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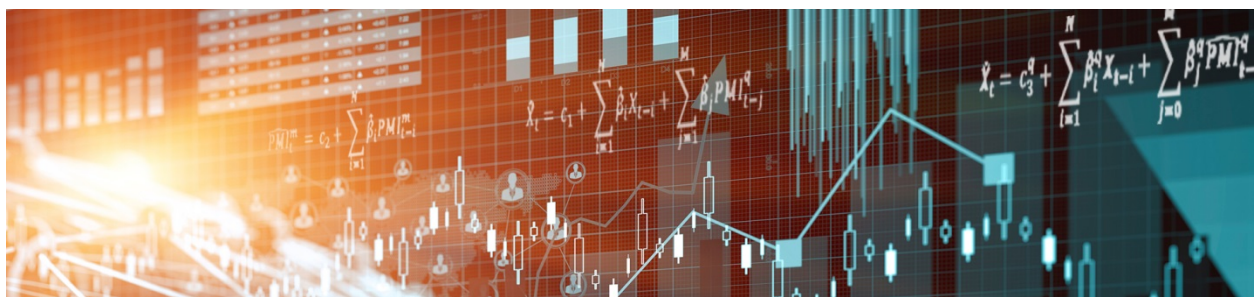
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A Policy Framework for E-Money: A Report on Bank of Canada Research



by Mohammad Davoodalhosseini and Francisco Rivadeneyra

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A Policy Framework for E-Money: A Report on Bank of Canada Research

by

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Abstract

We present a policy framework for electronic money and payments. The framework poses a set of positive questions related to the areas of responsibility of central banks: payments systems, monetary policy and financial stability. The questions are posed to four broad forms of e-money: privately or publicly issued, and with centralized or decentralized verification of transactions. This framework is intended to help evaluate the trade-offs that central banks face in the decision to issue new forms of e-money.

Bank topics: Digital currencies; Monetary policy; Payment clearing and settlement systems

JEL codes: E41, E51, E52, E58

Résumé

Nous présentons un cadre stratégique pour la monnaie électronique et les paiements. Le cadre comporte un ensemble de questions objectives liées aux domaines de responsabilité des banques centrales : les systèmes de paiement, la politique monétaire et la stabilité financière. Les questions portent sur quatre grandes formes de monnaie électronique : la monnaie d'émission privée ou publique accompagnée d'une vérification centralisée ou décentralisée des transactions. Le cadre est conçu dans le but de faciliter l'évaluation des arbitrages que doivent effectuer les banques centrales lorsqu'elles décident d'émettre de nouvelles formes de monnaie électronique.

Sujets : Monnaies numériques; Politique monétaire; Systèmes de compensation et de règlement des paiements

Codes JEL : E41, E51, E52, E58

1. Introduction

In the last few years there has been rapid technological change in the field of electronic money and payments, and the trend is likely to continue. Technological innovations like cryptocurrency, distributed ledger technology (DLT) and mobile computing have created a flurry of interest by central banks, financial intermediaries and the public. Central banks are evaluating whether these changes pose challenges to their mandates or provide opportunities to better achieve them, and how they should respond to these developments, for example, by potentially regulating or issuing their own digital currency.

In this paper, we present a framework for e-money to help policy-makers focus on the trade-offs relevant to the mandates of central banks. “E-money” is the umbrella term we use for assets with some characteristics of money (means of payment and store of value) in electronic format. This definition covers a variety of forms, from commercial bank deposits, central bank reserves, prepaid cards and Bitcoin, to digital currency potentially issued by central banks. This framework emerged from the research conducted at the Bank of Canada over the last two medium-term plans and consists of two parts.¹

The first part of the framework establishes the issues and questions that are important to central banks. The issues and questions stem from the typical areas of responsibility of central banks: (i) providing safe and efficient means of payment, (ii) conducting monetary policy to ensure price stability and (iii) overseeing the financial system to ensure financial stability. More specifically, we ask the following positive questions: With respect to payments, will new forms of e-money increase the efficiency of the payment systems provided by central banks? Relatedly, what factors govern the adoption of these new forms of e-money? With respect to the implementation of monetary policy, how would the effectiveness of monetary policy be affected if a private e-money were widely adopted? Would a central bank e-money improve the effectiveness of monetary policy? And, would general welfare increase? Lastly, with respect to the financial system, would a central bank e-money increase competition in the market for means of payment and spur innovation in financial services?²

¹ Compared with the paper by Fung and Halaburda (2016), our framework addresses the wholesale and retail versions of e-money as well as monetary policy and financial system considerations.

² In this paper, we focus on the traditional areas of responsibility of central banks, although the framework can be used to address other public-policy objectives that could be addressed with e-money such as financial inclusion, reduction of tax evasion and anti-money laundering.

The second part of the framework discusses the different forms of e-money. Discussing the forms is important because the answers to the questions above depend on the specific forms of e-money. Specifically, our framework classifies e-money along two dimensions: (i) who is the issuer and (ii) how are transactions verified. We categorize issuers as either having a welfare-maximizing criterion or not. Obviously, the objective of central banks is to maximize social welfare. However, the alternative type of issuer can have a variety of criteria; for example, a private issuer can have the objective of maximizing profits, the Bitcoin system has a fixed money growth rule, and foreign central banks try to maximize the welfare of their local population. We categorize the type of verification of transactions as either centralized when performed by a central party, like the issuer, or decentralized, for example, when performed by a network of computers. There are many other dimensions along which e-money can be classified, but we believe that the ones mentioned here are the most relevant for central banks. These dimensions capture the incentives for the provision of e-monies and their key technological aspects that jointly determine the efficiency of each type of e-money system. In other words, the framework addresses the trade-offs between the public and the private provision of different forms of e-money.

