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The Positive Case for a CBDC

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Abstract

In this paper we discuss the competition and innovation arguments for issuing a central bank digital currency (CBDC). A CBDC could be an effective competition policy tool for payments. On innovation, we argue that a CBDC could be necessary to support the vibrancy of the digital economy by helping solve market failures and fostering competition and innovation in new digital payments markets. Overall, competition and innovation are supporting arguments for issuing a CBDC.

Topics: Digital currencies and fintech, Financial institutions, Financial stability
JEL codes: E42, E58, L4, L5

1. Introduction

As part of its mandate to promote the economic and financial welfare of Canada, the Bank of Canada strives to support secure, reliable and efficient payment options for the benefit of all Canadians. Current activities that support this goal include providing liquidity to the financial system; overseeing prominent and systemically important financial infrastructure; and designing, producing and distributing bank notes.

However, as modern economies become increasingly digital—bringing not only competition challenges but also large economic opportunities—central banks are considering whether they should provide a form of digital central bank money for use in everyday retail payments. In this paper we present additional substance to the public policy objectives of competition and innovation that could motivate the Bank of Canada to issue a central bank digital currency (CBDC). We label the arguments "a positive case" in the sense that a CBDC that enhances competition and fosters innovation could lead to a net increase in welfare relative to the status quo.[1]

Our first key argument is that, without a public digital payment option, current problems related to competition are likely to worsen, and promising future markets might not fully realize or equitably distribute the benefits of innovation. In other words, a CBDC could be necessary in the future to ensure a competitive digital economy. More specifically, a CBDC, as a simple outside option, can be a more effective competition tool in digital payments than the current approach of regulation and legal enforcement. In addition, with the increased digitalization of the economy, cash is becoming less relevant as an outside option for payments, increasing the potential for abuses of market power in payments.

Second, we argue that a CBDC can enable a vibrant and competitive digital economy. The digitalization of the economy seems to herald a new generation of general-purpose technologies with large social value, for example, the internet of things (IoT) and programmable money. A CBDC could support the efficient functioning of the new markets that use these technologies, thereby fostering competition and innovation.

Underlying the discussion of motivations to issue a CBDC is the question about the mandates of central banks. For good reasons, central bank mandates tend to change quite slowly. Currently the mandate for the provision of bank notes is motivated by the recognition that safe and trustworthy bank notes are important for efficient trade. The original intent, however, was

[1] Here we use the word positive to mean an increase in welfare instead of its other use in economics as descriptive.

largely for financial stability, i.e., to regulate the creation of money to reduce risks of runs and discounting between private notes.[2]

Recent literature has highlighted the role that cash has in limiting market power in payments.[3] Therefore, as the economy becomes more digital, a CBDC—as a digital version of cash—can serve the public policy objective of maintaining competition in payments in digital markets.

This paper is organized as follows. In Section 2 we present a simple decision-making framework to be precise about the meaning of improvement in welfare and to distinguish between proactive and reactive policies. We also put this framework in the context of the scenarios that the Bank articulated in 2020 as potentially motivating the issuance of a CBDC. Section 3 discusses the first part of the positive case: a CBDC as a more effective competition policy tool. Section 4 discusses the second part: a CBDC as support for a vibrant digital economy. Section 5 concludes.

2. Defining a positive case

In this section we develop a simple welfare-analysis framework to distinguish reactive from proactive reasons for issuance. A positive case refers to reasons, not necessarily in the form of scenarios, that warrant a proactive plan to issue a CBDC.

Two potential scenarios for issuance

The Bank has articulated two scenarios under which the issuance of a CBDC might be warranted (Bank of Canada 2020). The first scenario involves an economy where cash is not widely used or accepted, which leads to significant adverse consequences, especially for disadvantaged groups. This scenario is concerning largely because of its distributional effects: while a vast majority of Canadians might willingly move away from cash and toward electronic means of payment, some groups in society might not have the option to make that transition. The inability to transition to electronic means of payment could be, among other reasons, a function of a group's socioeconomic factors such as income or geographical location.

