the implementation of the Pilot Project was accompanied by communication between representatives of central banks and international financial

institutions (including the International Monetary Fund and the World Bank) on the topic of CBDC implementation.

The received consultations helped the NBU to better understand the essence of CBDC and receive expert feedback on the Pilot Project and e-hryvnia.

In particular, experts of the World Bank's Technology and Innovation Lab registered their own e-wallets and tested e-hryvnia transactions.

3.15. Technology and Architecture of Platform

Before launching the Pilot Project, NBU specialists studied technical and technological means for building innovative online retail payment services (including at the level of banks), the popularity of which grows globally. Review and comparison covered both the systems that functioning on innovative distributed ledger technologies solutions and the systems with the classical architecture that uses relational databases.

The main criteria for selecting technological characteristics for the Platform were as follows:

- simplicity and availability for final consumers
- speed of the transaction execution regardless of the volume of transactions that occur at once
- scalability – the potential to enhance the Platform's infrastructure and performance by involving additional nodes, including the nodes of commercial participants
- reliable means of information protection, solutions for ensuring durability
- a simple, trustful, convenient system for adding and storing user personal data and for users to access their own funds at the Platform with an option of restoring access through additional means
- minimization of computer and other information resources needed for the Platform's operation
- cutting-edge technological solutions that are used globally to create payment systems and/or real time transfer funds
- prevailing use of open-source system and freeware soft applications.

Based on the above criteria, the NBU selected the distributed ledger technology, in particular the private version of the Stellar protocol, to study opportunities of issuing e-hryvnia and to carry out the Pilot Project.

The decision was made after one of the project's participants suggested to provide free-of-charge a ready-made basic solution of such a system to be used in the project on the Platform's implementation with an option to finalize that basic solution in line with the requirements that would be established at the preparation phase of the Platform's implementation.

The Platform's main technical and technological characteristics:

- operating system for server equipment of main nodes: Linux
- system and application software: open-source software that can be used on the grounds of a free software license (GNU General Public License, Apache Software License, etc.)
- elements of a node: web server, cluster of applications, encryption server, distributed database
- system software of the Platform's components (at the Pilot Project stage):
- OS: Red Hat Enterprise Linux, kernel version 3.10 or later
- Ngnix web server
- Riak KV distributed NoSQL database
- relational PostgreSQL database
- the system's application software is based on the SDK Stellar network with Stellar Core Horizon API, server components of which function in a regular and reliable way on Linux systems (of any kind, without limitation to RHEL) with kernel version 3.10 or later
- the basic customer software (JavaScript) meant for web browsers. Developers receive the open API to develop their own customer applications for any gadget with access to the Internet.
- protection: digital signing of transactions using the Ed25519 algorithm
- the TLS cryptographic protocol of the latest version, but no earlier than 1.2.

Requirements to the Platform regarding the e-hryvnia transaction speed:

1) the maximum time of a transaction: 5 seconds (the time of a block finalization)
2) the minimum number of transactions that can be executed at once without a queue: 500 transactions in 5 seconds.

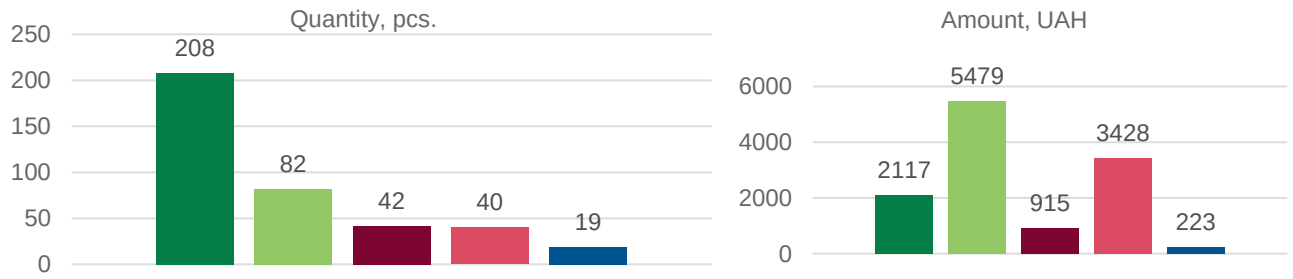
4. Assessment of Pilot Project's Outcomes