The ultimate questions for policy-makers are, however, normative: For example, should the Bank of Canada offer a new form of e-money? If it does, in what form should it be? If not, should the Bank of Canada regulate private e-monies? Should the Bank open the wholesale payment system to new participants? To answer these questions, policy-makers can use our framework to carry out an evaluation of the trade-offs implied by the positive questions posed above.

An argument for issuing a new form of e-money is the provision of public goods. Indeed, the provision of outside money, as opposed to inside money, is a public good insofar as outside money provides a non-excludable and non-rivalrous *service* (per the standard definition of public good taken from Stiglitz 1988).³ This service is the ability to conduct safe and efficient payment transactions. Central banks already offer different forms of outside money such as cash and reserves. The cash “system” fits the typical public good description because the central bank allows anyone to acquire this means of payment, and the positive network externalities from its usage benefit every individual making use of the system. While the wholesale payment system is slightly different because access to reserves is obviously limited, the externalities benefit the financial institutions, which in turn provide payment services to their clients.

The mandate of the central bank is not to offer all types of means of payment as outside money. The question here is whether central banks should offer a *new* type of outside money in electronic form. As mentioned above, there are economic justifications for the role of central

³ According to Lagos (2010, 132), outside money is the money that is “either of a fiat nature or backed by some asset that is not in zero net supply within the private sector,” while inside money is “an asset backed by any form of private credit that circulates as a medium of exchange.”

banks in issuing *some* forms of outside money. Historical examples and theoretical work have shown that leaving the provision of safe and efficient means of payment to the market may not result in an efficient and stable outcome. However, the specific form the bank should offer depends on how that form serves the objectives of the central bank regarding payment system efficiency, monetary policy and financial stability. This is what we study in this paper.

We conclude that for the payment systems that central banks currently operate, new forms of e-money are unlikely to improve their efficiency, at least given the technology available today. Regarding monetary policy, the widespread adoption of private e-monies could pose a threat to the effectiveness of monetary policy. On the other hand, a central bank e-money could offer monetary policy improvements if it is interest-bearing and universally accessible. On competition and innovation, we conclude that depending on the form, a central bank e-money would be either a competitor or a complement to commercial bank deposits. Some important questions remain to be addressed, especially how e-money would affect the structure of the financial system, and how the transmission mechanisms of monetary policy would change in the presence of e-money.

This paper is organized as follows. Section 2 discusses the framework organized by questions and forms of e-money. Section 3 presents the specific questions related to payment systems. Section 4 discusses questions concerning monetary policy. Section 5 addresses the questions of financial system competition and innovation. Section 6 applies the framework to discuss more specific policy questions, for example, issues around international competition in digital currencies and timing of issuance. Section 7 discusses an additional aspect of the normative debate: whether central banks should issue new forms of e-money because they can be thought of as public goods. Section 8 concludes and suggests future research questions.

2. The Framework

The objective of the framework is to allow policy-makers to identify the relevant trade-offs in the different policy decisions—for example, to issue a central bank e-money or to regulate private versions. The relevant trade-offs that are important to central banks derive from their areas of responsibility: payment systems, monetary policy and financial stability. For each area, we ask several positive questions and answer them in the context of specific forms of e-money.

2.1. Key positive questions

Central banks are typically responsible for (i) providing or ensuring safe and efficient means of payment, (ii) conducting monetary policy to ensure price stability and (iii) overseeing the financial system to ensure financial stability. The specific questions we ask in each area are the following.

Payment systems

1. Will new forms of e-money increase the efficiency of the payment systems currently provided by central banks?
2. What conditions govern the adoption of these new forms of e-money?

Monetary policy

1. How would the effectiveness of monetary policy be affected if a private e-money were widely adopted?
2. Would an interest-bearing, universally accessible central bank e-money improve the effectiveness of monetary policy?
3. Would general welfare increase following the introduction of a central bank e-money?

Financial system

1. Would a central bank e-money increase competition in the market for means of payment and spur innovation in financial services?

Other policy issues

Some other important issues, not directly related to central bank responsibilities, are whether e-money would affect anti-money-laundering measures, whether e-money could serve as a reserve currency and whether it would aid in extending financial inclusion. There are certainly many others. Although we do not answer these questions directly, the trade-offs implied by the forms of e-money can be used to give a general direction of the trade-offs underlying these other considerations. We explain the forms next.

2.2. Forms of e-money

The answers to these questions depend on the form of e-money. Therefore, we provide a taxonomy of forms based on two dimensions of e-money: (i) who the issuer is and (ii) how transactions are verified.⁴ **Figure 1** includes the diagram of the forms and examples of each form.

Issuers are categorized as either having the objective of maximizing welfare or not. The welfare criterion is with respect to a local population. For example, the objective of the Bank of Canada is to maximize the economic welfare of Canadians. The alternative type of e-money issuer can

⁴ Other papers have provided a taxonomy for e-money. See for example Bech and Garratt (2017) and references therein. We believe that these two dimensions are the most important ones for the questions of interest to central banks, although other dimensions, such as whether the money is universally accessible and whether the identity of the bearer of money should be verified, are important for some other questions.

be a private issuer with the objective of maximizing profits, for example, commercial banks or PayPal. Another example is the Bitcoin system, which has a fixed money growth rule not designed to maximize profits but, potentially, to maximize adoption. Another example of an issuer without a welfare criterion is a foreign central bank trying to maximize the welfare of a different population. Figure 1 labels the non-welfare-maximizer issuer as non-central bank.