It is important to highlight that the Bank is committed to supplying cash for as long as Canadians demand it. Therefore, if most Canadians moved away from cash, it would be due to the choices of consumers, merchants and distributors of cash (like banks and white-label

[2] See, for example, Fung, Hendry and Weber (2017). Today, the safety of private money and uniformity of money in the entire monetary system is underpinned by the oversight of financial institutions, deposit insurance and interoperable payment systems.

[3] See, for example, Kim, Martin and Shcherbakov (2021) and Huynh et al. (2020). What is unclear is the role that cash could have in limiting market power in a scenario where few customers choose to carry it or pay with it (even if merchants accept it). For example, from the perspective of the incumbent payment processors of point of sale transactions, the presence of cash, even if seldomly used, might still be a restricting but diminishing factor in their negotiation of fees with merchants.

automatic banking machine companies). Despite the Bank's commitment to supply cash, the usefulness of cash as a means of payment depends on its wide acceptance at the point of sale and for peer-to-peer transactions.

Cash remains widely accepted. While the trend may be toward less use and acceptance at the point of sale, the outstanding amount of cash as a percentage of nominal gross domestic product (GDP) has been increasing.[4] In the past few years, the outstanding amount of cash has been to close to 4 percent of nominal GDP.[5] This increase has likely been driven by a store-of-value motive, suggesting a low likelihood of a rapid transition to a cashless society in the near future. The long term, however, is less clear because if the trend toward less acceptance continues, the function of cash as a medium of exchange will eventually erode, likely leading consumers to look for more convenient stores of value.

The second scenario envisions a situation where one or more alternative digital currencies—public or private—become widely adopted in Canada, threatening our monetary sovereignty. In this scenario, the alternative digital currency would be denominated in a unit of account different from the Canadian dollar and would use settlement systems out of reach for Canadian regulators.

While cryptocurrencies (such as Bitcoin) and stablecoins (such as Tether) have been the subject of media attention, their use as means of payment in Canada remains, at the moment, a novelty for a small number of enthusiasts. Some traditional payment service providers, such as PayPal, Square and even Mastercard and Visa, are beginning to provide methods for customers to hold and for merchants to accept cryptocurrencies. Clearly, ease of access is increasing, but this is occurring through established payment companies with an interest in maintaining the compliance and sound risk management practices used in their traditional fiat currency businesses. Further, customers attempting to use cryptocurrencies to pay for goods and services face some exchange rate risk. This risk arises because all merchants accepting cryptocurrencies quote their goods and services in the fiat unit of account and not in the cryptocurrencies they accept. Therefore, the consumer bears the risk of converting the cryptocurrency to fiat at the time of purchase.

Overall, the likelihood of the widespread adoption of an alternative digital currency not denominated in Canadian dollars remains small. Granted, the risk of this scenario has increased with the rapid development of other CBDCs and the efforts of consortiums such as Diem to launch a global stablecoin arrangement.

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[4] See Henry, Huynh and Welte (2018) and Huynh, Nicholls and Nicholson (2019). It remains to be seen whether the trend toward lower acceptance at the point of sale has accelerated due to the COVID-19 pandemic.

[5] Between 1980 and 2015, bank notes in circulation averaged close to 3.5 percent of nominal GDP. The increase in the past five years might be due to the Canadian dollar being considered a reserve currency since the mid-2010s (see Pomorski et al. 2014). During 2020, bank notes in circulation increased to 4.63 percent despite a large fall in nominal GDP. See Chart A-1 in the Appendix.

These two scenarios are not meant to be an exhaustive description of all circumstances under which the Bank would consider issuing a digital currency. Further, the scenarios are not defined as strict triggers for issuance because other issues would have to be considered even if the scenarios materialized. In other words, the scenarios are not meant to be necessary or sufficient for issuance. So, under what conditions would a central bank find it necessary to issue a digital currency?

A simple decision-making framework

Theoretically, the answer to the previous question is somewhat trivial: if a CBDC is expected to increase welfare, then a central bank should issue one. A complete evaluation of the welfare effects of a CBDC is too complicated because it would depend on the currency design, the dynamics of adoption, responses of other firms providing means of payment, distributional effects and multiple other effects.[6] Therefore, we present a simple framework to clarify how different central bank policies can be understood as reactive or proactive.

