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IMPLEMENTING CENTRAL BANK DIGITAL CURRENCY (CBDC) INTO THE NATIONAL MONETARY SYSTEM: THE CASE OF ESTONIA

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Programme Technology Governance and Digital Transformation

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ABSTRACT

This study aims to gain a better understanding of Estonia's readiness to implement a blockchain-based digital euro. The study analyzes how well the current digital infrastructure, organizational forms, and institutional arrangements support the implementation of the central bank digital currency (CBDC) into the national monetary system. In this exploratory case study, the technology enactment framework (TEF) served as the basis for investigation.

On the basis of the results of this research, it can be concluded that Estonia has established an overall favorable environment for a blockchain-based digital currency, however certain additional elements are required. In Estonia, the objective information technologies are extremely advanced utilizing blockchain technology, X-Road ecosystem (X-tee), and digital identity card system. However, the security risks of the current digital infrastructure, including cyber threats and disruptions with hardware, have to be mitigated to link parts of it with the digital euro. Further, additional methods to acquire user identification data must be implemented because the current ID-card system fails to meet the global accessibility requirement. In terms of X-tee, additional security systems should be developed to ensure that organizations using the network fully comply with essential security measures in order to consider it as a possible data exchange layer for the CBDC project. In the institutional arrangements dimension, Estonia's strong national branding as a digital nation increases citizens' openness to adopt future digital initiatives. Further, changes in legislation on the European Union level are required to include retail CBDC as a legal tender. The study concludes that further user research is needed to find the most crucial attributes that people expect and need from the digital euro.

Keywords: central bank digital currency, digital euro, monetary policy

INTRODUCTION

The rise of modern cryptocurrencies and private digital currencies has made governments and central banks eager to research possibilities to create their own digital form of money, commonly referred to as central bank digital currencies (CBDC). In recent years, CBDC pilots have risen sharply worldwide. Research conducted by the Atlantic Council (n.d.) estimates that over 80 countries, which represents over 90 percent of global GDP, are now exploring CBDC. In May 2020, the council estimated the number of countries to be 35.

There is a growing body of literature that recognizes the importance of digital currencies in today's digital area. Rodeck (2021) argues that digital currencies provide much faster and less expensive international transfers, especially when the transfer involves converting the funds; and support unbanked and underbanked people around the world, which the World Bank (2018) estimates to be 1,7 billion adults globally. These people now have the means to transfer money abroad and protect themselves from highly volatile local currencies. Governments and central banks are now exploring the possibilities to create their own digital currencies to provide secure means of digital payment and a stable store of value, which cryptocurrencies often fail to provide.

Further, the implementation of CBDC could assist in meeting the growing demand for digital payments, which has increased significantly in response to peoples' changing needs. Recently, the Covid-19 pandemic has accelerated the shift even more. The European Central Bank (2020b) estimates that almost half of euro area consumers now prefer using cashless payment instruments, up from 43% in 2016. Along with the rise in demand for digital payment methods, the number of private digital currency providers has increased steadily, contributing to the declining use of central bank money. The adoption of CBDC can play an important role in addressing the issues of declining use of fiat money, which endangers the effectiveness of the nation's monetary policy. Further, payment system disruptions can pose risk to financial stability. The goal should not be to replace decentralized private currencies entirely but provide a secure and stable means of digital payment backed by the central bank. As Panetta (2021, n.p.), a member of the executive board of the European Central Bank puts it "history shows that financial stability and public trust in money

require a widely used public money alongside private moneys". It is crucial that nations carefully consider the motivation driving the adoption of CBDC and what challenges the adoption solves.

Like in aforementioned, the number of central banks experimenting with CBDC is growing rapidly. Sweden was one of the first pioneers who announced work on retail CBDC in 2017. As stated by the Sveriges Riksbank (n.d.), the central bank of Sweden, the e-krona project aims to create digital krona, which is "simple and user friendly and, at the same time, compiles high requirements for security and performance". List of CBDC pioneers includes China with Digital Currency Electronic payment (DC/EP); the Bank of Canada who launched Project Jasper in 2016; the European Central Bank (ECB) and the Bank of Japan who launched a joint research project called Project Stella in 2017; the Eastern Caribbean Central Bank (ECCB) who launched a pilot called DXCD in 2019 (Auer et al., 2020, 6).

As the interest in adopting CBDC rises, it is crucial to have a clear overview of the foundational principles of CBDC and what are the preconditions that nations should investigate before adopting it into the national monetary system.

The thesis aims to answer the following research question: **To what extent is Estonia ready to implement CBDC into the monetary system and what are the preconditions that support the implementation process based on the TEF framework?**

In order to satisfy the objectives of this case analysis, qualitative research based on existing research, documentation, and artifacts is conducted. The wide range of data sources helps to form further open-end discussions on the vital topic of the central bank digital currency. First, the emphasis is on analyzing the existing research about similar topics and forming a better understanding of the concept of central bank digital currency. Secondly, the research question is analyzed through the technology enactment framework (TEF), which provides a framework for an in-depth investigation of the implementation process of a technology-intensive initiative. The enacted technology, in this thesis considered the digital euro, will be analyzed through different dimensions of society.

The thesis has been divided into four chapters. The first chapter provides a theoretical overview of the best available knowledge. The theoretical part is divided into three subchapters. First, a brief overview of foundational principles of the central bank digital currencies (CBDC) is discussed,

including the comparison between CBDCs and cryptocurrencies. Further, the list of requirements, benefits, and challenges of adopting CBDC as a legal tender are analyzed to understand better which problems the adoption solves and what are the potential downfalls. Finally, the theoretical framework used for the case analysis is presented.

The second chapter is concerned with the methodology used for this thesis. It brings out the reasons for choosing a case study methodology and explains the data collection and analysis procedure. It also discloses the limitations of this study and suggestions for further research.

Last but not least, the empirical part analyzes the implementation of CBDC as a legal tender in Estonia through technological, legal, and social aspects of the society. The empirical part focuses on demonstrating the interconnection between objective IT, organizational forms, institutional arrangements, and enacted technology. First, the objective information technology dimension analyzes the existing digital infrastructure. Secondly, the dimension of organizational forms is evaluated by network efficiency and the level of organizational bureaucracy in the Bank of Estonia. Finally, the institutional arrangements dimension points out how Estonia's national branding as a digital nation and formal governmental laws and regulations affect the implementation of CBDC.

1. THEORETICAL BACKGROUND

In the following chapter, foundational principles of CBDC are analyzed to better understand the core features. Also, the ways CBDC differs and resembles modern cryptocurrencies like Bitcoin are listed. Further, the chapter provides an overview of the benefits, requirements, and challenges of adopting a virtual form of fiat money as a legal tender, which are essential to consider before the implementation.

1.1. Foundational principles of CBDC

Central bank digital currency (CBDC) is still a relatively new term and lacks a widely accepted definition. There are several possible definitions proposed, but the author believes that it is essential to highlight a couple of definitions from international financial institutions to better understand the underlying concept of CBDC. The Committee on Payments and Market Infrastructures (CPMI, 2018, 1) defines it as:

> CBDC is potentially a new form of digital central bank money that can be distinguished from reserves or settlement balances held by commercial banks at central banks. Many forms of CBDC are possible, with different implications for payment systems, monetary policy transmission as well as the structure and stability of the financial system.

The International Monetary Fund (IMF) defines CBDC as "a widely accessible digital form of fiat money that could be a legal tender" (Mancini-Griffoli et al., 2018, 9). The paper emphasizes that it "could be a legal tender" because many countries remain skeptical even though several central banks have undertaken pilots.

Central bank digital currencies are generally classified as wholesale or retail (or "general purpose"). In 2017, Bech and Garratt introduced "the money flower diagram", which classifies different types of money based on their characteristics. In the Venn diagram, they point out that the main difference between wholesale and retail CBDC is that retail CBDC is universally

accessible to the general public while wholesale CBDC is only accessible to authorized financial institutions. The retail and wholesale CBDC are highlighted in grey.

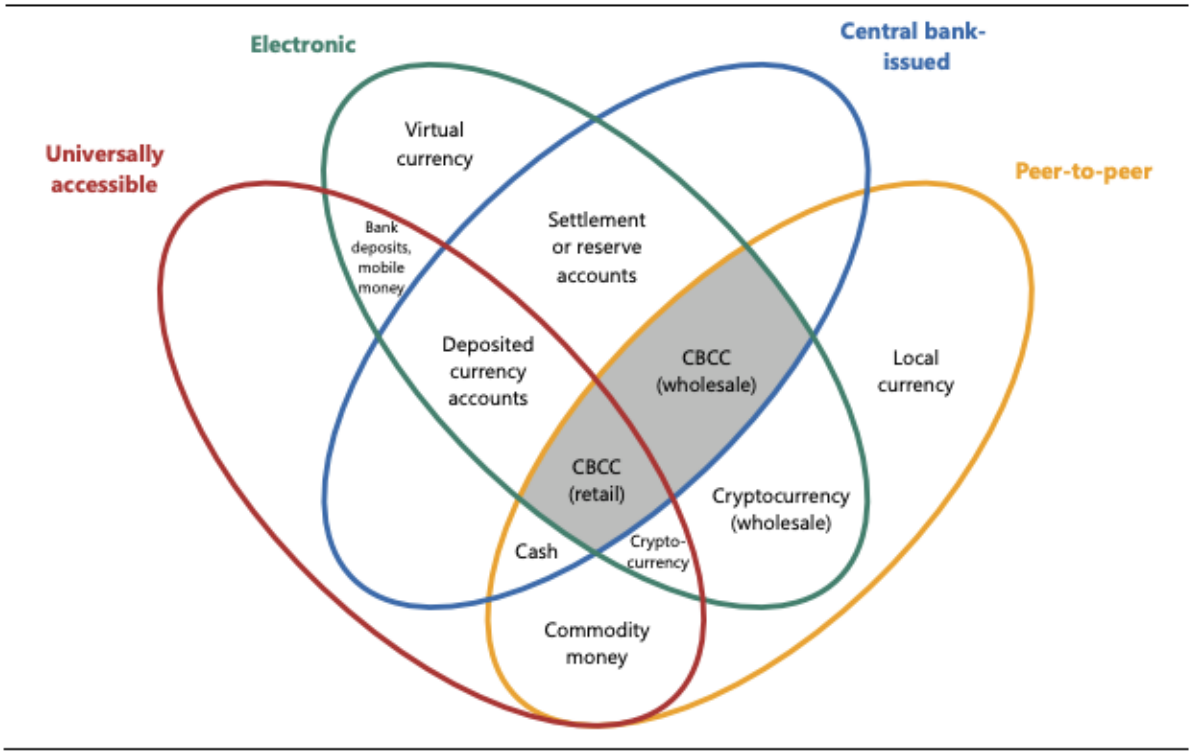

Figure 1: The money flower: a taxonomy of money (Bech and Garratt, 2017, 60).