Transactions done by money in the electronic form necessarily require some form of verification. Since the cost of attempting to double-spend with electronic means of payment is very low, verification by some third party is typically essential. We categorize the third-party verification as performed in a centralized or a decentralized way. Centralized verification means that a single central party (that is, neither the buyer nor the seller) is involved in making sure that the transaction is valid. This central party could, but need not, be the issuer. The decentralized verification is a set-up in which multiple parties are involved in validating the transaction. What matters in this distinction is who bears the liability for making sure the transaction is indeed valid, either by verifying that the means of payment is not a counterfeit and has not been spent before or that the party wanting to pay is indeed who he says he is. In a centralized set up, the liability aligns incentives and results in a trusted central party. When distributing the liability among more parties, or, in the extreme, not having any at all, incentive mechanisms must be put in place to prevent the verifiers from colluding with each other or with the payors (i.e., the buyers).

This distinction in verification is important because it captures key aspects of the technologies and whether the information on transactions and balances is available to multiple parties. This last aspect matters for privacy issues.⁵

Figure 1 Forms of e-money

| | Issuer | Central bank | Non-central bank |
|---------------|--------|--------------|-----------------------|
| Verification | | | |
| Centralized | | Reserves | PayPal, bank deposits |
| Decentralized | | Jasper 1 | Bitcoin |

⁵ The distinction between centralized and decentralized could apply more generally to record keeping, which could be divided into two parts: the verification of balances against the existing record and the updating of the records by incorporating the new transactions.

Some examples are useful to illustrate the different forms. Reserves are one example of an e-money issued by the central bank and verified centrally: transfers of reserves between commercial banks are verified and executed by the central bank. E-money issued by central banks but verified in a decentralized way is less common and, so far, experimental. The token used in Phase 1 of the Bank of Canada's Project Jasper is a form of central-bank-issued e-money but verified in a decentralized way. The Bank of Canada creates digital tokens, called CAD-Coin, in exchange for the cash collateral pledged by commercial banks into a special account at the Bank of Canada. Market participants who have access to the network can exchange CAD-Coin, but these transactions are verified by the Ethereum network without the involvement of the Bank of Canada.⁶

A well-known example of a non-central-bank-issued and decentralized e-money is Bitcoin. There are many older forms of e-money that are centralized, for example, commercial bank deposits and PayPal balances.

This taxonomy is useful to distinguish between the plethora of terms currently being used. One frequently used term is "central bank digital currency" (CBDC). It usually refers to a widely accessible central bank e-money. Most papers and commentators do not make a distinction between the types of verification, although this aspect is crucial to the safety, efficiency, privacy and monetary policy trade-offs.

This simple framework captures the essence of the issues that policy-makers should look at without getting distracted by many technological points. The dimensions mentioned here are the most relevant for the incentives in the provision of e-money and the key technological aspects that jointly determine the efficiency of each type of e-money system.

3. Payment Systems

In this section, we address two questions. First, how can e-money affect the efficiency of payment systems? Second, will these new forms of e-money be widely adopted, and, more specifically, what factors influence their adoption?

3.1. Efficiency

To study efficiency, we consider various forms of e-money separately.

⁶ See Chapman et al. (2017) for details of Project Jasper.

Privately issued decentralized e-money

The first type of e-money considered here is privately issued e-money with decentralized verification, the best example being Bitcoin. We start from this case because it has attracted a lot of attention in the media and even among academics. It has also been proposed that using the underlying technology of Bitcoin could improve the efficiency of payment systems. More specifically, in this section we are interested in the following question: How efficient would a payment system that operates using the Bitcoin technology be compared with current payment systems? The short answer is that, given its current set-up and technological constraints, this type of system is unlikely to improve the efficiency of the current retail or wholesale payment systems (Chiu and Koepl 2017).

To elaborate, the receiver of money in any electronic transaction should verify that the money is genuine, i.e., the money has been issued by the issuer or the system, and that the money has not already been spent in an earlier transaction. Since the verification of transactions in the Bitcoin system is decentralized and without a trusted third party, the system designers put a mechanism in place, based on cryptographic techniques, to address this issue. This mechanism provides rewards for being the party verifying a transaction, but doing so requires time-consuming computational operations. The costly nature of these operations also makes tampering with the records generally not worthwhile. Without getting into more details, we mention only the most important implications of these types of verification mechanisms.