4.1. Assessment of Practical Phase of Pilot Project

During the practical phase of the Pilot Project (September–December 2018), the NBU issued the limited volume of e-hryvnia (UAH 5,443), and participants of the working groups completed the following steps (Fig. 4.1):

1. creation of personal e-wallets
2. installation of the e-wallet mobile application on personal devices with the Android or iOS operating system
3. refilling of e-wallets in a cashless way using the NPS PROSTIR card via a specialized virtual terminal integrated with the Platform
4. e-hryvnia transfers between e-wallets (P2P transfers)
5. merchant transactions (topping-up e-hryvnia to mobile phone balances, LifeCell operator)
6. charitable contributions to help soldiers of the Joint Forces Operation
7. exchange of e-hryvnia for non-cash funds using an NPS PROSTIR card.

Figure 4.1. Volume and number of e-hryvnia transactions executed during the Pilot Project (as at 15 December 2018)



Transaction name	Transaction volume (UAH)	Number of transactions (pcs.)
Transferring e-hryvnia to another e-wallet (P2P)	2,117	208
Refilling e-hryvnia to the e-wallet from the NPS PROSTIR card	5,479	82
Exchanging e-hryvnia for noncash funds credited to the NPS PROSTIR card	915	42
Charitable contributions to help soldiers of the Joint Forces Operation	3,428	40
Topping-up e-hryvnia to mobile phone balances (LifeCell operator)	223	19

Over the practical phase of the Pilot Project, participants of the working groups opened 121 e-wallets, 79 of which became active.

The prevailing type of transactions was e-hryvnia transfers between e-wallets (208 transactions amounting to UAH 2,117). The total volume of the e-wallets refilling with the e-hryvnia through NPS PROSTIR cards was UAH 5479. On the occasion of the Ukraine Defender Day, we've launched an option to make charitable contributions to the soldiers of the Joint Forces Operation, which resulted in 40 contributions amounting to UAH 3,428. To test the e-hryvnia merchant transactions, participants of the working groups toped-up UAH 223 to the balances of their mobile phones (19 top-ups).

Considering that the Pilot Project had a limited list of transaction types and a limited range of users, as well as the minor quantity and volumes of executed transactions, the project did not fully uncover the instrument's attractiveness and the potential level of involvement of Ukraine's population in using it.

Thus, it is hard to predict the number of Ukraine's citizens to become e-hryvnia users if the decision to implement e-hryvnia at a national scale is taken.

It is more likely that the citizens using smartphones and payment services will become e-hryvnia users, while it is less probable for the citizens who were not financially inclusive before (did not have a bank account).It should be noted that introduction of any innovative product to the market is carried out in stages and requires great efforts and financial investments.

For example, some companies, including Google, make investments by paying users USD 5–15 for installing and using their each new mobile application.

One of the first issues that arise in relation to the further implementation of e-hryvnia is the creation of the respective retail infrastructure for processing e-hryvnia.

Currently, the ratio of Ukrainian citizens to the payment cards issued by Ukrainian banks is close to 1.4. Since 1995, card payment systems and their participants have made huge investments, in particular, to build the respective card infrastructure, so that a payment card would become the most common online payment instrument.

Ukraine's market of payment services is characterized by the high competition and concentration. Therefore, implementation of e-hryvnia is impossible without major investment in upgrading the payment infrastructure for this instrument.

Another area of investment is the need to promote e-hryvnia among the population in order for this tool to become a truly mass product, taking into account already existing consumer habits.