Opare and Kim (2020) pointed out that wholesale CBDC is only accessible to a narrow scope of people and is issued and fully maintained by the central bank or a designated entity. They emphasized that there is no autonomy of transactions as all transactions and participants of the payment are pre-registered and authorized by the central bank. Data privacy is guaranteed by only providing access to the transaction information for the parties involved.

The concept of retail (or general purpose) CBDC is similar to modern cryptocurrencies like Bitcoin and is accessible to the general public. Bech and Garratt (2017, 56) explain that one feature that distinguishes retail CBDC from other forms of central bank issued electronic money is the "peer-to-peer" function. They stress that the "peer-to-peer" function enables transactions to occur directly between the payer and payee and therefore there is no need for a central intermediary to control the transactions. There are two possible ways to implement retail (or general purpose) CBDC based on the type of access they provide: account-based or token-based. As stated by Mancini-Griffoli et al. (2018, 8), "a transaction in account-based CBDC would resemble today's transactions between commercial bank depositors, except accounts would be held with the central

bank". Similar to wholesale CBDC, transactions of account-based CBDC are not anonymous because the users are required to be pre-registered and authorized by the central bank (Opare and Kim, 2020). The key difference between the account-based and token-based CBDC is the anonymity aspect. Token-based CBDC ensures user anonymity by requiring access with a private/public key instead of user identification. Once distributed by the central bank, token-based CBDC can be stored locally on the user's card, mobile app, or electronic wallet (*Ibid.*, 3).

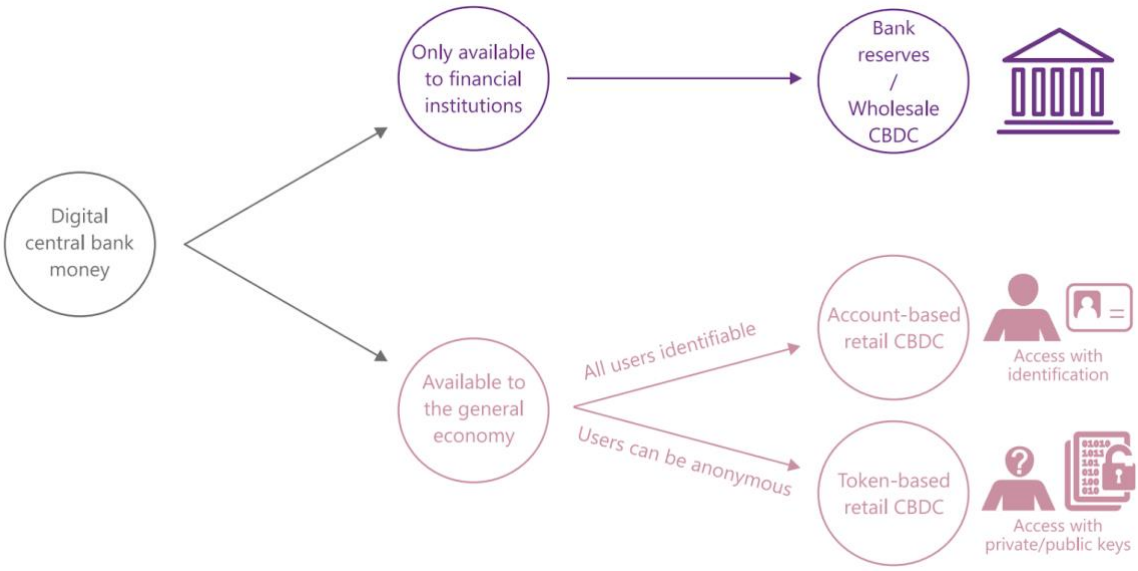

Figure 2: Forms of digital central bank money (BIS Annual Economic Report, 2021, 73)

In this case analysis, the author will focus on the account-based retail (or "general purpose") CBDC, which is issued by the central bank, is universally accessible, and the access is permitted by identification.

1.2. Comparison of cryptocurrency and CBDC

The key difference between cryptocurrencies and CBDC is that cryptocurrencies like Bitcoin are decentralized, while CBDCs are centralized. Bitcoin and other modern cryptocurrencies like Ethereum use blockchain, a form of distributed ledger system (DLT), which Bech and Garratt (2017, 58) refer to as "record of activity that is shared across computers in different locations". Many central banks are also experimenting with the DLT or blockchain system as an infrastructure for the CBDC projects. Nevertheless, there is a difference in how the distributed ledger system is utilized. Cryptocurrencies use the DLT to allow remote peer-to-peer transfer because of the absence of a trusted intermediary overseeing the transactions (Bech and Garratt, 2017). In addition,

the DLT serves as a measure of security to ensure that the information of transactions is not modified or removed. Central bank digital currencies, on the other hand, will most likely use a blockchain ledger that is backed by the central bank, so-called “permissioned DLT”, which uses decentralized ledger but the information can be accessed and modified with limited capability (Raj, 2019).

Further, the level of user anonymity can differ between cryptocurrencies and CBDC. As aforementioned, this thesis focuses on account-based retail CBDC, which requires users to prove their identity. Based on the level of anonymity, token-based CBDC is rather similar to cryptocurrencies, where privacy is guaranteed by private/public keys. Satoshi Nakamoto (2009), a pseudonym behind the original whitepaper about Bitcoin, emphasizes that the privacy of cryptocurrency transactions is guaranteed by keeping public keys anonymous. The person or group of people compares the level of information released with stock exchanges, where the list of transactions is available to the public but the actual person behind these transactions is unknown. Transactions with account-based retail CBDC are non-anonymous and central banks have the right to establish the identity of the accounts connected to specific transactions.

Additionally, there is a difference in how cryptocurrencies and central bank digital currencies are issued. CBDCs are electronic forms of fiat money that are issued by the central bank. Cryptocurrencies are typically not issued by a central authority. For example, Bitcoins, the most popular and highly valued cryptocurrency, are mined by people using software that solves mathematical equations (Kulkarni, 2018). Moreover, there is a difference in procedures that ensure the store of value. Based on the description by Bech and Garratt (2017), CBDCs have peer-to-peer functionality similar to cryptocurrencies, which means that CBDCs can be exchanged in a decentralized manner without the need for a central server. However, the store of value is secured by the central bank. They emphasize that cryptocurrencies, on the other hand, are not the liability to anyone meaning that encryption rather than a trusted authority secures the store of value for cryptocurrencies.

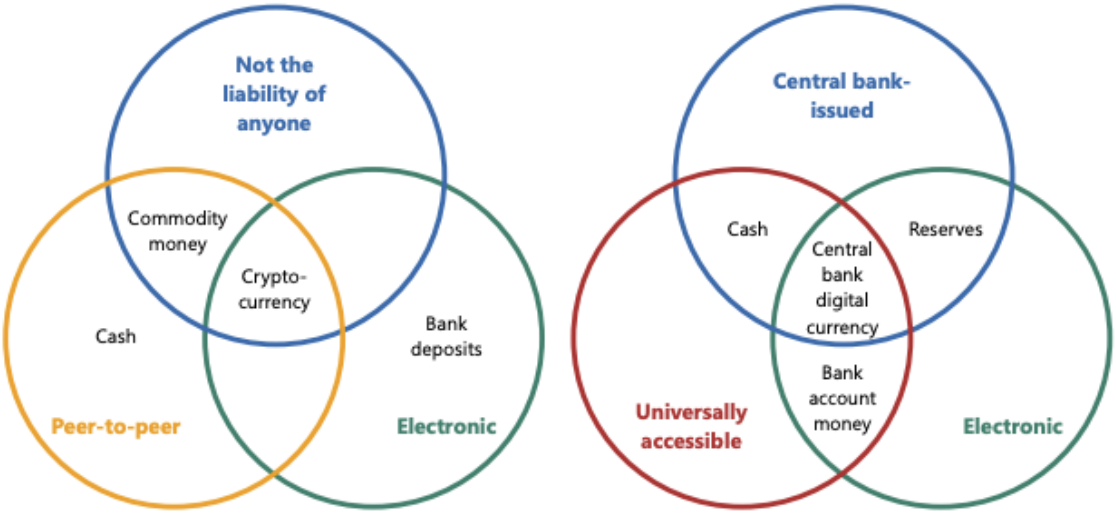

Figure 3: Two taxonomies of new forms of currency (CPMI, 2015; Bjerg, 2017 cited in Bech and Garratt, 2017, 59).

1.3. Adaption of CBDC as a legal tender

To keep up with rapid technological change, governments worldwide have started to explore ways to adopt CBDC as a new means of payment and store of value. This following chapter provides an overview of requirements that governments and central banks should consider before adopting CBDC. Also, this chapter lists some of the benefits and challenges of adopting CBDC as a legal tender.

1.3.1. Benefits of adopting CBDC

CBDC pilots have risen in the light of the increased demand for digital payment methods and decreased cash usage. As stated by Viñuela et al. (2020), one of the benefits of adopting CBDC is that the public money does not lose its position as the most demanded unit of account considering the increased usage of private digital currencies. Retail transactions are increasingly made with digital means of payment and the cash circulation is shrinking. Recently, the global COVID-19 crisis facilitated the rise of digital payment methods even more.