The finality of the payments is not immediate. This is because the transactions should be communicated to a network, and then the network members verify the transactions. This entire process is time-consuming. Moreover, the verification is probabilistic. The longer one waits, the higher the probability is of the finality of transactions. Although the finality of transactions is very high, it can never be exactly equal to 100 per cent. Furthermore, this process of verification requires a lot of electricity consumption. And finally, the larger the size of the transaction, the greater the incentives of agents to double-spend. For example, the incentive to defraud is significant if one can buy a house using bitcoins. Thus, such a system is more suitable for small-value transactions. Chiu and Koepl (2017) confirm this theoretical finding in a quantitative exercise. They show that the welfare cost of processing large-value transactions is orders of magnitude higher than small-value transactions if the underlying technology of Bitcoin is used for a payment system.⁷

The verifiers of transactions, called miners, are incentivized through reward schemes that include the newly created money and transaction fees. The current Bitcoin system is poorly designed as

⁷ They use two data sets—US debit card data, which is a set of small-value transactions, and Fedwire, which is a set of large-value transactions—and feed them into a system like Bitcoin with optimally chosen parameters.

it attracts too much mining activity, which leads to a significant deadweight loss (Chiu and Koepl 2017). Indeed, it is possible to design the parameters of the reward scheme for miners in a more efficient way than the current Bitcoin system to reduce the electricity consumption and welfare loss. Of course, if there is a trusted party in the system, the verification of transactions can be done more efficiently as the mining activities can be significantly reduced or even eliminated.

Central-bank-issued decentralized e-money

In the last subsection, we concluded that using a decentralized verification technology run by a private party is not an efficient way to run a payment system. We now turn to another case where the central bank runs the payment system but still uses the same technology as the Bitcoin system. We make two related points.

First, the research on Project Jasper (Phase 1) concluded that even if the central bank runs a wholesale payment system based on this technology, the system would not be efficient relative to the current payment systems (Chapman et al. 2017). Second, it may be argued that a digital equivalent to cash, which is anonymous and has immediate finality, can be created using the technology of Bitcoin. As mentioned earlier, this decentralized technology requires communication to a network and verification by the network, so the process is time-consuming. Thus, the finality of transactions will not be immediate. This presents a trade-off for policy-makers. With the current state of technology, either the system must sacrifice some anonymity, in which case many other design options are available, or it must sacrifice the immediate finality of transactions.

Central-bank-issued centralized e-money

We have concluded so far that using a decentralized verification technology, whether the issuer is a central bank, would not make a good payment system with the current technology. What if the central bank, using a centralized verification technology, issues e-money? Would this e-money promote the efficiency of payments?

Because the issuer is, by definition, welfare maximizing, it is not surprising that issuing this type of e-money can promote efficiency. The reason is that this form of e-money provides the central bank with an expanded set of policy tools compared with traditional cash. For example, the issuer can control (tax or subsidize) users' access to the system and charge fees on users' transfers (Chiu and Wong 2017). These arrangements are not possible with cash but are commonly used in digital payment systems such as credit and debit. This type of arrangement, however, requires the central bank to acquire a lot of (potentially private) information on balances and transactions to be able to implement such schemes to improve welfare, but the central bank may not want to do that for legal or ethical reasons. Again, this presents a trade-off

for policy-makers: the greater the amount of information used, the more efficiency can be obtained.

This concludes our discussion on the efficiency of different forms of e-money. The last type of e-money (i.e., privately issued centralized e-money), which we did not cover in this subsection, is considered in depth in the next subsection on adoption.

3.2. Adoption

We have thus far studied whether various forms of e-money provide efficiency of payments. We have taken as given that e-money has already been adopted by economic agents. In this section, we analyze the adoption of privately issued means of payment, whether or not the verification is centralized, and study the factors that influence their adoption. Briefly, the adoption of private e-moneys is typically inefficient because of network externalities (Chiu and Wong 2014).

A payment system is a two-sided platform consisting of the buyers and the merchants (sellers). The incentives for a buyer to adopt a payment instrument depend on the extent to which sellers are willing to accept that payment instrument; similarly, the incentives for a seller to accept a payment instrument depend on the extent to which buyers are willing to use that payment instrument. However, individuals do not internalize the effect of their usage on other participants in the system. This is a form of externality, and it can lead to a coordination problem between buyers and sellers. For example, an inferior payment instrument might be widely circulated, while a superior payment instrument may not be adopted. These coordination problems also explain why, while hundreds of similar cryptocurrencies were introduced, only a few of them, most notably Bitcoin, are widely circulated.

Consequently, because of network externalities, it is likely that only one issuer monopolizes the market (or a few issuers capture all the market share). This is a natural monopoly, and following a standard argument, monopolists tend to charge a higher price to extract more surplus from customers. Particularly in payment systems, the issuers usually tax merchants substantially and subsidize the buyers to maximize their monopoly rents. Inefficiency and welfare loss follow. These theoretical findings are well established in the literature. See for example the seminal work of Rochet and Tirole (2003).

Jiang and Zhang (2017) conduct laboratory experiments to verify these theoretical findings. In their experiments, agents can choose between two types of payment instruments—a well-known existing means of payment like cash, and a new means of payment like a private e-money. The new means of payment is socially more efficient, but the merchants need to incur some costs in advance to be able to use it. For example, they should acquire certain machines or establish a stable and secure internet connection to a server. The authors find that there are mismatches and coordination problems between various means of payment of buyers and

merchants in the experiment. Specifically, the coordination problems are the most severe when the merchants' adoption cost is high. That is, although the new means of payment is socially more efficient, merchants do not accept it.

Because of externalities, interventions exist that improve welfare (Jiang and Zhang 2017). If the government or central bank believes that a means of payment is more efficient but not well adopted by the market, the government can often make coordination easier, for example, by imposing that in a certain set of transactions, only e-money should be used. It is shown that this policy would substantially promote the adoption of this means of payment by both sellers and buyers (Arifovic, Duffy and Jiang 2017).