4.2. Assessment of Technological Solution for Building Platform

At the preparation phase of the Pilot Project, the NBU thoroughly studied technological approaches to implementation of innovative systems of cashless retail settlements. In particular, the NBU studied the options of using the distributed ledger technology (DLT) and open-source software.

As stated above, developer companies volunteered to participate in the Pilot Project.

Only "clones" (copies with the modified configuration) of application software for the Platform's nodes were used in the Pilot Project. This shows that the Platform's resources are easy to scale in terms of technologies. However, using clones prevented the full assessment of effectiveness of the APIs suggested to external participants (developers) and the requirements for connection to the Platform.

At the practical phase of the Pilot Project, the Platform was functioning continuously, including even technical emergencies that typically pertained to shutdowns or reboots of servers and communication equipment. It should be noted that the Platform required minimum monitoring and administrating by technical specialists responsible for operation of the Platform's system and application resources.

Performance assessment of the chosen technological solutions in ensuring main functions of the Platform allows making the following conclusion: the chosen technology (DLT), architecture, and required administration functionality are adequate for implementing and supporting the core (the Platform's main critical nodes at the NBU), given that the whole customer interaction functionality is transferred to the level of the agents' nodes. Such functionality includes registration, network connection, customer software installation, as well as secure storage and administration of accounts with the secured secret keys. The Proof of Authority consensus is reached by two out of three validators approving a decision. Such method is effective for the chosen centralized model of e-hryvnia issuance and circulation, as it requires no major calculation but ensures the stable operation of the Platform thanks to decentralization. Given the emergencies that modelled artificially or occurred unexpectedly, it is reasonable to raise performance by increasing the number of Platform cores to 5, which should use various hardware, communicate through reserved channels of different providers, and be dispersed. Then, the consensus should be reached by at least 3 out of 5 validators. Such configuration will ensure smooth functioning of the Platform's core if two out of five validators fail (disconnect).

The use of Docker Containers technology to separate and isolate different types of software on each server proved to be technologically successful, as it simplified the processes of rolling out (cloning) the application software at the core's nodes and the nodes of the Platform's agents.

In general, the roll-out and support processes demonstrated suitability and efficiency of the applied technological solutions. If the decision is made to further develop the Platform or design its new version that would be based on similar technological approaches, it will be worthwhile to consider the following:

- the basic technological components must be chosen from the developments of well-known and recognized companies and/or communities with a positive image in the area of developing and supporting software
- clearly defined and established relationships (including in respect to copyrights) with the development companies and/or the companies that perform the development and support functions. It turned out to be inefficient and risky to involve volunteering commercial institutions in the project.
- the open-source software, if applicable, requires compatibility with the versions of software products,

so that official updates of software from external producers can be installed in a regular mode.

However, when building the Platform, it was impossible to use some of the main features that separate DLT from the classic technologies for building financial information systems. In particular, the idea of decentralizing the transaction validation function in the network, which can be implemented most successfully by means of DLT, in fact contradicts the principle that only the NBU may issue e-hryvnia. The public accessibility of the Platform's financial transactions for review and verification is not a crucial or, in certain cases, even desired feature of a technology used for CBDC.

Assessment of the basic technological solution used for implementation of the Platform allows for a general conclusion that it will be fully possible and effective, although not mandatory (due to the lack of fundamental advantages), to use the distributed ledger technology for the Platform's operation under the centralized model of e-hryvnia issuance and circulation.

The main technological risk for development and distribution of the Platform in its current version is that a private version of the Stellar blockchain protocol (which was brought in line with the NBU's requirements) was used for the Platform. Such version hampers (virtually prevents) the elimination of errors and vulnerabilities of the Stellar blockchain protocol as well as the development of the Platform's functions as new options are being added to the basic blockchain protocol. Moreover, the private version of the blockchain protocol makes the system highly dependent on the company developing a certain protocol version, which creates competitive advantages for such company for the whole period of the Platform's operation.