We start by defining the central bank's welfare function, which depends on the state of the economy s and on a set of current policy choices p:

$$W(s, p).$$

The policies here represent the central bank's set of regulatory choices. The welfare function represents the central bank's own evaluation of welfare across different economic outcomes.

We can define the status quo as the level $\overline{w}$ of welfare observed given the current state s_0 and policies p_0:

$$\overline{w} = W(s_0, p_0).$$

The evolution of the state of the economy depends on shocks to the state and changes in the set of policies. To distinguish reactive and proactive motivations, we do not need to be explicit about how expectations of future policy and the state interact. Therefore, we can simply embed all expectations about policies in the shocks to the state. In that way the evolution of the state can be represented simply as $s_{t+1} = S(s_t, p_t, \omega_t)$, where ω is the complete set of shocks to the economy coming from policy changes and fundamental factors such as technological change. In this framework, and in reality, policies change quite slowly. Therefore, policy changes are infrequent and discrete.

We now describe reactive and proactive policies. Let's say some fundamental shock could lead to an outcome with lower welfare than the status quo:

$$W(s_t, p_0) \ll \overline{w}.$$

[6] Some papers have evaluated the effects on consumer utility of the introduction of a CBDC in specific settings. See, for example, Huynh et al. (2020).

A reactive policy is defined as a policy p' that attempts to ensure a level of welfare:

$$W(s_t', p') = \overline{w},$$

where we are explicit that the state s_t' is now also endogenous to the policy changes p'.

The two scenarios described earlier—a cashless economy and the wide adoption of alternative digital currencies being widely adopted in Canada—are examples of the fundamental shocks that, absent any policy reactions, could lead to that lower level of welfare. In the case of a cashless economy, the reduction of welfare could be the effect on segments of the population. For example, Canadians may have to pay higher fees to use electronic payments because cash is no longer widely accepted at the point of sale. Or a large portion of the population may not be able to make payments if economic activity moves online where cash is difficult to use. Similarly, welfare could be reduced if the adoption of alternative digital currencies by many consumers in Canada is accompanied by price risks—due to the currency not being denominated in Canadian dollars—and risk of malfeasance—due to the lack of oversight of Canadian authorities. Welfare would also be reduced if the adoption of alternative digital currencies hampers the Bank's ability to implement monetary policy.

It is important to note that in our framework, the technological change that is part of the fundamental shocks, ω, could be welfare enhancing to large segments of the population. Indeed, most of the migration away from cash is largely due to the convenience that electronic payments offer to consumers. Likewise, alternative digital currencies might offer benefits such as faster and cheaper remittances.

We now turn to the definition of a proactive policy. Let p'' be a policy such that welfare is higher than in the status quo, given the same fundamental technological shock described above and the reaction to the policy itself:

$$W(s_t', p'') > \overline{w}.$$

The key argument of this note is that some form of a CBDC could be part of proactive policies such as p'' that could deliver a level of welfare higher than the status quo.

A natural question is if p'' could increase welfare, why has it not been implemented before? The answer is that p'', or a CBDC for the purpose of this paper, was not feasible or relevant to the particular state of the economy. Regarding feasibility, the technological developments that are enabling alternative digital currencies, the rise of electronic payments and the emergence of the digital economy, i.e., the fundamental shocks, ω, are also enabling central banks to issue a digital form of cash (Kahn, Rivadeneyra and Wong 2020). Regarding the state of the economy, a CBDC could enable new markets in the digital economy. Further, since digital platforms were not prevalent a couple of decades ago, a digital central bank liability was not relevant.

The framework outlined here depends on the central bank's assessment of the likelihood that certain shocks could lower welfare. This assessment in turn depends on the weighting that the

central bank places on different segments of the population. This weighting is, however, a consequence of the central bank's public policy objectives. For example, technological developments in the market for electronic payments could put at risk the ability of cash to achieve social policy goals such as universal access to a risk-free and low-cost means of payment. The effect on this segment of the population would be significant, therefore warranting added weight on this objective.

Note that the scenarios for issuance that the Bank articulated in 2020 imply that some form of CBDC could be part of reactive policies p'. So, the design of the CBDC and its components would distinguish the two types of policies. In short, different components of a CBDC system can be part of reactive policies, to maintain welfare, or proactive policies, to enhance welfare. Therefore, the positive case is the rationale to issue a CBDC with a form that ensures the largest increase in the expected welfare, be it from mitigating downside risks to welfare or unlocking new benefits.