4. Monetary Policy

We study two cases in this section. First, we consider the case in which a private e-money is extensively adopted in the economy and used in transactions. We show that this would negatively affect the ability of the central bank to conduct monetary policy. Next, we study the optimal monetary policy if the central bank issues its own e-money.⁸

4.1. Competition between privately issued e-money and central-bank-issued money

Consider the case in which a private e-money, like Bitcoin, or even a digital version of a foreign currency, is extensively used in the economy. The extensive adoption of private e-money can negatively affect the central bank's ability to conduct monetary policy due to the coordination issues that arise between the central bank and the private issuer (Zhu and Hendry 2017).

Private issuers typically aim to maximize profits or have other objectives in their minds (other than maximizing welfare), so their policy might not be aligned with the central bank's objectives, which makes it hard for the central bank to achieve its objectives. Hence, the central bank must respond to correct these negative effects. The effectiveness of central bank policy is dependent on whether the private issuer exhibits strategic behaviour.

An optimal policy intervention is relatively effective if the e-money issuer is passive. The issuer is called passive if the issuer does not respond to the central bank's monetary policy. For example, the money supply in the Bitcoin system follows a deterministic path and will eventually stop growing in the long run. In this case, it may be easier for the central bank to achieve the optimal

⁸ The type of policy that we refer to in this paper is setting the money supply, which automatically determines the inflation. Increasing the money supply raises inflation, which in turn reduces the real value of money, so agents would have less incentive to acquire money balances to use in their purchases. Therefore, the real amount of consumption and output decreases with a higher inflation rate. Other monetary transmission channels are absent in the models surveyed here, and we propose that these channels merit careful study in future work.

money supply to promote welfare, for example, by using traditional open market operations (OMO). However, even when the private issuer is passive, the central bank is still constrained in its attempts to depreciate private e-money, since its OMO is constrained by the amount of private e-money it holds.

An optimal policy intervention is less effective when the issuer is active. The issuer is called active if the issuer responds to the central bank's monetary policy. In this case, if the central bank believes, for example, that the domestic currency is over-valued, it may attempt to sell domestic currency and purchase private e-money through an OMO. However, the private issuer may take advantage of the central bank's monetary policy by selling private e-money to generate more seigniorage. This response may significantly impede the effectiveness of the central bank's intervention and may even lead to a worse outcome relative to the case of no intervention. Even when the private issuer is passive, the central bank is still constrained in conducting OMO, because the central bank has only a limited amount of private e-money to supply to the market if it attempts to depreciate private e-money. Hence, even if the central bank does its best, the resulting allocation in the economy in which a private e-money is extensively adopted is inferior relative to the case where the central bank has complete control over money in circulation in the economy. This conclusion applies to both cases of passive and active private issuers, although the coordination problems are more severe when the issuer is active.

4.2. Central-bank-issued e-money and monetary policy

We argued that privately issued e-monies can pose a threat to monetary policy. Now we consider the case where the central bank issues its own e-money. The type of e-money considered here is an interest-bearing, account-based e-money with centralized verification. All agents in the economy can open an account with the central bank and use balances in the account for their transactions of any size. This version of CBDC was first proposed by Tobin (1987). As we discuss below, this type of e-money has superior features relative to the existing payment instruments that are issued by the central bank and government and allows the central bank to better conduct monetary policy and improve welfare (Davoodalhosseini 2017).

This type of e-money is superior to reserves because it is universally accessible; reserves, on the other hand, are accessible only to a limited number of financial institutions. Therefore, the conduct of monetary policy does not require the intermediation of financial institutions.⁹ It is also superior to government bonds because bonds are not liquid enough, are indivisible and are not recognizable for many agents in the economy, especially in retail transactions. Finally, it is

⁹ If there are inefficiencies in the transmission of monetary policy caused by the intermediating financial institutions, then this public access is even more crucial.

superior to cash because it is interest-bearing, potentially in a non-linear fashion (like different interest rates on different balances).

Despite the advantageous features of this type of e-money, cash has other advantages. It is anonymous, and many people value anonymity for legitimate reasons. Also, cash is available in almost all circumstances and geographical locations, while electronic means of payment are vulnerable to electricity outages or cyber risks and may not be available in some geographical locations. Furthermore, some segments of the population may face significant costs in learning to use e-money and may therefore be more comfortable using traditional means of payment. Given these advantageous features of cash, it is important to study the coexistence of cash and the central-bank-issued e-money.¹⁰

Davoodalhosseini (2017) shows that the coexistence is not necessarily optimal. That is, if the advantages of cash are sufficiently great, it would be optimal for the central bank to keep cash and not issue the central bank e-money, and if the advantages are not significant, then it would be optimal to issue the central bank e-money and get rid of cash. In short, the coexistence of cash and e-money constrains policy.

It is unlikely that the central banks will eliminate cash from circulation soon, and even if they do issue e-money, the coexistence of cash and e-money is expected. The welfare gains of introducing e-money into the Canadian and US economies are estimated in Davoodalhosseini (2017). In a counter-factual exercise, if the advantage of cash over e-money is 25 basis points in terms of monetary value, then issuing e-money would increase welfare up to 0.7 per cent for Canada, but it has only negligible effects for the United States. These estimates should be taken with caution, because the monetary value for the advantages of cash is chosen somewhat arbitrarily at this stage, and more precise measurements of this value could be estimated from micro-level data. Another reason for caution in interpreting these results is that the estimation does not consider the transmission channels of monetary policy, which should be explicitly modelled to provide a more precise estimate.