This risk makes it virtually unacceptable to apply at a national scale the solution used in the Pilot Project. The risk has to be taken into consideration in further development and reengineering of the Platform.

4.3. Assessment of Technical Results and Specifics of Creating Platform and Its Operation

The technical and technological specifics make the Platform's hardware and software stand out from the most systems that are implemented and function at the NBU (that is, the systems purchased from development companies with available support and maintenance or the systems developed by the NBU). Therefore, during the implementation of the Platform, some technical issues arose, which were difficult to resolve given the current methodological documents, typical processes and procedures in the National Bank. Technical issues at the preparation phase of the Pilot Project pertained to the fact that the software development for modern information systems based on open-source projects requires direct Internet access to web repositories at bitbucket.org, github.com, etc. A software component from a repository may require additional scripts, libraries, or software modules from repositories of other developers.

Such projects usually have the system of automated control over "dependency" of the software being developed on the source code by other developers that is used in the project, as well as the software version control system. Thus, creating a local supervised repository with all software scripts and modules that may be compiled and assembled into the Platform's components was a difficult task without open Internet access, which was impossible to solve during the Pilot Project. The solution that implies storing all source scripts and modules in our own local repository would be neither efficient nor worthwhile, since developers continuously improve their software code to eliminate all found errors, discrepancies, and vulnerabilities as well as to improve the software's performance, speed, etc. Therefore, the only effective way of implementing the systems based on open-source projects would be to use a test solution with open Internet access to build and test the Platform's components and to develop an efficient procedure for testing and introducing changes in the production environment.

The specifics of the blockchain solution selected for the Pilot Project include a requirement of time synchronization between the Platform's nodes (especially validator nodes). In the test environment, blocks were closing unstably in the event of time desynchronization of over 10 seconds between validator servers.

It is worth noting that, once a certain volume of data is stored to the Platform, there is a major slowdown in recovering a registered validator node and in adding a new one. Such an effect was found in the test system and, to some extent, during the recovery of validator nodes in the production environment in the course of the Pilot Project. After six or more weeks of collection of data on the Platform's operation, the recovery rate of the last 20% of data was only three times higher than the speed with which new blocks emerged, which led to the long recovery (over several days) of validators. The company that had developed the basic version of the Platform was not able to help in eliminating the found discrepancy. According to open sources, such issue was resolved in later versions of Stellar libraries after the basic one, but it was impossible to make the required modifications to the Platform's software, since it was forked without ensuring the compatibility with the source code of the basic version, and the nodes of the test and production environments had no free Internet access.

In addition a potential system-level emergency was identified. It may arise if validation of transactions (closing of blocks)

stops at the Platform but gateway nodes continue functioning. In such a case, any customer transaction will end with an error (transaction timeout), as any transaction is executed only after it is added to the ledger based on the respective decision made by validators who reach the consensus and close the block. Then, the transaction will remain with the validated status at the gateway node and will be successfully completed once validators resume closing blocks.

We've identified and partially corrected other shortcomings pertaining to specifics of web browsers and customer software for smartphones with Android and iOS operating systems. We had repeated cases of loss connection with the nodes of agents who were external participants of the Pilot Project. All of the mentioned shortcomings can be fixed in commercial versions of the software.

As we learned from the development and implementation of the Platform, the irreversible nature of Platform transactions had both its pros and cons. Such irreversibility rules out any misuse of potentially available functions of cancelling or deleting the executed transactions by administrators or other special authorized roles of the Platform. However, the irreversibility adds complexity and challenge to the Platform's integration with other hardware and software systems, in particular the NPS PROSTIR virtual terminal, which was adapted and integrated with the Platform. When engineering transactions of e-hryvnia transfers to the NPS PROSTIR card, we've identified and only partially eliminated the problem with execution of such transactions in case of emergency shutdown of the NPS PROSTIR card refilling, which was due to the irreversible nature of Platform transactions.