In the next two sections we elaborate on two specific types of shocks that could warrant a proactive policy stance. These are based on the dynamics of competition in payments and the digital economy.

3. CBDC: A more effective competition policy tool

In this section we argue that issuing a CBDC could be helpful for promoting competition in the increasingly digital financial sector. We focus on the worsening competition problems in the digital payments market and on the market power that large financial institutions, card networks and technology platforms may exert. First, however, we turn to the traditional banking market and consider a CBDC as an outside option.

Outside money in the form of a CBDC would improve the consumers' choice by giving them the option of a digital non-bank store of value that is risk-free. Retail deposits in Canada have several advantages over cash: they can earn interest, have a high degree of safety from theft and can be used for online payments. A CBDC, however, could offer the same level of safety as cash (because central banks cannot default on their nominal obligations) while allowing use in payment systems for online transactions and peer-to-peer transfers. A CBDC would be priced to further the objective of a universally accessible and low-cost means of payment. In Canada, in addition to offering little to no interest earnings on deposits, commercial banks are able to charge monthly fees.[7] After the issuance of a CBDC, retail deposit accounts would have to offer

[7] Gibney, Bibi and Lévesque (2014) document that commercial bank accounts with limits on the number of transactions offered for free have moderate monthly fees and accounts with an unlimited number of free transactions have larger monthly fees. Also, in comparison to large US banks, the minimum balances to waive fees were much higher in Canada at the banks with the most market share. While a more complete analysis must consider the entire bundle of products a consumer uses, there is ample evidence of market power.

value above the CBDC for the consumer. For this reason, a CBDC would spur increased competition in the market for retail deposits.[8]

A key concern about a CBDC is the risks of disintermediation of commercial banks. Some research has identified this risk and argues for its salience, particularly in the context of liquidity crises.[9] In Canada, these effects are estimated to be limited and may be mitigated by large incumbents tapping funding sources outside retail deposits.[10] In addition, issuing a CBDC may offer the most competition to the largest banks, those with deposits that consumers may consider beyond risk. The entry of small firms is unlikely to threaten the position of the large incumbents.

Turning to the means of payment aspect, Canadians are well served by several widely accepted instruments like credit and debit cards. However, these instruments' ubiquity and ease of use come at the expense of high fees for retailers, which they eventually pass on to customers in a regressive manner.[11] The Competition Bureau has voiced concerns about the anticompetitive practices of payment card networks in the past (Competition Bureau 2012). In 2010, the Commissioner of Competition launched a case against the Visa and Mastercard associations alleging that the no-surcharge rule had an anticompetitive effect. While the Competition Tribunal dismissed the case on the grounds that the law regarding resale price maintenance did not apply, the Tribunal found evidence of market power and adverse effects on competition.[12]

The federal government entered into an agreement with the credit card networks. This agreement included a code of conduct that regulated some actions but stopped short of regulating interchange fees or anticompetitive practices such as "honour all cards" or the "no-surcharge rule" (Government of Canada 2010).

The Canadian case is similar to several others around the world (in the United States, the European Union and Australia, to name a few) and demonstrates that enforcement of competition in payment systems can be quite challenging, sometimes bringing mixed results. The Australian case also shows that even direct regulation can have unintended consequences. In that case, the no-surcharge rule was deemed anticompetitive. One result, however, was

[8] See Chiu et al. (2019). The Bank is pursuing empirical work around the effects of issuing a CBDC and how commercial banks would respond.

[9] See Schilling, Fernández-Villaverde and Uhlig (2021) and the references therein. See also Brunnermeier and Niepelt (2020) for a contrasting view.

[10] See the calculations in García et al. (2020).

[11] See Competition Bureau (2015) for a description of the Canadian payments landscape. The distributional effects are also important. The terms of simple deposit accounts may require the so-called underbanked to pay fees for each transaction made using debit cards. Also, there is strong evidence that credit cards' rewards programs are quite regressive, the incidence falling mostly on debit and cash users because merchants pass on the costs of the expensive card fees through a general price increase. See Felt et al. (2021).