To the best of our knowledge, there is only one other estimate in the literature on the welfare gains of introducing e-money. In Barrdear and Kumhof (2016), these welfare gains are estimated to be around 3 per cent. Both papers share the result that introducing e-money provides welfare gains. However, the estimates are distant from each other, suggesting that more research is needed focusing on the following: First, how much more liquid is this type of e-money relative

¹⁰ Sometimes it is argued that if cash were eliminated, criminal activity would be reduced. This argument should be taken with caution. Theoretically, it is not clear what the response of criminals would be if cash were eliminated. For example, the elimination of cash might lead to the extortion of firms, which could create further problems. Empirical evidence is needed to support this argument. Thus, the advantages of cash should not be underestimated. (This question remains to be investigated.)

to government bonds, and what are its (dis)advantages relative to cash? Second, the monetary transmission mechanism should be considered explicitly because introducing this type of e-money has non-trivial effects on the existing channels of monetary policy transmission.

4.3. Transmission of monetary policy under e-money

To elaborate on the effects of central-bank-issued e-money on monetary policy transmission mechanisms, note that when a central bank offers an interest-bearing instrument, agents, whether firms or households, would use that not only as a means of payment but also as a store of value. The optimal portfolio decision of agents regarding other assets (including cash and deposits) is likely to be changed, leading to a change in the demand for and price of other assets. This, in turn, could affect the consumption of individuals through wealth channels, the investment decisions of firms through changes in the relative price of different assets and through changes in their balance sheets (and their ability to borrow), and the lending decisions of financial institutions through standard balance sheet channels. The size and the sign of the overall effect, on both theoretical and empirical levels, is a matter for future research.

5. Financial System

In this section, we discuss the potential effects of e-money on financial intermediation, especially through competition and innovation (Kahn, Rivadeneyra and Wong 2017). To tackle this issue, we need to understand how central-bank-issued e-money would compete with established means of payment, particularly bank deposits. To analyze the competition between different means of payment, it is useful to categorize payment systems as either account-based or token-based.

Account- and token-based systems are distinguished largely by the identification requirements in each system: whether the identification of individuals or objects is required. In the process of conducting a transaction, the identification requirement in an account-based system amounts to asking whether the individual paying is the true owner of the account from which the payment will be made. In the case of tokens, the question is whether the payment object being transferred is genuine or counterfeit.

These identification requirements frequently, but not always, correspond respectively to a centralized and decentralized verification of transactions: account-based systems tend to be centrally verified, while token-based systems are decentralized. Two examples of account-based systems are the large-value payment systems that record the central bank reserves, and commercial bank deposits in the form of chequing accounts. Examples of token-based systems are Bitcoin and cash.

Now we describe the elements needed for an account- or token-based central bank e-money and how they would compete with private means of payment. An account-based e-money issued by a central bank largely implies that the central bank would open its balance sheet to the public. This system would require the central bank to perform certain activities that it does not typically do today on a large scale: (i) opening accounts, (ii) processing transactions and (iii) managing direct relationships with the public. Note that the new technologies that are motivating the issuance of e-money—mainly mobile computing and DLT—have not altered the fact that these three activities are essential for an account-based system. In fact, the ability to perform these activities has been possible for a long while; therefore, this type of system has been feasible for just as long.

Central banks do not typically provide accounts to the public,¹¹ most likely because of comparative disadvantages in performing the above-mentioned activities, which implies that this type of system would not be more efficient than private alternatives (Kahn, Rivadeneyra and Wong 2017). Should central banks issue e-money based on accounts, these systems would compete directly with commercial bank deposits. As a store of value, central bank accounts would be free from the credit risk of commercial banks. As a medium of exchange, provided adequate ease of use to perform transactions, these accounts could be as convenient as their commercial rivals. The effects on banks, the main suppliers of deposits, will depend on their response. Banks could increase deposit rates or increase the convenience of bank accounts; they could also reduce lending if they are forced to turn to more expensive—and less stable—sources of funding.

The elements necessary for a token-based e-money are (i) the wallet to store and access the digital tokens and (ii) the technology to verify the transactions of tokens. Token transactions could be verified based on DLT, but they could also be centrally verified by the central bank or an entity regulated by the central bank. The key difference from the account-based system is that the elements of a token system are simpler to delegate or acquire in a competitive market.

The token-based e-money could be a complement to bank deposits instead of a substitute, much like cash is today. Further, this system is more likely to spur innovation because incumbents and new entrants could have incentives to develop applications on top of this system. As opposed to the account system, the activities necessary to run the token system could be delegated or kept in house by the central bank, much like today the development of security features and the printing of paper currency are done in conjunction with private firms.

¹¹ There are certainly some exceptions. For example, as a service to residents, the Bank of Spain allows residents to [open a direct account at the Bank of Spain](#).

6. Policy Questions

Although the framework is general enough to address many policy issues, we recognize that many of the relevant questions policy-makers might ask are not posed in the context of our framework. In this section, we address these specific policy questions.

Should the central bank issue e-money?

Put differently, would the benefits of central bank e-money outweigh its costs? Existing research does not provide sufficient guidance to help answer this question. The framework aims to shed light on the trade-offs of private and public e-monies. To answer this question, central banks need to better understand and quantify the channels by which e-money will affect monetary policy and its transmission mechanisms, the potential effects on the financial system and its stability, and the technological risk and opportunities of the chosen form of e-money.