Overall, the Platform was functioning regular and may be used for issuance and circulation of electronic hryvnia after certain finalization considering the found flaws and specifics as well as with the required monitoring and technical administrating of the Platform.

5. General Conclusions

1. E-hryvnia as a tool for instant retail payments has the potential to become an alternative to the existing means and tools of retail payments, such as cash, payment orders, payment cards, and electronic money. The advantages of e-hryvnia include ease of use, safety (repayment and settlements are guaranteed by the NBU), as well as the speed of acquiring the user status and the settlement speed.

2. Considering that the Pilot Project had a limited list of transaction types and a limited range of users, as well as the minor quantity and volumes of executed transactions, the project did not fully uncover the instrument's attractiveness and the potential level of involvement of Ukraine's population in using it. Thus, it is hard to predict the number of Ukraine's citizens to become e-hryvnia users if the decision to implement e-hryvnia at a national scale is taken.

3. E-hryvnia may be considered as the disruptive technology, since it has the potential to change the ecosystem of Ukraine's payment market and reassign the current roles of market participants.

4. Implementation of e-hryvnia is impossible without major investment and time needed to upgrade the payment infrastructure for this instrument. The reason is that Ukraine's market of payment services is characterized by high competition and concentration as well as the established infrastructure.

5. For e-hryvnia to become a truly mass product, it should be promoted to the population bearing in mind the existing customer habits.

6. Implementation of e-hryvnia in Ukraine's payment market should be in line with the possible implementation of other innovative payment instruments, including instant payments and new Open Banking instruments.

7. The distributed ledger technology (DLT, blockchain) can be used as a platform for e-hryvnia issuance and circulation.
   However, main advantages of the technology, including the absence of a single center of trust and the capability of any person to check any transaction, cannot be used together with the centralized e-hryvnia issuance model. Thus, it is not critical whether this technology is used if the centralized model is chosen.
   The mentioned advantages would be more efficient for the decentralized model of e-hryvnia issuance versus the centralized one.

8. The private version of the Stellar blockchain protocol, which has been tested under the Pilot Project, was functioning in the regular mode and may be used in local (bank-level) electronic money systems after some finalization. We cannot use that version to build the national-scale system, as it is practically impossible to update it following the development of the basic Stellar blockchain protocol. Instead, the national-scale system can be designed on the basis of one of the public versions of modern powerful blockchain protocols.

9. On the one hand, involvement of volunteers in the Pilot Project helped save money considering the high cost of software solutions and high labor costs, but on the other, it turned out to be ineffective. External participants of the Pilot Project prioritized their commercial activities over the work on the project.

10. The business model requires further thorough consideration by the payment market participants.
    The Pilot Project's participants and the NBU had not reached the consensus regarding an e-hryvnia tariff/commission model in the course of respective consultations. Zero commission fees were set for all e-hryvnia transactions for the period of pilot testing.

11. The NBU showed its capability to implement similar projects.
    The Pilot Project involved limited personnel from eight structural units (the internal working group). Bringing the project to the national level requires major human resources.

12. Only anonymous e-wallets were used in the Pilot Project, however, the further development of e-hryvnia may come with the full or partial user identification under the KYC principles, inter alia, to increase the transaction limits.
    The further implementation of e-hryvnia should incorporate the AML/FATF requirements to the limits on the balances of e-wallets and the volumes of transactions.

13. The implementation of e-hryvnia should be regulated by law.

14. E-hryvnia may be implemented in Ukraine's payment market using one out of two alternative models of interaction: the centralized and the decentralized models.
    Under the decentralized model, e-hryvnia will no longer be classified as CBDC, since it will be issued not by the central bank but by payment market participants under the regulator's control.
    For both models, the issue of choosing an optimal basic technology remains open.
    The main benefits of the distributed ledger technology (DLT) may be leveraged more effectively with the decentralized model versus the centralized one.