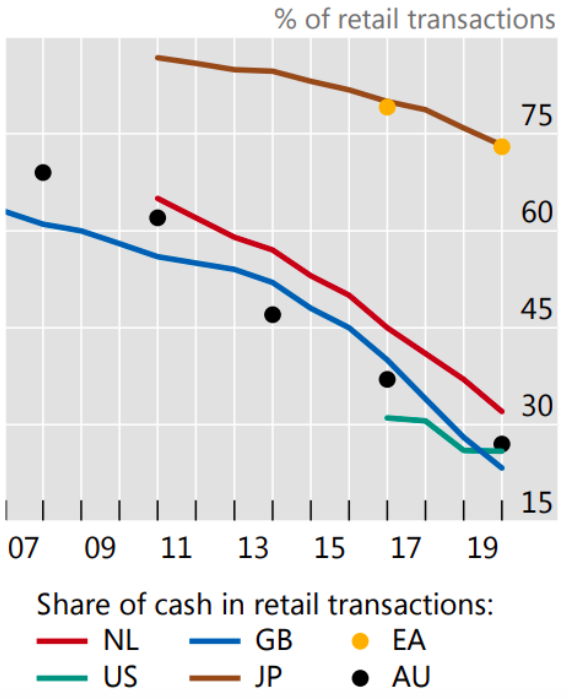

Figure 4: Share of cash in retail transaction (%) (BIS Annual Economic Report, 2021, 67).

The rising number of digital payments are now made by private digital currencies. As noted in the BIS Annual Economic Report (2021, 67) the increased usage of modern cryptocurrencies and stablecoins issued by big technology firms could lower the effectiveness of a country's monetary policy and lead to market concentration. The report emphasizes that the amount of data the big techs have about their users through existing services give them a competitive edge to continuously increase their user base and attract them to use payments services. The report concludes that this could eventually give the big techs a dominant position and lead to higher fees than currently charged by credit and debit card companies as well as weaken data governance. Additionally, Lee et al. (2021) argue that data collected by big techs is difficult to regulate, therefore, increases the likelihood of data abuse. The usage of cryptocurrencies as a payment method is also on the rise. However, the fact that cryptocurrencies are highly volatile and cannot be considered a unit of account makes this payment method unreliable. A central bank digital currency could help to ensure that the payment system works smoothly and people have access to secure and universally accessible central bank money.

Additionally, according to Adrian (2021), CBDC can help to make payment systems more cost-efficient by reducing the need to manage physical cash. The view is supported by Lee et al. (2021) who write that issuance cost of paper money is high and requires a continuous expenditure on labor and materials. They argue that the issue of central bank digital currency will decrease the spending

on traditional paper money issuance and circulation, which is especially beneficial for countries that experience high inflation rates and currency counterfeiting. They add that CBDC would also facilitate more efficient and rapid cross-border financial transactions. Cross-border transactions are costly in some countries where the financial infrastructure lags. It is almost impossible for many people in developing countries to send money to their families or start businesses abroad. CBDC can help to improve the efficiency of cross-border payments and make them more affordable. Therefore, CBDC fosters financial inclusion of unbanked and underbanked people around the world (Viñuela et al., 2020).

Also, CBDC provides "managed anonymity", which helps the central bank to detect illegal activities like money laundering, tax evasion, and terrorist financing (Lee et al., 2021, 59). While modern cryptocurrencies and privately owned digital currencies make it more difficult to trace transactions, the CBDC permissioned ledger system permits the central bank to access needed information to detect possible fraud or criminal activity.

1.3.2. Requirements of adopting CBDC

Some foundational elements have to be considered before adopting CBDC as a legal tender. The ones the author believes are the most crucial are listed below.

First, the government has to decide whether it is reasonable to keep both cash and CBDC in money circulation. The research conducted by Davoodalhosseini (2021, 2) found that "having both cash and a CBDC available may result in lower welfare than in the cases where only cash or only a CBDC is available". In his study, three different schemas were analyzed: only cash is available (cash-only scheme), only CBDC is available (CBDC-only scheme), and both cash and CBDC are available (co-existing scheme). He concluded that in the case of a cash-only scheme, the optimal inflation rate would be zero because a negative inflation rate would be impossible to implement and a positive inflation rate could lead to a distorted production level. However, a zero inflation rate is not something a government should strive for as it leads to deflation. On the other hand, Davoodalhosseini (2021) argues that having only CBDC in money circulation can help to bear interest but could also lead to some welfare loss caused by the cost of carrying the CBDC. He explains that the cash inflation must be strictly positive to avoid the situation where a negative inflation rate motivates people to switch from CBDC to cash and the CBDC becomes under-utilized, therefore increasing the cost of carrying CBDC for the central bank. There are some advantages and disadvantages with all three scenarios but the underlying conclusion is that in the

co-existing scheme, there is an increased risk of tax evasion and under-utilization of CBDC. All three scenarios should be analyzed before making the final decision on how to best utilize the money circulation.

Secondly, it is crucial to consider the identification process and privacy of the users. The BIS Annual Economic Report (2021) underlines the benefits of using a digital identification system as a building block of CBDC. The report emphasizes that using a digital ID utilizes the authentication process of users and eliminates the need for physical documents. A report by the Monetary Authority of Singapore (2021) mentions the possibility of using the existing physical identity infrastructure as a base for the digital identity. The report argues that digital identity is the core of digital infrastructure, enabling individuals, businesses, and public institutions to participate in the digital economy by using a single means of authentication across multiple digital services. Furthermore, it is stated in the report that digital infrastructure requires efficient data governance to generate the trust of the individuals who use the system, which can be achieved by adopting privacy and security-enhancing technologies. The exact way to adopt digital ID and ensure transparent digital infrastructure differs based on the country's existing identity authentication infrastructure and regulations. For instance, Estonia has one of the most advanced digital infrastructures in the world. This is possible by providing a digital ID to every citizen, which allows access to all of the county's e-services. Transparent and secure digital infrastructure serves as a foundation to successfully adopt CBDC into a country's monetary system.

Additionally, the payment system has to be efficiently designed to keep up with technological innovations while ensuring the security of user data. As mentioned in the BIS Annual Economic Report (2021), the ultimate advantages of adopting a new payment technology will be determined by the underlying payment system's competitive structure and data governance procedures. The report suggested that central banks should use the banks' expertise, fintechs, and big techs to lead innovative initiatives. The key element of designing an efficient payment system is public-private collaboration. The report adds that the proposed design of CBDC should follow a two-tier system, where the commercial banks and non-bank payment service should focus on "providing retail service on a competitive level playing field" and the central bank "guarantees the stability of value" and "system's overall security" (*Ibid.*, 79). The importance of data governance rises with the amount of available user data. The transaction ledger has to be designed and managed in the most optimal way to keep users' data secure. The BIS Annual Economic Report (2021, 79) concludes that transaction ledger can either be managed by a "trusted central authority" or be based on a

"decentralized governance system". Innovative and competitive payment systems and safe and transparent digital ledger recording are the critical design factors for effective CBDC implementation.

Last but not least, it is essential to decide whether CBDC would be available offline as it may require additional technologies to support the function. The CBDC system should be available even in extreme conditions like natural disasters. Joint report conducted by the Bank of Canada et al. (2020) emphasizes that the offline transaction features help to ensure that users can make offline payments during electrical or network connections outages. As stated in the report, a centralized ledger ensures more efficient security features, whereas a decentralized ledger makes offline payments easier to incorporate. The report concludes that a combination of both ledger systems is possible, but the complexity can significantly lower the system's efficiency. Therefore, governments should conduct an in-depth analysis of which ledger system is the best fit to ensure both network security and resilience to operational failure and disruptions.

1.3.3. Challenges of adopting CBDC

In recent years, increased digitalization has facilitated the use of digital payments. However, based on the report from a group of central banks, some "sections of society" can find themselves lagging behind as "potential barriers around trust, digital literacy, access to IT and data privacy concerns create a digital divide" (The Bank of Canada et al., 6). The digital divide has significantly risen in developing countries. The circulation and management of CBDCs would not function without the Internet and smart devices. Even though the access and usage of the Internet and smart devices have been growing rapidly over the past years, there are still many people especially in rural areas who don't have the necessary means to access and use CBDCs. Lee et al. (2021, 60) argue that in order to adopt CBDC and use it efficiently, it is essential to provide wide internet coverage, increase the penetration rate of smart devices, and increase the level of digital literacy. If these aspects of society are not met, the adoption of CBDCs will only benefit a certain number of people and will not serve its purpose. If nations focus on developing these aspects, it will increase the likelihood of successful adoption of CBDC projects and decrease the digital divide.

Additionally, the adoption of CBDCs can bring various technological challenges. The security aspect relies strongly on the DLT or blockchain technology, which is still a relatively new innovation. Lee et al. (2021) claim that from the perspective of personal information security, there is a cybersecurity risk that identities and private user information could be stolen or abused. They

argue that if the hackers can somehow steal users' private keys, they have instant access to users' private information and assets and the fact that CBDCs only exist in a digital form increases the number of affected users of hacker attacks or system failure than those of traditional currency. Moreover, the digital form of money brings additional challenges with the issuance and supervision process. Banks can determine if the currency is legitimate by tracking counterfeiting of physical cash by sophisticated systems like security features on the physical notes and coins (Lee et al. 2021, 60). CBDC does not exist in physical form, which requires new ways to ensure that the digital currency in circulation is legitimate.

It is important to note that the list of challenges of adopting CBDC as a legal tender varies based on the nation's legal, economic, and social background. There should be an in-depth analysis of all benefits and challenges to see if CBDC is the best fit and which problems and needs it solves.

1.4. Technology enactment framework (TEF)

The theoretical framework used in this thesis is Jane Fountain's technology enactment framework (TEF). Based on Danziger (2004), TEF is perhaps most useful in defining the essential aspects that shape information technology implementation. Several other theories have been developed to measure the impacts and level of acceptance of technological innovations. The most prominent theories are mentioned below to demonstrate why the author believes TEF fits the best for this particular study.