What are the prerequisites for a decision?

In addition to the work done so far, we need to understand and quantify at least three more aspects of e-money: (i) how the transmission mechanism of monetary policy would change with e-money, (ii) how the financial system would respond in the presence of a central bank e-money and (iii) which form and technology the central bank should use. Other public-policy aspects, not directly related to central bank mandates, could also be considered, for example, the distributional implications of the access to and availability of e-money.

Related to the transmission mechanism of monetary policy, the macroeconomic models used so far are informative but limited in scope. Particularly, they need to incorporate heterogeneity (along various dimensions such as firms' productivities and households' preferences) to obtain a more precise understanding of the transmission of monetary policy as well as estimates of welfare gains from introducing central bank e-money.

Also, as mentioned earlier, many research questions on the effects on the banking system should be addressed. More precisely, if interest-bearing e-money is offered, commercial banks could respond by increasing deposit rates to keep attracting deposits. This could imply a reduction of lending amounts or an increase in lending rates. Commercial banks could also change their risk-taking behaviour—for example, by investing in more risky projects—potentially making the financial system less stable.

Similarly, the technology should be explored in more detail. Some of the technologies that would underpin a token-based system are being developed, and at this stage many improvements in their safety and efficiency could still lie ahead. Another important aspect that needs careful consideration is the risk of cyber attacks, mostly to token-based systems. Cyber

risks can be systemic, for example, if an unexplored security vulnerability leads to a compromise of the entire system.

What would be the benefits and risks of making the decision to issue e-money earlier than other countries? Does it matter whether other countries get ahead of Canada?

Being the first mover could deliver certain advantages, for example, capturing a larger share of the latent demand for this type of means of payment in both international and domestic markets.

However, there are considerable reputational concerns for the central bank if it issues an e-money that does not get adopted widely or, more importantly, is implemented poorly. These reputational risks could spill over to its ability to conduct monetary policy. If the central bank issues e-money and the financial system responds in an unforeseen way, the difficulty of implementing the desired monetary policy could have significant and long-term consequences for the broader economy. Finally, there are significant cyber-security issues that must be addressed before a final decision is made. It is true that the Bank of Canada is one of the leading central banks in the world in this area, but not being the first mover would allow the Bank to learn from the experience of others without incurring these costs and risks.

Some may argue that the first mover may help promote their currency as a reserve currency in the international financial system. This may be true to some extent, but we should keep in mind that having the currency available in electronic form is a necessary but not sufficient condition to have it used as a reserve currency. Being adopted as a reserve currency would depend on other conditions, such as the size of economy, the openness of the financial system and the availability of safe assets denominated in that currency. With Canada's current safe asset capacity, it is unlikely that the Canadian dollar could be a leading reserve currency in the international financial markets. Further, the huge flows of capital into the Canadian economy coming from reserve currency status could pose a serious threat to financial stability.

We believe that there is no critical deadline for the Bank of Canada because the current national payment systems and monetary policy framework are performing well, and the financial system has been quite resilient. Also, cash in circulation has been relatively stable in gross domestic product terms for the past three decades in spite of its usage declining in retail transactions (Jiang and Shao 2014). There is of course room for improvement, but no substantial change should be made until the outstanding issues are fully explored to make sure that all risk factors have been taken into consideration.

If cash is eliminated from circulation, will the central bank lose its ability to implement monetary policy?

No. Because of regulation or the need for safety, financial institutions settle payments in Canadian dollars using central bank reserve balances. This allows the Bank of Canada to influence the lending rate between banks and therefore implement monetary policy. In addition, the public will demand balances denominated in Canadian dollars to the extent that authorities require taxes to be paid in Canadian dollars. These balances would most of the time be held at commercial banks.

How could the central bank regulate private e-monies?

Several options are available to policy-makers (government agencies or the central bank). We mention some below, but this list is probably not exhaustive. The optimal mix of policies would depend on the circumstances.

- (i) The government could regulate private e-monies in terms of their access and interchange fees, and it could even decide to tax or subsidize either side of the market. In some cases, the central bank might be able to regulate the money growth rate.
- (ii) The government could follow the legislative process to outlaw e-monies. Enforcement would be an issue especially for anonymous forms of e-money.
- (iii) The government could set or coordinate technological standards for private e-monies. These standards might be harder to enforce in digital settings.
- (iv) The government could regulate and supervise issuers to ensure their soundness (Fung, Hendry and Weber (2017) conclude that government intervention in Canada during the 19th century helped ensure the safety of privately issued notes).

Are private e-monies generally inferior to a central bank e-money?

This is true as a general statement because there are externalities in payments markets. However, in certain applications, it might be the case that some types of private e-money are used extensively by market participants. We do not want to suggest that the government or the central bank should always intervene either by offering its own means of payment or by regulation. For example, consider PayPal, which offers payment services on many online retailers, including eBay. eBay provides the platform for buyers and sellers to meet and trade, while PayPal not only provides payment services but also provides customers with assurance regarding the security of their payment information. This is a case of "economy of scope," where performing one activity decreases the unit cost of performing the other activity.

If the platform or application is not designated as systemically important or prominent to the economy, the central bank might not want to intervene, as such intervention is likely not within

its mandate. In these cases, despite the presence of network externalities, it is mainly the job of consumer protection agencies, and not the central bank, to address monopoly and oligopoly of platform makers. Alternatively, the case could be made to designate these platforms as a prominent payment system under the available regulation.