[12] See Competition Tribunal (2013) for the summary of the decision and Katz (2014) for a brief analysis of the case.

excessive surcharging by merchants to card users, which the Reserve Bank of Australia subsequently regulated.[13]

In the context of the difficulty of regulating payment networks, a CBDC could be a simpler competition policy tool because it would provide an alternative low-cost payment instrument for customers and merchants. This would help bring down the interchange fees charged by the established networks.

Interchange fees have been the focus of competition issues in payments at the point of sale. Yet, with the rapid adoption of online commerce, the next frontier of competition issues will be online payments. At present, no outside money is offered to consumers for online transactions. Therefore, further to helping moderate interchange fees for point of sale transactions, a CBDC as an online means of payment could give Canadians an alternative to credit cards and other emerging methods of payment. A CBDC for online transactions would provide the same safety from default and counterfeiting as well as the affordability that cash has offered in the offline world for 75 years.[14]

In addition to the increasing digitalization of commerce, we are likely moving toward a world where a few large digital platforms have wide-ranging interactions with our economic lives. Recently big tech firms have considered entering the payments arena, which raises new and distinct concerns about competition and other public policy objectives such as privacy.[15] Platforms combining payments with other services (such as social media or web search) represent a larger problem for competition policy. The business model of big tech relies on the monetization of data derived from user activity, which is reinforced by network effects, known as the data-network-activities loop. Regulation is especially hard because, while consumers derive significant benefit from the services of the platforms, the network effects and exploitation of data make switching difficult, hurt privacy and facilitate price discrimination.[16]

The first-best option for ensuring competitive discipline in pricing and non-price conduct is unclear in the context of network externalities and fast-paced technological change. Antitrust lawsuits are not only necessary tools, but also complicated and uncertain avenues for enforcing the public policy objectives discussed here. In addition, these lawsuits are potentially difficult

[13] See the reports of the Reserve Bank of Australia (2016, 2019).

[14] While cash and a CBDC would be substitutes at the point of sale, it is possible that offering a CBDC would make cash retain some of its attractiveness. Additionally, a CBDC usable for point-of-sale transactions would ensure the existence of a public form of money even if cash were to decline to the point of diminished acceptance or availability.

[15] See, for example, the announcements of the Diem association and other partnerships between big tech firms and financial institutions, such as Google and Citibank (Citibank 2020). In China, Alipay and WeChat pay have made significant advances into payments—becoming the dominant means of electronic payments.

[16] See Chiu and Koeppl (2020) for a theory model on the data-network-activities loop of big tech platforms. Also see Carstens (2021) for a policy discussion of this business model. See also the US House of Representatives Subcommittee on Antitrust (2020) report on competition in digital markets.

for a Canadian policy-maker to bring against multinational corporations. The threat of non-compliance or abandoning the Canadian market altogether is real and undesirable.[17]

For these reasons, a CBDC could be a measured path that enforces competitive discipline at least on the payments-related aspects of these digital platforms. A central bank liability that is universally available, widely accepted and without risk to both the consumer and merchant could insure the marketplace against being captive to the worst aspects of monopoly and concentration, such has high prices, or under provision of goods, such as privacy.

4. Enabling a vibrant and competitive digital economy

The digitalization of the economy—online commerce, online payments and new representations of value—is accelerating, aided in part by the COVID-19 pandemic. On the one hand, this will likely worsen competition problems in digital markets served by platforms (due to their economies of scale and the ability of operators to monetize data). On the other hand, this trend seems to herald a new generation of applications with the potential to be general-purpose technologies, for example, the IoT and programmable money. While the previous section dealt with current competition problems, this section deals with questions about the value of prospective markets in the future, their competition and the role for a CBDC in them.

Here we argue that a CBDC could be necessary to support the vibrancy of the digital economy by helping solve market failures and fostering competition and innovation in new digital payments markets. To make this argument we need to identify three things: i) the potential societal value of those new markets; ii) if those markets will be subject to market failures; and iii) if those failures cannot be solved by other policies. First, we discuss smart contracts specifically and their potential for providing large societal benefits. Second, we discuss some of the potential market failures in smart contracts and the role of a CBDC in that market.