First, the technology acceptance model (TAM) by Davis (1989) incorporated a multi-item scale to measure user acceptance of information technologies. He included perceived usefulness and perceived ease of use as the determinants of technology adoption. However, he emphasized that perceived usefulness and ease of use are "people's subjective appraisals of performance and effort, and do not necessarily reflect objective reality" (*Ibid.*, 335). This particular thesis is not focused on gaining an in-depth understanding of people's perception of new technology, which makes TAM unsuitable for the current paper. Also, diffusion of innovation theory, first introduced by Rogers in 1962, is often used to describe "either adoption or non-adoption of new technology" through Roger's proposed five steps: knowledge, persuasion, decision, implementation, and confirmation (MacVaugh and Schiavone, 2010, 198). Rogers (2003) explains that the diffusion of innovation theory seeks to explain the adoption curve of new ideas and innovations potentially over a long period of time. The model Roger proposed is mainly focused on describing the pattern

and speed of new technologies adoption and therefore is not suitable for the current paper. Further, Venkatesh et al. (2003) introduced the unified theory of acceptance and use of technology (UTAUT), which is a combined method from eight earlier models, including the technology acceptance model (TAM) and the innovation diffusion theory mentioned above. By reviewing and empirically comparing previous models, the researchers established four groups of factors that play a significant role in user acceptance and usage behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions. However, UTAUT is originally meant as an agent-based approach focusing on user intentions and expectations to use information technology and therefore does not fit the goal of this current paper.

Compared to the other technology acceptance models mentioned above, which mainly focus on users' perceptions and their level of acceptance on new technologies, TEF includes additional "variables contributing to an explanation of the processes by which IT systems are adopted", including (Danziger, 2004, 101):

a) the actual information technologies in use

b) the two crucial organizational forms that constitute the context of use – bureaucracy and networks

c) certain institutional arrangements that shape the perception and behaviors of actors

The decision to use TEF was based on the fact that it enables to analyze the research question through multiple dimensions of the society and helps to identify key elements that shape the adoption of information technology. The current research based on Estonia has mainly been focused on how suitable the e-government core technology is for operating CBDC leaving out cultural, social, and institutional features. For example, the research project by Eesti Pank (2020) in collaboration with Guardtime and the SW7 Group tested the suitability of KSI Blockchain as the digital money infrastructure and how electronic identity and other Estonian e-government solutions support the implementation process. However, Fountain (2005, 153) emphasizes the importance of including "soft" organizational structures like behavioral patterns and norms, while designing and implementing ICT initiatives. Fountain (2006) adds that the interdependencies between organizations and technical systems are overlooked when focusing just on technological capability as ICTs are integrated and work within and across organizations. She concludes that for this reason, understanding organizational structures, processes, cultures, and organizational change is critical in order to comprehend and possibly influence the direction of technology use in

an organization. This case study will contribute new knowledge on essential aspects that shape CBDC implantation and hence fill the current research gap.

It is important to note that TEF was first introduced to analyze the implementation of information technology on the organization level whereas in this thesis, TEF is used to describe the implementation process at the country level. The dimensions however are suitable for analysis on different levels.

The technology enactment framework consists of five dimensions. It is essential to note that the causal arrows in TEF flow in both directions, which based on Fountain (2006) indicate a causal connection in all directions among the variables. All five dimensions are described in more detail in the following subchapter.

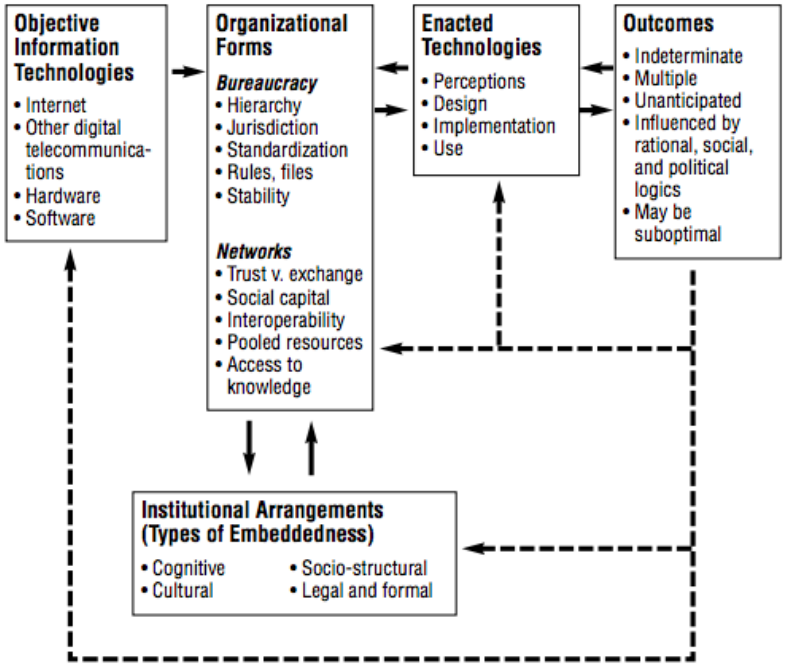

Figure 5: Technology Enactment: An Analytical Framework (Fountain, 2001, 91)

1.4.1. Dimensions of TEF

Like in aforementioned, TEF consists of five dimensions: objective information technologies, organizational forms, institutional arrangements, enacted technology, and outcomes (Fountain, 2001, 91).

Objective Information Technologies

The first of the five dimensions of TEF is objective information technologies, which Fountain (2001, 25) refers to as "the internet, other networked computing systems and telecommunications, hardware, software, and middleware". Based on Fountain (2011) the enacted technology can be presented through the existing technological features or objective information technologies and the ways in which different users take advantage of those IT characteristics (cited in Gil-Garcia, 2012). In contrast, the objective technology dimension also includes all features that might have been chosen as part of the enacted technology but are not, for whatever reason, part of the adopted information technology (Gabriel Puron Cid and Gil-Garcia, 2004 cited in Gil-Garcia, 2012). The existing digital infrastructure, including blockchain technology and digital identification system, has been mentioned in previous research as potential requirements for successful CBDC adoption (BIS Economic Report, 2021; Monetary Authority of Singapore, 2021). The objective information technologies dimension helps to further analyze how Estonia's present digital infrastructure may be utilized and which specific technologies can be employed for the CBDC project.

Organizational Forms

The second dimension of influencers is summed up as organizational forms, which Fountain (2001) describes mainly through the level of bureaucracy (hierarchy, jurisdiction, standardization, rules, files, stability) and networks (trust vs. exchange, social capital, interoperability) between public entities. She argues that organizational arrangements mediate the technology enactment. She concludes that the lower the level of organizational bureaucracy and the higher the network efficiency between different entities, the higher the chance that the enacted technology will succeed.

Network efficiency is often determined by the level of interoperability between entities. Eriksson and Goldkuhl (2013), who focused on studying e-infrastructures, indicate that success in e-government initiatives requires working together and exchanging information across traditional boundaries. The view is supported by Mullen (2003), who specified that interagency data exchange is one way to improve the government's overall information capabilities and implement effective e-government solutions. Even though the CBDC project does not particularly fall under an e-government initiative, it requires integration and data exchange between multiple public and private ICT systems. Therefore, the interoperability of different applications is an essential indicator to evaluate network efficiency in Estonia.

Additionally, Kim et al. (2014) note that the relationship between IT and bureaucracy is interactive, meaning that it is important to look at how technology impacts bureaucratic organizations but also how the traits of bureaucracy can affect the impact of IT. To produce a favorable climate for technological enactment, Fountain (2006, 3) argues that organization bureaucracies and related challenges, based on Max Weber's notion of bureaucracy, such as accountability, jurisdiction, power distribution, and equality, must be debated and resolved. CBDC will be managed by the central bank, thus it's essential to look at the bureaucracy and associated obstacles that might either encourage or hinder CBDC adoption from the central bank's perspective.

Institutional Arrangements

Next, the institutional arrangements dimension focuses specifically on cognitive behaviors and habits, cultural beliefs and symbols, social structures, and formal governmental systems of laws and rules, which sometimes resist, delay, or modify IT systems (Danziger, 2004; Grafton, 2003). In more detail, cognitive institutions refer to "mental habits and cognitive models that influence behavior"; cultural institutions refer to "shared symbols, narratives, meanings, and other signs that constitute culture"; socio-structural institutions refer to the "social and professional networked relationships among professionals that constrain behavior through obligations, history, commitments, and shared tasks"; governmental institutions refer to "laws and governmental rules that constrain problem solving and decision making" (Fountain, 2006, 8). Schellong (2007) points out that existing institutional arrangements impact actors' perceptions and behaviors of technology. Institutional arrangements can either support peoples' trust in future technology initiatives or prohibit the acceptance of technology.

From the legal perspective, IT-related laws and regulations, as well as other formal and informal rules, are commonly referred to as institutional arrangements (Gil-Garcia, 2012). It is essential to look at how the current legislation supports the adoption of CBDC as a legal tender

Enacted Technologies

Fountain (2001, 25) explains the concept of enacted technology as "the perceptions of users as well as the designs and uses of IT in particular settings". She emphasizes that the capability and potential of information systems are enacted to a large extent by its users. She adds that "actors enact technology by their interpretation, design, implementation, and use of it." (*Ibid*., 10). As argued by Danziger (2004, 104), IT will be perceived by individuals and units "as they consider how IT will affect their interests and goals and respond strategically to protect and, if possible, to

enhance those interests". In the aforementioned, all dimensions in TEF have a causal relationship and therefore the way IT is perceived by the units and individuals is influenced by the organizational forms and institutional arrangements.

Outcomes

Last but not least, the outcomes dimension concludes how the enacted technology, organizations and institutions interact. More specifically, the analysis of the previous four dimensions should help to conclude on how well IT, as enacted technology, "will interact with bureaucracy, networks, and the institutional arrangements within which those networks are embedded" (Danziger, 2004, 103). Fountain (2021) emphasizes that possible outcomes could vary depending on the design, implementation approach, and the actual use of the technology and the outcomes can be either direct, indirect, indeterminate, multiple, or unanticipated. As pointed out by Bretchneider (2003), implementing new technologies does not automatically generate organizational change, organizational and institutional arrangements mediate the process and therefore technology adoption often results in unexpected outcomes.