15. If the centralized model is chosen, the NBU will perform non-typical duties of working with individuals (including the dispute resolution).

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Annexes

Annex 1

Studied of CBDC by countries *

Country	Current status	CBDC scheme	Details
Australia	Study has been completed	CBDC for interbank settlements CBDC as a cash equivalent	The purpose of study was to gain better understanding by the central bank of the DLT technology and the outcomes of CBDC introduction. Presently, the Reserve Bank of Australia has no ongoing projects in this area
The Bahamas	Pilot project was launched in 2018	CBDC as a cash equivalent	
Venezuela	El Petro virtual currency has been introduced in circulation	Not a CBDC per se	The El Petro was launched by the government to bring in additional investments. The exchange rate is pegged to energy prices, not the country's currency
Denmark	Study is underway	CBDC as a cash equivalent	
Ecuador	Pilot project has been implemented	CBDC as a cash equivalent	
EU – Japan	Joint pilot project (Stella 2) has been completed	CBDC for interbank settlements	
Israel	Study is underway	CBDC as a cash equivalent	Experience of other countries has been analyzed in detail
India	Study is underway	CBDC as a cash equivalent	
Canada	Study and pilot project are underway	CBDC for interbank settlements CBDC as a cash equivalent	The purpose of Jasper Project is to test the DLT technology for interbank settlements
China	Study is underway	CBDC for interbank settlements CBDC as a cash equivalent	A pilot project is being considered for CBDC as a cash equivalent (two-level model: central bank + banks)
New Zealand	Study is underway	CBDC as a cash equivalent	
Norway	Study is underway	CBDC as a cash equivalent	
South Korea	Study is underway	CBDC as a cash equivalent	
South Africa	Pilot project (Khokha) is underway	CBDC for interbank settlements	The project is being implemented jointly with the Monetary Authority of Singapore. The project's main purpose is to test the technology's resilience
Singapore	Pilot project (Ubin) is underway	CBDC for interbank settlements	The pilot project is currently in the second phase out of the planned six phases. The testing of cross-border transactions is expected
Thailand	Pilot project (Inthanon) is underway	CBDC for interbank settlements	

Uruguay	Pilot project (E-peso) is underway	CBDC as a cash equivalent	
Sweden	Preparation continues for the launch of a pilot project (E-Krona) in 2020	CBDC as a cash equivalent	Two reports were published in 2017 and 2018, respectively. Work is presently underway on defining the regulatory framework, technical and economic details of the e-krona slated for launch in 2020.

* Information taken mostly from open sources. Should you have any comments, please e-mail them to us at euah@bank.gov.ua

Annex 2

Comparative characteristics of the e-hryvnia versus other forms of money





Indicator	E-hryvnia Centralized issuance model	Cash	E-hryvnia Decentralized issuance model	E-money	Funds in bank accounts
Essence	Fiat currency	Fiat currency	Unit of value	Unit of value	Fiat currency
Monetary aggregate	M0*	M0	M1	M1	M1
Form of issue/accounting	Electronic	Paper	Electronic	Electronic	Electronic
Profit yield	No	No	No	No	Yes
Technology	Databases (1) or DLT (2)	Printing	DLT (1) or databases (2)	Databases (1) or DLT (2)	Databases
Identification	Anonymous, partially anonymous or identifiable	Anonymous	Anonymous, partially anonymous or identifiable	Anonymous or partially anonymous	Identifiable
Limits on retail transactions	Yes	No	Yes	Yes	Depending on transaction type
Liquidity	with the NBU	with households / the banking system / the NBU	with the banking system	with the banking system	with the banking system
Issuer	NBU	NBU	Bank/nonbanking financial institution under NBU's supervision	Bank	NBU
Relative turnover speed	High	Low	High	High	Medium

* In the opinion of the People's Bank of China, CBDC belongs to the monetary aggregate M0.