7. Public Good Aspects of Money and Payment Systems

Are money and, more generally, payment systems public goods? And if so, does this direct central banks to issue new forms of e-money? In other words, are the trade-offs discussed above dominated by the inefficiency imposed by the failure of the private sector to offer the new forms of electronic money?

There are two aspects to these questions. First, what functions of money and payment systems can be thought of as public goods? Second, how should the public good (or its different functions) be provided? In this section, we describe which of the three functions of money—unit of account, medium of exchange and store of value—fit the definition of a public good. A pure public good is one for which the marginal cost of providing it to an additional consumer is zero (therefore non-rival) and for which it is infeasible to exclude individuals from consuming the good (non-excludable).

This is an important discussion since central banks might feel compelled to issue new forms of electronic money out of the custom of having issued money in paper form. This custom might lead central banks to conclude that only they can issue a stable and safe money in electronic form.

A unit of account is a public good. Just like general knowledge or technical standards that help coordination of agents, an established unit of account is non-rival and non-excludable. Note that a standard established by a common unit of account does not need a publicly supplied physical or electronic form of money to be adopted. However, just like weights and measures, it is helpful for adoption when the government establishes and enforces a common standard. New forms of electronic money, public or private, can, without any cost, be denominated in the established national currency.

As a medium of exchange, money, like other platforms, exhibits increasing returns to scale due to positive network externalities. Therefore, to achieve efficiency, it is desirable to increase access. Thinking of money as a medium of exchange in abstract terms is somewhat unhelpful because the payments function of money usually requires some associated arrangement like accounts and terminals. This leads to the related free-rider problem because these arrangements are fixed costs of setting up the platforms. In the case of cash, these include, for

example, the costs to research and develop the anti-counterfeiting measures of bank notes. Exclusion is one way to recoup the fixed costs of the platform; for example, credit cards have inexpensive ways to exclude some customers via membership fees. In the case of cash there is no exclusion, so the government uses seigniorage to finance the fixed costs.

As a store of value, money, like any other asset, clearly confers property rights over the *balance* held by an individual and therefore is clearly and fully excludable. However, the *ability* to hold any balance might not be excludable if the access to the asset is perfectly elastic. In other words, the asset is not excludable if individuals can acquire any amount of the asset at a fixed price. Alas, assets generally have an upward-sloping supply curve. In addition to access, to perform its function as a store of value, an asset should maintain its real value over longer horizons. Compared to private issuers, central banks have an advantage because they have a larger influence on the real value of their liabilities as well as on the elasticity of supply. However, the elasticity of supply of central bank money depends on the available amount of safe assets the central bank is willing to receive in exchange. These safe assets are usually government bonds, whose supply in turn depends on the power of taxation and the credibility of the government. Since taxation is inherently distortionary, its supply cannot be entirely elastic.

Central banks offer different forms of money—cash and reserves—which bundle the three functions described above. The cash “system” does fit the pure public good description because the central bank cannot cheaply prevent individuals from acquiring cash in exchange for their deposits, for example. Also, the costs of supplying bank notes to an additional individual are zero at the margin. This supply is potentially limited, as discussed above, but this rarely binds because, on the demand side, the cost of using or storing cash deters users from demanding such large amounts.

In addition to having an elastic supply, bank notes are easily recognizable, hard to counterfeit and widely accepted. This results in positive network externalities from their usage that every individual benefits from regardless of whether or not they use them. The wholesale payment system, where central bank reserves are typically held, is different to cash because by design access to reserves is limited to financial institutions. Thus, reserves do not fit the pure public good definition.

The second aspect to the public good question is the issue of provision. As is well known, in cases of pure public goods, private provision results in under supply and hence in an inefficient outcome. This motivates public intervention, either directly supplying the good or service or introducing regulation of the private suppliers to try to achieve the efficient level of provision.

The entire ecosystem of payment systems can be interpreted as a pure public good: every consumer has access to *some* payment instrument (non-excludable), and the ecosystem exhibits increasing returns to scale (therefore non-rival). In this case the service provided by the public

good is the consumers' ability to conduct efficient payment transactions and the ability to safely store value. To achieve this outcome, the role of the central bank in the payments ecosystem does not need to be the provision of an entire system but possibly the regulation of some parts of it and the provision of others.

8. Concluding Remarks

This paper presented a framework to help policy-makers evaluate the developments in electronic money and payments and consider appropriate responses. The main question for policy-makers now is whether central banks should take advantage of new technologies to issue a new form of e-money. To help evaluate this normative question, the framework posed several positive questions on payment systems, monetary policy and financial stability.

For the payment systems that central banks currently operate, like national payments systems, the new decentralized forms of e-money are unlikely to improve their efficiency, at least with the state of the technology available today. On monetary policy issues, the widespread adoption of private e-monies could pose a threat to the effectiveness of monetary policy. On the other hand, a universally accessible central bank e-money could strengthen the monetary policy transmission mechanism, particularly if it is interest-bearing. On competition and innovation, we conclude that central bank e-money could be either a competitor or a complement to commercial bank deposits, depending on the form it takes.

The next step for research is to understand and quantify the potential effects of e-money on the transmission mechanisms of monetary policy as well as its effects on the structure of the financial system. With answers to these questions and a deeper knowledge of the technology, policy-makers would be in a better position to take a decision on the form and timing of the issuance of a new form of central bank e-money.

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