1.4.2. Limitations of TEF

TEF helps to propose explanations to complex social relationships in real-world settings but as Fountain (2001, 31) put it, the guiding propositions are not clearly operationalizable nor easily falsifiable and serve as "guides to a complex problem area". As a result, the findings should not be interpreted as absolute truth, but instead as a guideline.

Additionally, in her book *Building the Virtual State*, Fountain (2001) applied and tested TEF in three different case studies all based on the United States, making the framework's global generalizability unclear.

Further, TEF fails to include communication as a matter for successful technology enactment. As stated by Schellong (2007), perception, use and acceptance of technology are all influenced by how objective factors and goals are communicated.

2. METHODOLOGY AND LIMITATIONS

2.1. Research strategy

A case-study approach was chosen to conduct this exploratory analysis, which Yin (2003) has described as an empirical investigation of a current and specific phenomenon in its real-world setting. According to Yin (2003), it allows to investigate a contemporary phenomenon when boundaries between phenomena and context are not immediately obvious and numerous sources of information are used (cited in Denzinger and Andersen, 2002). The study looked into Estonia's readiness to implement the digital euro by delving into the nation's technological, economic, and social development in real-world scenarios, which naturally fall under the case study approach. Since the aim of this research was to investigate a subject rather than seek the causes of a certain problem (Van Thiel, 2014), exploratory research was conducted. Further, based on Eisenhardt (1989, 537), "the cases may be chosen to replicate previous cases or extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types". By selecting this case study, the author aims to extend Fountain's (2001) technology enactment framework to show aspects that shape CBDC implementation into the nation's monetary system.

By focusing on one particular country, the in-depth analysis increases the understanding of the preconditions that countries should focus on before deciding to adopt CBDC. Based on Gerring (2011), the results of one particular case could serve as a base to understand a larger population, but Bennett and Elman (2006) stress that generalizing depends on several factors like the frequency and contexts in which the underlying findings of the case operate. However, the paper does not develop a comprehensive model and examples are specifically about Estonia. Therefore, the external validity is rather low and caution must be taken when generalizing the results.

2.2. Research design

Qualitative research was conducted to gain further in-depth information on how well the current digital infrastructure, organizational forms, the level of bureaucracy, and institutional arrangements in Estonia perform as a prerequisite of a successful implementation of CBDC. Read and Marsh (2002, 232) argue that qualitative analysis enables to generate a better understanding of the social world and understand the existing data rather than producing causal explanations, which is often the purpose of quantitative analysis. Therefore, the qualitative approach fits better with the aim of this study. Moreover, qualitative research helps to establish further open-end discussions, which the author believes is essential for a vital phenomenon like the central bank digital currency.

Data collection for this case study consisted of desk research to gain an in-depth understanding of the phenomena. The main tool of collecting information was through document analysis, previous research, artifacts, working papers, and government reports. Brown and Hale (2014, 111) argue that the key advantages of using secondary data include that data is immediately available and it reduces the time and cost to collect the data. The empirical data will be compared and analyzed in this thesis using a prior developed framework (Eisenhardt, 1989). The unit of analysis in this study has a geographical focus, focusing on one particular country.

2.3. Limitations

This research has several limitations concerning its research design. First, the qualitative case study approach makes the results of this study non-generalizable, which several researchers have assessed as one of the main limitations of the qualitative research design (Brown and Hale, 2014; Ochieng, 2009). In contrast, Yin (2003) argues that the purpose of case study is to generalize theories and not particular findings. Even though the results are specifically about Estonia and could differ tremendously for other countries, the aim of this study is not to draw a general conclusion. The goal is to demonstrate and analyze the preconditions, which could serve as a base for further investigation for countries with similar phases of technological and economic development.

Secondly, the analysis is based on secondary data. Based on Brown and Hale (2014), the limitations of using only secondary data relate to the level of quality and reliability. They

emphasize the importance of finding the most appropriate source of data and collecting background information about the data collection methods in order to increase the reliability of the study. To minimize the concerns regarding data reliability, desk research was conducted via authoritative sources, including peer-reviewed publications and journals, government websites, trusted national and international news sources. The study focuses on explaining to what extent is the country ready to implement CBDC based on a variety of factors, therefore no surveys or interviews were included. Further research should be conducted to figure out what the citizens of Estonia, specific organizations, and groups expect and need from CBDC.

Last but not least, this study is only based on qualitative research and fails to include quantitative methods. Some researchers believe that combining methods increases the "validity of research because using a variety of methods means that one method serves as a check on another" (Read and Marsh, 2002, 237).

3. CASE STUDY: IMPLEMENTING CBDC IN ESTONIA

In 2020, the Bank of Estonia (Eesti Pank) collaborated in a pilot study to explore the adoption of a central bank digital currency - the digital euro. The goal of this research project by the European Central Bank (2020a) in collaboration with seven other European central banks is to explore the issuance process of the digital form of euro from the perspective of the Eurosystem. The report indicates that introduction of the digital euro into the monetary system could help to address the declining usage of cash, people's changing needs in terms of retail payments, and support financial inclusion. In terms of Estonia, Eesti Pank (2020) carried out a research project on the suitability of KSI Blockchain as the digital money infrastructure and how electronic identity and other Estonian e-government solutions support the implementation process. The findings of this research project showed that digital euro based on blockchain technology is highly scalable as the experiment established no limits on the size of the money supply. The experiment also concluded that "electronic ID (eID) can be linked to the digital euro so that security is ensured and various levels of privacy are allowed" (*Ibid*., n.p). In terms of the high energy cost often associated with blockchain technology, the research project showed a smaller carbon footprint than the current card payment system is producing.

To contribute to the already existing research on the possible technical solutions for the central bank digital currency, in this case study, the implementation of CBDC will be analyzed through different aspects of the Estonian economic, social, and legal environment. This analysis will help to demonstrate additional preconditions that should be considered before implementing CBDC.

3.1. Objective Information Technologies

Estonia is known as one of the most advanced digital societies globally, providing a solid digital infrastructure for future information and communications technology (ICT) initiatives. In this case analysis, Estonian e-government core technology will be analyzed to see how suitable current

digital infrastructure is for the implementation of central bank digital currency and what are the possible limitations of the current system.

The Government of Estonia has established an extremely advantageous environment for a technological initiative like the blockchain-based digital euro. One of the ICT projects that has created a convenient environment for adopting the CBDC in Estonia is the digital identity card (ID-card), which was launched in 2001 as a form of identification for Estonian citizens. It serves as an identification document both physically and digitally. An ID card allows the user to digitally sign documents and the digital signature is legally equal to the physical one (Kimmo et al., 2018, 420). Based on e-Estonia (n.d.) the number of Estonians owning a digital ID has reached 98% of Estonia's population. Additionally, the digital identity card allows Estonians to use almost all governmental services online. It is regularly used as a legal travel document within the EU, national health insurance card, proof of identification on the Internet sites, for digital signatures, for i-Voting, to use e-services (e-Estonia, n.d.). As pointed out by the Eesti Pank researchers (2021), electronic ID could be linked to the digital currency to identify the people involved in transactions and carry out anti-money laundering controls. However, the existing ID card system has a significant flaw in terms of one of CBDC's major principles, which specifies that it should be widely accessible. As stated by Eesti Pank (2021), the current eID scheme excludes non-EU citizens because there is no mutual recognition of ID-card outside Europe. To achieve the global accessibility criterion, additional means of obtaining identifying data are required.

Also, it is important to note that the Estonian digital identification system does not come without security risks. The University of Tartu researcher Arnis Paršovs (2021) points out that the first bigger security issue was discovered in 2012 when all ID cards issued in 2011 were affected. The vulnerable ID cardholders were invited to renew the affected cards. He writes that in total, 78 760 ID cards were revoked. Based on the Information System Authority (RIA) (2017), around 800 000 Estonian ID cards issued since 2014 were affected by a security vulnerability found in chips used in ID cards in 2017. RIA report concludes that the ID-crisis was resolved by a software update two months after the initial discovery of the security risk. Paršov (2021, 154-155) concludes in his dissertation that in order to avoid the security risks happening again, the state should have a bigger role in managing and overseeing the ID card manufacturing process, continuously look for more "security fault tolerant ID card technological solutions", as well as require a "detailed description of security procedures and measures" while implementing ID card related developments. He emphasizes "greater transparency, openness and expert involvement is needed" to encourage

research in this field and ensure more appropriate risk assessments in the future (*Ibid.,* 162). Even though the Estonian identification card system has a history of some security flaws, it has successfully served as the cornerstone of the digital society without having any major security outbreaks. Therefore, based on the wide utilization of ID cards in Estonia and the manageable security risks, it is appropriate to argue that ID cards could successfully serve as an authentication method for the users of the digital euro. The key is to be publicly open about any security risks and work with cross-functional teams to continuously improve the security aspects of the digital identity card. This would increase people's trust in the ID-card system and confirm that continuous improvements are in place to mitigate any security risks that are, on some level, inevitable.

Another essential technological innovation to support the central bank digital currency implementation is blockchain technology. It has been successfully used in Estonia to build an e-government system, making Estonia the first country to use blockchain on a national level (KSI Blockchain, 2021). First introduced as a backbone of Bitcoin in 2008, blockchain has now been utilized in variety of sectors. According to Kulkarni (2018), the initial blockchain structure now has multiple versions and variants that comply with the needs of different industries and enterprises. The blockchain technology designed for the Estonian e-government system is the Keyless Signature Infrastructure (KSI), which ensures that data cannot be manipulated nor rewritten (e-Estonia, n.d.). KSI blockchain was first developed by Guardtime in 2008 to ensure that critical data is protected from cyber-attacks and data can be securely accessed and archived on a long-term basis (Guardtime, 2021). One of the most critical factors KSI blockchain provides to Estonian e-services infrastructure is that it supports massive volumes of data transactions (*Ibid.*). The system resistance to handle high volumes of data is also essential for the CBDC project. Based on the experiment conducted by the Eesti Pank (2021) in collaboration with The SW7 and Guradtime, the KSI Blockchain solution "handled over 300,000 simultaneous payments a second and the money reached the payee in less than two seconds". In addition, the central bank must have an option to oversee and redeem transactions in the core ledger. Therefore, the blockchain ledger has to be adapted to give the central bank permission to access the transactions data if needed. Guardtime (2020) has already started researching ways to provide a full-stack infrastructure for CBDC. The research led to the invention of KSI Cash, which is built on the KSI blockchain and provides suitable infrastructure for the CBDC projects. The blockchain technology behind KSI Cash provides the security requirements essential for CBDC projects. The company emphasizes that public cryptographic proofs provide users and regulations security that everything functions correctly and immediately shows any possible cyber threats. The fact that Estonia has

an existing partnership with Guardtime and the KSI Blockchain has efficiently worked for the e-government system makes KSI Cash a promising infrastructure for the CBDC project in Estonia.