Annex 3

E-hryvnia vs other payment instruments: cost






Indicator	E-hryvnia Centralized issuance model	Cash	E-hryvnia Decentralized issuance model	E-money	Cashless funds	
					Cards	Payment orders
For users						
Exchange into other forms of money	Possible to refilling and/or repayment fees	Refilling and cash withdrawal fees	Possible to refilling and/or repayment fees	Refilling and/or repayment fees	n/a	n/a
Purchase payment transactions	None	None	None	None	None	High (for paper) Low (for electronic)
P2P money transfers	None	None	Low	Low	High	High (for paper) Low (for electronic)
For merchants						
Purchase payment transactions	Low	Medium/high	Low/medium, depending on business model	Low/medium, depending on business model	High	Low
For the central bank						
Issuance/servicing cost	Potentially lower than for cash, but requiring a substantial initial investment	Substantial	Medium (the bulk of costs is borne by market participants)	n/a	n/a	Operational costs of SEP NBU
For market participants						
Initial investment	High	High	High	Medium	High	High
Operating expenses	Low	High	Medium	Low	High	Low

Annex 4

E-hryvnia vs other payment instruments: functionality

Indicator	E-hryvnia Centralized issuance model	Cash	E-hryvnia Decentralized issuance model	E-money	Cashless funds	
					Cards	Payment orders
User-friendliness	Requires knowledge	Does not require knowledge	Requires knowledge	Requires knowledge	Requires knowledge	Almost does not require knowledge (for paper) Requires knowledge (for electronic)
Payment infrastructure available / required	Required	Available	Required	Available within certain systems	Available	Available and improved by the NBU
Transaction speed (end-to-end)	High (instant)	High (instant)	High (instant)	High (P2P transfers) Medium (purchase payment transactions)	High (P2P transfers) Medium (purchase payment transactions)	Low (up to 3 business days) SEP NBU considers the launch of “instant” payments ISO 20022 end-to-end
Accessibility of technology	A device connected to the Internet is required	Yes	A device connected to the Internet is required	Infrastructure (SSK) and/or the Internet is required	A visit to a bank branch is required to open an account / pick up the card	A visit to a bank branch is required (for paper) A device connected to the Internet is required (for electronic)

Annex 5

Main operations performed on the Platform

	Operation	Brief description
1.	setting the maximum amount of e-hryvnia circulation	a transfer of an e-hryvnia amount from the base e-wallet for which this amount will be subsequently shown with the negative value to the issuer's e-wallet where the balance of issuable e-hryvnia is accounted for
2.	e-hryvnia issue	provision of the e-hryvnia by the issuer to users and distribution agents in exchange for cashless funds (i.e., recording the successful exchange of the national currency, the hryvnia into the e-hryvnia at the rate of 1:1)
3.	e-hryvnia distribution (refilling e-wallets of Platform users):	a transfer of an e-hryvnia amount from the distribution agent's e-wallet to the Platform user's e-wallet in exchange for cash or cashless funds
4.	e-hryvnia transfers between Platform users	a transfer of an e-hryvnia amount from the e-wallet of one Platform user to the e-wallet of another Platform user
5.	e-hryvnia payments for purchases	a transfer of an e-hryvnia amount from the Platform user's e-wallet to the merchant's e-wallet
6.	cashback of e-hryvnia payments for purchases	a transfer of an e-hryvnia amount from the merchant's e-wallet to the Platform user's e-wallet involved in the *e-hryvnia payment for purchases* transaction in the amount not exceeding the amount of the said transaction
7.	e-hryvnia exchange into cash or cashless funds	a transfer of an e-hryvnia amount from the e-wallet of a Platform user/merchant to the e-wallet of a settlement agent
8.	e-hryvnia repayment	withdrawal of the e-hryvnia from circulation with the subsequent provision of cashless funds to settlement agents