Smart contracts and the benefits of programmability

One way in which a CBDC can foster innovation in the digital economy is by supporting smart contracts. A smart contract is "a computerized transaction protocol that executes the terms of a contract" (Szabo 1994). These contracts may depend on events, identities, states or time, and their execution is enforced without relying on a trusted authority. A smart contract resides in a computing environment and requires four elements:

- a programming language that permits defining the conditions of the contract

[17] See, for example, the recent action of Facebook to remove any Australian news articles because of draft legislation requiring renumeration for newspapers.

- an ability to escrow the monetary value to be delivered under the terms of the contract
- a method to verify the conditions stated in the contract
- the ability to execute the contract, which involves continuously checking the state and delivery of the escrow value

Although still early in their development, smart contracts could enable entirely new digital economy applications with many potential benefits. To start, smart contracts could enable programmable money by adding certain attributes to it. For example, money could be programmed to gain or lose value over time, or it could be programmed to be used in transactions for only specific goods or services. Furthermore, smart contracts can enable programmable payments—automated payments that are executed after certain conditions are met. These can range from simple push payments to more complex ones. For instance, smart contracts could enable automatic routing of tax payments to authorities at the point of sale, pay-as-you-go insurance or payments that can support IoT applications.

The rising popularity of blockchain has fuelled interest in smart contracts, even though these contracts can be implemented in centralized ledgers as well. Another major factor contributing to the growth of smart contracts is their adoption in different industries such as banking, supply-chain management, government, insurance and real estate. Two of the main benefits that smart contracts provide include cost savings and enhanced efficiency. Smart contracts are self-executing, thus eliminating the need for human involvement during execution; have escrow capabilities that reduce or eliminate reliance on third-party intermediaries to provide "trust" services; and are unalterable. These properties are especially important in the finance industry where the cost of intermediation remains high and its efficiency is low.[18] Smart contracts also have the potential to increase the speed and accuracy of execution by using code to automate tasks that are usually done manually.

Smart contracts are usually coded by developers that are independent from the platform in which the contracts are stored and replicated. The programming language used in smart contracts is crucial given that the platform cannot explicitly trust these developers. This creates risks to users if the execution does not go according to the intended terms of the contract.[19] Bitcoin can support only limited forms of smart contracts, in part, because it features a programming language that is not Turing-complete.[20, 21] Other platforms can be more

[18] For example, Philippon (2015) finds that financial intermediation in the United States has an annual cost of 1.5 to 2 percent of intermediated assets.

[19] To solve this problem, some current platforms (such as NXT) use samples of existing smart contracts in their systems.

[20] A programming language is said to be "Turing-complete" if, given enough resources, it can program and run anything that is computable.

[21] For examples of smart contracts Bitcoin supports, see Atzei, Bartoletti and Ci (2018).

complex. Ethereum is the standard platform that implements smart contracts in a Turing-complete language. In such platforms, you can code any logic into a smart contract and it will be executed by the network (Buterin 2013).

The ability to implement the complex logic of smart contracts is quite limited with today's payment arrangements and infrastructure. Traditional payment systems do not have the technical capability to integrate smart contracts into payment processes. Direct debits or standing orders can carry out simple forms of programmable payments; however, these existing instruments are very limited in terms of use cases. New innovative solutions are therefore needed to allow new use cases.

Smart contract implementation comes with a new set of risks that are more difficult to resolve than risks in traditional payment systems. Risks associated with the first element of smart contracts—that of the programming language—are, for instance, logic errors. These errors might be simple software bugs in the code that can drain or lock funds in contracts. Such errors or unsafe programming design choices may negatively affect platform security by making it vulnerable to attacks that might lead to large losses of funds (Siegel 2016). Furthermore, even if no logic errors occur, smart contracts executed on public blockchains are prone to attacks from adversaries that might want to profit from open source contracts.[22]

Another potential risk is oracle risk, which relates to a smart contract's ability to verify the conditions of a contract. This risk emerges when the smart contract needs data inputs from outside the platform to verify certain conditions. Such inputs are crucial because they enable contracts to be triggered by real events and data, such as different market indicators. This can be achieved using oracles that provide information from third parties. Many real-world applications of smart contracts rely on such data feeds, so a process to validate those feeds also needs to be secure and reliable.