To leverage the usage of CBDC, the majority of people must have access to a fast and reliable Internet connection. Based on the World Bank (n.d.), 89% of people in Estonia used the Internet in 2020. According to the information released by Statistic Estonia (n.d.), the share of Internet connections in households has consistently increased over the past decade. In 2021, the percentage of households having internet connections reached 91,8% compared to 60,6% in 2010. Based on the report, even bigger increase has occurred in the percentage of households with mobile internet connections, which increased from just 4,2% in 2010 to 72,5% in 2021.

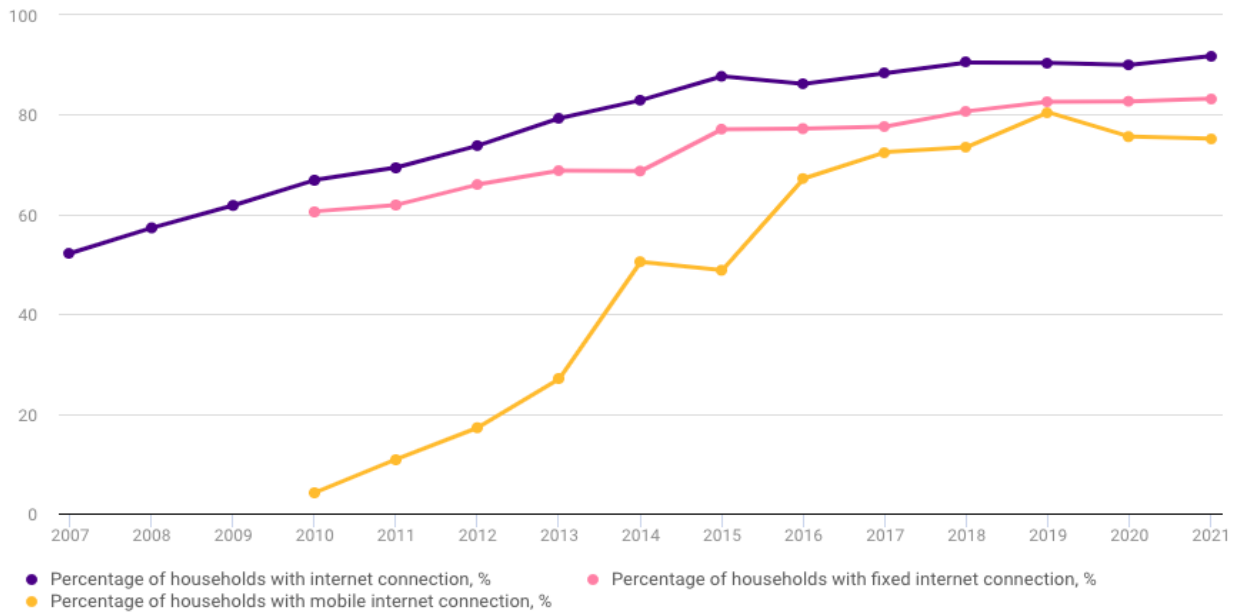

Figure 6: Share of households with internet connection 2007 - 2021 (Statistics Estonia, 2021).

To further improve the Internet connection everywhere in Estonia, multiple telecommunication providers are testing a 5G network. At the end of 2020, Telia Estonia in a partnership with Ericsson, was the first provider to launch a commercial 5G network in Estonia. The network is now accessible at over 50 locations around Estonia and available for Telia clients who own 5G compatible smartphones (The Baltic Times, 14 June 2021). The development of the 5G network is an essential milestone to ensure that people anywhere in Estonia can access fast and reliable Internet connection crucial for the implementation of digital initiatives like CBDC. Currently, the 5G network implementation in Estonia has not been as fast as planned, and the adoption processes are lagging behind the initial deadlines. Therefore, the government of Estonia should more actively

promote the adoption of the 5G network to ensure that in case of the digital euro adoption, it would be accessible to everyone no matter the location.

It is important to note that even though a fast and reliable Internet connection is essential to download necessary applications, there should be an option to use the digital euro offline as well. Further research is needed to analyze possibilities to build an infrastructure that supports offline payments with the digital euro.

3.2. Organizational forms

Fountain (2006) argues that networks and bureaucracies are two of the key influences on technology enactment. These factors either facilitate or prohibit successful implementation of new technologies.

Schellong (2007) states that network efficiency is greater with trust and open information and data sharing between different entities. It is an essential factor of successful implementation of CBDC because it is not scalable nor efficient to expect the central bank to provide all the related services. For instance, it might be beneficial to outsource customer service and client acquisition processes to more experienced entities in these fields. Intermediaries could also be used to perform customer onboarding, billing, etc. This requires well-functioning communication and data sharing between different actors to ensure that data moves smoothly and securely between several databases. Network efficiency in Estonia is supported by X-Road software based X-tee, a data exchange layer that provides consistent and secure data exchange across companies (X-Road Global, n.d.). X-tee might be an alternative for facilitating data exchange between intermediaries in the CBDC project. Kimmo et al. (2018) describe X-Road as a virtual environment that links public and private sector databases. The researchers emphasize the importance of decentralization, as well as the fact that X-Road connects different databases to enable effective information exchange. As stated by Tammpuu and Masso (2018), "X-Road formed the spine of the national digital infrastructure and became the basis for the further development of public and private e-services in different areas of society." Adopting the X-Road system eliminated the need to have one massive database, which brings security risks and gives too much power to one entity overseeing the data. Based on e-Estonia webpage (n.d.), approximately 52000 organizations are now direct or indirect users of the X-Road software based X-tee, and over 1000 organizations use the system daily. The system is

built in a way that allows an unlimited number of organizations to use the system. This is an essential factor considering that the amount of services offered digitally increases constantly and the networks between different entities get more complex. The encryption technology ensures the security aspect of the data transfers in X-Road, “all outgoing data is digitally signed and encrypted, and all incoming data is authenticated and logged” (e-Estonia, n.d.). However, while the number of public and private entities joining the network is consistently increasing, there is a greater chance that the security measures are not properly followed. An audit conducted by the National Audit Office (2001) found that the background of the majority of private firms using X-Road has not been sufficiently checked. There is a lack of standardized service contracts, and some entities do not sign the contracts at all before joining the X-Road system. The audit emphasizes the lack of approved governmental agencies currently regulating whether a private firm joining X-Road implements effective security measures to protect data integrity, confidentiality, and availability. The audit argues that even though the private entities entering a contract confirm that they will follow the necessary security measures, there are no additional controls in place to confirm that adequate measures are implemented. As stated by audit manager Toomas Viira, “this may allow unauthorized persons to have access to state databases and the ability to make unauthorized changes” (National Audit Office 2021 cited in Whyt, 2021, n.p). In order to use the X-Road ecosystem as the communication and data exchange layer between public and private organizations for the CBDC project, additional security systems should be developed. The National Audit Office concludes that an additional system should be developed that allows auditing private entities in the ecosystem to ensure that they follow necessary security measures and perform regular recovery tests on the X-Road system itself (2021 cited in Whyte, 2021). That would reduce the possibility of unauthorized persons gaining access to confidential data, which is essential if X-tee is considered as the data exchange layer between intermediaries for the CBDC project.

In addition to network efficiency, the organizational bureaucracy is a critical indicator that the enacted technology will succeed. CBDC will be managed by the central bank, thus it's essential to evaluate the level of bureaucracy and associated obstacles that influence CBDC adoption from the Bank of Estonia’s perspective. Hence, the level of bureaucracy will be analyzed based on bureaucratic characteristics such as administrative burdens, hierarchy, technical competence as discussed by the dominant theorists in this field including Max Weber (Kim et al., 2014). It is important to note that this particular study does not go into great detail on the Bank of Estonia's organizational structure. The analysis is solely based on secondary information mainly from Bank

of Estonia's webpage and corresponding legislations. Further in-depth research should be carried out to assess the Bank of Estonia's organizational bureaucracy.

The level of administrative burdens, or frequently referred to as red tape, could be used as indicators of the central bank's capacity to manage CBDC. The OECD (2006) defines administrative burdens as regulatory expenses such as obtaining permits, filling out paperwork, and complying with government reporting and notification obligations. In terms of CBDC adoption, the preconditions and potential administrative burdens include outdated accounting and reporting systems. Based on Lönnberg (2013), tested systems must be in place for independent auditors to guarantee currency reform's integrity by ensuring accurate accounting and reporting of the currency exchange. Moreover, the adoption of CBDC as a liability of the central bank brings changes in the accounting practices and therefore further clarifications might be needed. Kiff et al. (2020, 42) argue that central banks should establish transparent accounting mechanisms for CBDC and publish internal audit findings to ensure accountability to its stakeholders including the parliament and society. To ensure the efficiency and transparency of the financial accounting and reporting division, the Bank of Estonia (Eesti Pank) (n.d.) has formed a separate department responsible for overseeing the bank's performance. The Internal Auditing Office of the Bank of Estonia follows the auditing principles agreed by the European System of Central Banks Currently and the audit reports are submitted to the Supervisory Board and the Governor of the central bank (Eesti Pank, n.d.). The bank should consider releasing the audit results to the parliament and potentially to a wider public to increase the transparency of CBDC accounting and reporting.

In addition, the technical competence of central banks, including building up the expertise and training the staff, should be analyzed to evaluate central banks' readiness to manage CBDC. Lönnberg (2013, 39) claims that "strengthening the institutional capacity of the central banks and ensuring it has the resources needed are critical preconditions for currency reform". Currently, Eesti Pank (n.d.) states on its webpage that continuous training and development of the staff is ensured by training courses, participation in the working groups of the Eurosystem, etc. Technical courses should be included in the training program in order to build up expertise for technology-intensive projects like CBDC. Also, additional expertise in DLT or blockchain technology might be needed. As mentioned before, one of the technological challenges with CBDC is the security aspect, which relies strongly on blockchain technology. The blockchain technology is a relatively new innovation and therefore requires additional expertise that is able to instantly respond to potential cyber-attacks.

Last but not least, the hierarchy of the central bank could be used to characterize the speed and transparency of decision-making. Since based on the Bank of Estonia (Eesti Pank) Act (1993), the central bank of Estonia operates independently of other state agencies and is not subordinate to the Government of the Republic or any other executive agency, the work of the Bank of Estonia is solely managed by the bank's Executive Board. Therefore, decisions regarding the monetary policy can be decided on the bank's management board level. However, digital euro adoption has to be looked at from the perspective of the Eurosystem and therefore the Bank of Estonia has to execute instructions from the European Central Bank (RT I 2006, 29, 219). As a result, the adoption procedure must comply with the European Central Bank's strict design and implementation regulations, which will require a significantly longer time to accomplish this monetary policy change. The list of possible legislation changes that the Bank of Estonia has to follow is analyzed under the institutional arrangements dimension.

3.3. Institutional Arrangements

Institutional arrangements shape the perception and behaviors of other dimensions of the TEF framework. The comprehensive list of "norms, beliefs, laws, and cultural understandings", which Fountain calls institutional arrangements, guide and constrain behavior and can either endorse or restrain new technology enactment (Danziger, 2004, 103).

Over the past decades, Estonia has formed a national image as a virtual state. Fountain (2001) explains virtual state as an outcome of well-established digital networks between government agencies and the clients with whom they interact. It can be argued that Estonia's strong national branding as a digital nation can increase citizens' trust in ICT initiatives like the CBDC project. As stated by Madisson (2016 cited in Tammpuu and Masso 2018, 548), "technology-friendly culture and extensive digitalization of the society have become a branding mechanism for the Estonian state, which not only has created the external image and reputation of the country as a digital forerunner but has also shaped local identity narratives". Tammpuu and Masso (2018, 544) argue that Estonia has successfully utilized national branding, which can be described as a "particular kind of communication strategy and meaning management employed by governments in order to create favorable national images and to manage the country's national reputation". Well-formed national branding has helped Estonia strengthen its position among the leaders of

digital transformation. Estonians, in general, take pride in the rapid information society developments over the past decades. The researchers conclude that well-established nation branding may "function as a re-nationalizing mechanism", meaning that nation branding contributes to "stronger national identities and solidarities" (*Ibid.,* 546). Moreover, a strong national branding as a technological frontrunner attracts international financing and private organizations to invest money and knowledge, contributing to Estonia's future digital success. To conclude, Estonia's strong national branding as a digital nation and technology-friendly culture have boosted technology acceptance and made citizens more willing to explore future technology initiatives like CBDC.

Next, the formal governmental systems of laws and rules influence the success of technology enactment. Research by IMF, which studied the legal, governance, and regulatory challenges faced by central banks considering CBDC, argues that some countries may need to alter their legal frameworks and central bank governance in order to issue CBDC (Kiff et al., 2020). The study emphasizes the importance of determining to what degree and under what conditions national legislative systems permit CBDC issuance, both directly and indirectly. The legal framework governing payments and securities settlement in Estonia is derived from both European Union and Estonian legislation, with Estonian law covering those areas not covered by EU legislation (Eesti Pank, n.d.). The European Central Bank (2020a) emphasizes in the initial report on the digital euro that any potential design of digital euro must comply with relevant legislation, including legislation on money laundering and the financing of terrorism. Additional legal issues, according to the report, include "the legal basis for issuance, the legal implications of different design features, and the applicability of EU legislation to the Eurosystem as the issuer" (*Ibid*., 5).

First, based on He et al. (2016), the legal concept of currency often refers to the banknotes and coins issued by the central authority. For the issuance of retail CBDC, central banks should examine whether or not the present legal provision on legal tender would or should include retail CBDC and if changes in legislation are required (Kiff et al., 2020; Mancini-Griffoli et al., 2018). Currently, "EU primary law does not exclude the possibility of issuing digital euro as legal tender", which means that payees must accept it for payments (European Central Bank, 2020a, 24). Estonia is part of the Eurozone, which means that the Bank of Estonia is required to implement the monetary policy set by the Governing Council of the European Central Bank (RT I, 09.05.2014, 2). As a result, any legislative changes necessary to make the digital euro a legal tender must originate at the European Union level. Additionally, it must also be decided at the policy level

whether cash will coexist with digital currency. As mentioned before, “having both cash and a CBDC available may result in lower welfare than in the cases where only cash or only a CBDC is available” (Davoodalhosseini, 2021, 2). Therefore, the Bank of Estonia has to decide whether to change the current handling of euro banknotes and coins.

Further, as mentioned before, it might be beneficial to outsource some of the related services and functions of CBDC. Kiff et al. (2020) argue that outsourcing vital central bank functions to external vendors requires great caution and vigilance. According to the European Central Bank (2020a) report, the design and issuance of digital euro cannot be outsourced, however incorporating supervised intermediaries with arrangements such as value storage, payment processing on behalf of the public, and so on is permissible. If the Bank of Estonia decides to outsource some of the services related to CBDC, it may require revamping corresponding regulations. Based on Kiff et al. (2020), the legal framework for CBDC must clearly determine the rights and obligations of parties in the system. Any outsourcing should be subject to strict supervision, which is backed by corresponding regulations.

Additionally, on the basis of managing money laundering and financing of terrorism, the CBDC design should follow strict customer due diligence requirements. Kiff et al. (2020, 29) point out that CBDC could either run on a decentralized (DLT) platform or a traditional centralized database but “neither centralized platforms nor DLT-base CBDC offer complete resilience”. They add that the decentralized platform allows some level of anonymity and assuages data privacy concerns but could jeopardize financial integrity. In Estonia, the Money Laundering and Terrorist Financing Prevention Act (2017, n.p.) states that “a credit institution and a financial institution is not allowed to provide services that can be used without identifying the person participating in the transaction and without verifying the submitted information”. Therefore, the current legislation prohibits CBDC on the decentralized platform, which allows anonymous CBDC transactions. The Bank of Estonia should consider both options to find the right balance between financial integrity, privacy, and transparency. However, changes in the Money Laundering and Terrorist Financing Prevention Act may be required based on the chosen platform.

3.4. Enacted Technologies

Fountain (2001, 25) explains the concept of enacted technology as “the perceptions of users as well as the designs and uses of IT in particular settings”.

The idea of issuing a national virtual currency in Estonia was first introduced in 2017 by Kaspar Korjus, a managing director of Estonia’s e-residency program. Korjus (2017, n.p.) proposed to issue a national cryptocurrency called “estcoin”, which would have made Estonia the first country to utilize an Initial Coin Offering (ICO). He saw an opportunity to provide “tradable crypto assets globally”, which could be based on the already existing e-Residency network. E-Residency applicants are authenticated by the national ID card, which provides a secure digital environment to trade crypto assets and provide the government with the necessary means to oversee possible counterfeiting and illegal activities (Korjus, 2017). However, the project did not meet much support from the representatives of Eesti Pank or the governmental institutions. In 2017, the president of the Bank of Estonia at that time, Ardo Hansson, stated that “the idea that we would have a kind of parallel currency won’t happen” because that kind of private-sector solution could endanger the financial equilibrium inside the country (Treeck, 2017 cited in Polyakova, 2018, 36). The current president of the Bank of Estonia, Madis Müller, was also critical while emphasizing that providing alternative financial services for non-residents is extremely risky as it helps to avoid internationally agreed anti-money laundering requirements (Pau, 2018). From a political perspective, there were concerns about the security aspects of the “estcoin” project (Polyakova, 2018, 37). The “estcoin” project remained an idea and was not implemented at the national level. It is important to emphasize that there are some significant differences between the “estcoin” project and the central bank digital currency initiative, eliminating some of the concerns that representatives of the Bank of Estonia and the government raised back in 2017. The digital currency issued by the Central Bank of Estonia would not compete with the official currency; it would be a digital form of euro. The digital euro would be controlled by the central bank, which gives the central bank the authority to force anti-money laundering controls and establish Know-Your-Customer (KYC).

To better understand the perception, expected design, and understanding of the digital euro, it is crucial to look into consumers' expectations. There is currently a lack of research on whether consumers in Estonia are actually ready to adopt CBDC and if they see a need for it. It is essential to first look into consumers' needs and expectations because people have several alternatives to

choose from including private digital currencies and cryptocurrencies. A study by Guradtime (n.d.) in collaboration with PureProfile is likely the first global consumer study on this topic. The researchers interviewed over 902 adults in relatively diverse countries based on social and political norms. The interviews were conducted in Germany, Singapore, South Africa, the United Arab Emirates, the UK, US, France, Hong Kong, Sweden, and Norway. The fact that the interviewees were selected from relatively diverse countries makes the findings to some extent universally applicable and could possibly be taken as a point of reference while designing the Estonian central bank digital currency. The findings of this study listed the most crucial functions and attributes that interviewees expect from CBDC including privacy, ease of use, no additional costs, and the ability to use it internationally. The list also included the ability to use it without an internet connection, which is a crucial aspect to make the digital euro as accessible as cash. The findings also pointed out some regional differences in enthusiasm to use CBDC. The study found that while more than 75% of adults in Singapore, South Africa, the UEA, and Hong Kong are willing to use CBDC at launch, only 50% of adults in Germany, France, the UK would use it right after the launch. It is hard to predict Estonians' willingness because even though other European countries are less willing to use CBDC compared to Asia and the Middle East countries, Estonia's agile government and digital image could possibly increase peoples' trust in CBDC compared to other European countries that participated in the research.

3.5. Outcomes

Estonia is known for its advanced e-government system and cryptographic expertise. The objective information technology dimension of the TEF framework is extremely advanced in Estonia compared to the majority of countries in the world. It is the first nation that started using blockchain technology on a national level and has reformed its identity system by introducing state-issued digital identity. Parts of the current digital infrastructure supporting e-government systems could potentially be used for the CBDC project. First, the digital euro could be linked to the ID-card system. That enables the Central Bank to identify people involved in transactions and oversee possible anti-money laundering risks. In order to use the ID-card system for the CBDC project, it is crucial that potential security risks are mitigated. In order to do so, the state should provide research and expert involvement to continuously improve security measures. Also, the government and other responsible entities should openly share any shortcomings and describe how these challenges are handled to increase people's trust in the system. Furthermore, additional methods

to acquire user identification data might be required because the current ID system excludes non-EU citizens. As a result, the current system fails to meet one of the digital euro requirements which states that it should be widely accessible.

Another objective information technology that could be used for the CBDC projects is the KSI blockchain technology. KSI blockchain has been previously used in Estonia to build one of the most advanced e-government systems in the world. In the light of the increased interest in introducing a virtual form of fiat money, Guardtime has started experimenting with KSI Cash, a full-stack infrastructure for digital money. KSI Cash is built on the KSI blockchain but has necessary adjustments that make it suitable for the CBDC projects. Estonia has an existing partnership with Guardtime and the KSI blockchain has worked for the e-government system without major shortcomings for over 13 years, making KSI Cash a promising infrastructure for the CBDC project in Estonia. Even while it appears that components of the current digital infrastructure could be used for the CBDC project, further research is needed to determine how the infrastructure can be advanced to facilitate offline payments. For online payments and to download necessary applications, the government of Estonia should more actively promote the 5G network that helps to guarantee that people anywhere in Estonia can access fast and reliable Internet connections crucial for the implementation of digital initiatives like the digital euro.

High network efficiency, smooth and secure data sharing between private and public organizations increase the likelihood that future ICT innovations will succeed. The X-Road system has formed an efficient ecosystem for data sharing between public and private organizations without the need to have one massive database. The X-Road system based X-tee has largely proven to be a reliable infrastructure for sharing classified data. However, the system does have some security risks that have to be considered. For instance, the way private entities are accepted to the ecosystem and how these entities ensure the security and availability of the data are currently not properly audited. Additional security systems should be developed to ensure that organizations using the network are fully in compliance with essential security measures in order to consider X-tee as a possible data exchange layer between different entities involved in potential outsourced services like client acquisition processes, customer onboarding, billing, etc.

In addition to network efficiency, the level of organizational bureaucracy provides valuable insights into whether the enacted technology will succeed. Since the digital euro will be handled by the central bank, the level of bureaucracy was assessed from the organizational level of the

bank. The findings show that accounting mechanisms might need to be altered to follow digital currencies accounting standards and the internal audit results should be published to the parliament and possibly to a wider audience to increase the transparency on the CBDC developments. Also, additional internal training should be established to build up the technical expertise of the staff. Additionally, CBDC will be based on blockchain technology, which is a relatively new innovation and therefore requires expertise that is able to instantly respond to potential cyber-attacks. Last but not least, even though the Bank of Estonia enjoys autonomous powers in the conduct of monetary policy, the digital euro adoption procedure must comply with the European Central Bank's strict design and implementation regulations, which will require a significantly longer time to accomplish this monetary policy change.

The analysis of the institutional arrangements dimension concluded that Estonia's appearance as a virtual state increases the likelihood of successful implementation of CBDC into the monetary system and increases peoples' trust in future digital innovations. Estonia has formed a national branding as a digital nation, which has in turn formed Estonians' identity narratives and made people more open to adopting digital innovations. Also, a strong national branding as a digital nation attracts international financing and foreign talent, contributing to Estonia's future digital success.

In addition, changes in legislation on the European Union level are required to include retail CBDC as a legal tender. The prospect of issuing digital euro as legal tender is currently not excluded in the EU primary law. Furthermore, policymakers must decide whether cash and digital currency will coexist, which would require additional legislative revisions. Also, in order to outsource some of the relevant services, the CBDC legal framework must explicitly define the rights and duties of involved parties. Further, based on the CBDC platform design, which could either be centralized or decentralized, changes in the Money Laundering and Terrorist Financing Prevention Act (2017) may be required, which currently permits financial institutions to provide services without identifying the people participating in the transactions.

In terms of the enacted technology, in this thesis considered the digital euro, it is crucial to conduct further user research. There is currently a lack of research on what people in Estonia expect from CBCD and if they are ready to adopt it. The users are the ones who eventually have to approve and start using it and therefore further user research has to be conducted to find the most suitable design and sort out the most crucial attributes that people expect from the digital euro.

DISCUSSION AND CONCLUSION

The aim of the present study was to examine to what extent is Estonia ready to implement CBDC into the monetary system and what are the preconditions that support the implementation process. The earlier research conducted by Eesti Pank was primarily concerned with the suitability of e-government core technology for running CBDC while excluding other features that influence technology enactment. Hence, the study sought to contribute new knowledge on essential aspects that shape CBDC implementation including technological, cultural, social, and institutional features.

To answer the research question, an analysis was conducted by applying the Technology Enactment Framework (TEF). Estonia's readiness to adopt the digital euro was analyzed through the five dimensions of TEF: objective information technologies, organizational forms, institutional arrangements, enacted technology, and outcomes. Based on the findings of this study, it can be concluded that Estonia has established an overall favorable environment for a blockchain-based digital currency, although certain additional elements are required.

First, the study concluded that the objective information technologies dimension is extremely advanced in Estonia and the current digital infrastructure meets many preconditions of CBDC adoption. This finding is consistent with that of Eesti Pank (2020), which argued that parts of the current e-government core technology can be used for the CBDC project including the ID-card system and KSI blockchain. However, the findings of this study show that the current ID card fails to meet one of the digital euro requirements which states that it should be widely accessible. Also, the KSI blockchain currently fails to support offline payments with the digital euro. In terms of internet access, which is based on Fountain (2001) one of the most crucial aspects of the objective information technologies dimension, this study stressed that the Estonian Government should more actively promote 5G network in order to ensure that the digital euro is accessible for everyone no matter the location. Therefore, improvements in the current digital infrastructure are required to use parts of it in the CBDC project.

Secondly, the organizational forms dimension currently meets the network efficiency requirement but further research is needed to adequately evaluate the level of organizational bureaucracy in the Bank of Estonia. The network efficiency is quite high in Estonia due to the utilization of X-Road software based X-tee. However, in order to consider X-tee as a potential data exchange layer between intermediaries for the CBDC project, additional methods to properly audit private enterprises entering and using the network are required. The level of bureaucracy in the Bank of Estonia was analyzed based on bureaucratic characteristics such as administrative burdens, hierarchy, technical competence. The study concluded that there is a need for additional technical training for the staff responsible for managing CBDC to increase their expertise in blockchain technology. Also, the current accounting and reporting systems should be updated based on the characteristics of CBDC and the bank should consider releasing the audit results of the Internal Auditing Office to the parliament and potentially to a wider public to increase the transparency of CBDC accounting and reporting. Further research should be conducted to analyze the Bank of Estonia through the level of administrative burdens like hierarchy and technological capability, which determine the organizational success in technology enactment. The current analysis was solely based on the Bank of Estonia's webpage and corresponding legislation.

Next, the study pointed out that Estonia's strong national branding as a digital nation increases citizens' openness to adopt future digital initiatives like the digital euro. However, the legal preconditions under the institutional arrangements dimension are currently not met. Currently, the digital euro is not considered as a legal tender by the EU primary law. Therefore, changes in legislation on the European Union level are required to include retail CBDC as a legal tender. Also, additional adjustments in legislation are required based on the chosen platform design and whether the bank decides to outsource some of the related services.

Further, the study concludes that the enacted technology dimension in Estonia should be elaborated by further user research to better understand the perception, expected design, and understanding of the digital euro. The idea of issuing a national virtual currency in Estonia was first introduced in 2017 by Kaspar Korjus but the "estcoin" project received a lot of criticism. Therefore, it is important to communicate that there are some significant differences between the "estcoin" project and the CBDC initiative, eliminating some of the concerns that representatives of the Bank of Estonia and the government raised back in 2017.

Last but not least, the outcomes dimension presented the findings of the previous four dimensions in order to conclude how well the enacted technology, the digital euro, interacts with other dimensions. However, as aforementioned, all variables in the TEF framework have causal connections in all directions (Fountain, 2006). It is currently impossible to describe the exact impacts that the enacted technology has on organizations and institutions because the digital euro is not yet implemented in Estonia. As mentioned before, it can take either a long or very short period of time before the impacts of CBDC can be recognized.

Overall, TEF was successful in giving a comprehensive picture of the factors driving CBDC adoption by looking at the research question from a variety of perspectives, not only through the technological capability. However, TEF fails to include some features that influence successful technology enactment on the country level. First, TEF does not include communication as a matter for successful CBDC adoption. Previous research has shown that perception, use, and acceptance of technology are all influenced by how objective factors and goals are communicated (Schellong, 2007). It is certainly true with the digital euro project, which requires clear and transparent communication about the foundational principles and core features to generate trust in individuals who will use the technology. Secondly, TEF studies users' perceptions and use of innovative technology but neglects to look into users' needs and motivations while designing the technology.

The findings of this case study will contribute to future research on the criteria for CBDC's effective integration into the national monetary system. Although the particular conclusions are exclusive to Estonia, the list of preconditions analyzed can serve as a baseline for nations contemplating CBDC implementation.

The main limitation of this study is the absence of interviews with participants and the lack of original data. All data used was secondary data collected from documents, previous research, and artifacts. Also, the qualitative case study approach makes the results of this study non-generalizable. The purpose of utilizing qualitative methods was to examine certain areas in depth, although this may not accurately reflect the overall situation. Further user research is required to establish the most crucial attributes that people expect and need from the digital euro because the users are the ones who eventually have to approve and start using it.

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