Finally, the use of complex smart contracts could have negative impacts on the performance and scalability of the network. This is known as scaling risk and is associated with the last element of smart contracts that we have described. Existing distributed ledger technology platforms that support smart contracts have suffered from such issues.[23] A high demand for smart contracts can thus result in congested networks.

CBDC and programmability

The potential benefits and risks of programmable money and payments are easy to envision and describe. It is difficult, however, to determine whether central bank involvement has a role in this area. Moreover, even if such intervention is needed, should this intervention be through

[22] For more potential benefits and risks arising from blockchain technology, see Harvey, Ramachandran and Santoro (2021).

[23] See "CryptoKitties craze slows down transactions on Ethereum," BBC News (2017).

a programmable CBDC or other regulatory means? The difficulty in providing answers to these questions arises mostly in the challenge identifying potential failures in markets that are either still not expansive enough or do not exist. We do not know if intervention through programmability will be warranted for reasons other than achieving the public policy objectives discussed here; however, below we list two potential issues that might lead a central bank to intervene.

First, it is natural to think that similar market failures that exist in current markets will remain a problem in more technologically advanced payments markets. In fact, these market failures could become even more worrisome. Following reasoning similar to Section 3, we consider that a CBDC might be necessary in promoting competition and, to remain a competitor in future payments markets, it might need to be programmable. Such an intervention might be mandated to avoid potential monopolization in new markets (e.g., by reducing concentration in smart contract networks such as Ethereum) or to lower barriers to entry. In terms of privacy, with the use of smart contracts and more complex payment logics, the amount of information that might be exploited will be even larger.[24] Without strong regulations on sharing payments' data, the central bank might issue a CBDC to achieve greater privacy in payments.

Second, coordination problems might be more complicated. This is because there will be additional dimensions to consider and coordinate. Implementing programmable money will require coordination on programming languages, riskless escrows, state verification and execution.

These potential market failures might require the central bank to step in. A programmable CBDC could overcome coordination failures involved in an inability to agree on a single new technological standard. To warrant the central bank's involvement, the risk and negative effects of market failure would have to be high. The central bank might play a role in solving these problems of competing standards and improve interoperability, cyber resilience and data protection. For instance, the central bank might be crucial in the process of smart contract adoption. Smart contracts can be beneficial for adopters but also costly. If the number of market participants that have adopted the smart contract technology is limited or initial investments in research and development costs are substantial, then the benefits may not justify the costs. Market inefficiencies may result from the network effects and high costs of smart contract adoption. This might also explain why the smart contract market is currently not expansive. In such situations, a public effort could help overcome these types of market failures by supporting the early development and adoption of smart contracts, as it did for the internet.[25]

[24] Garratt and van Oordt (2021) explore the impacts of a reduction in payment privacy. They show that because privacy protection generates an externality, consumers may make suboptimal choices. They discuss the issuance of electronic cash as a remedy.

[25] For more details, see Greenstein (2015).

Another open issue that that requires more study is how the programmability feature of a CBDC should be implemented. One approach can be to build such a functionality on the central bank's ledger. An alternative approach might be to build programmability through separate modules or to enable it from third parties. On the one hand, building smart contract functionalities in the core ledger would imply that the ledger itself would have to execute complex smart contracts, which might slow down its performance and affect its security. While more complex, this approach could allow the central bank to implement a new domain-specific language (not necessarily Turing-complete), which could be designed to avoid such vulnerabilities. On the other hand, allowing a CBDC to simply be a token on top of which third parties implement smart contracts would have less effect on the speed and performance of the core ledger. However, that approach would require other considerations, for example, user authentication.

5. Conclusion

In this paper we expand the Bank's discussion about the promotion of competition and innovation as motivations to issue a CBDC. This is complementary to the discussion about other public policy objectives that were put forward in Bank of Canada (2020). In general, we argue that a CBDC might be beneficial and probably necessary to ensure a competitive and vibrant digital economy. This argument has two parts. First, a CBDC could increase welfare relative to the status quo—by enabling new markets and applications. Second, a CBDC could also mitigate welfare loses—by limiting abuses of market power and avoiding coordination failures in payments and new markets such as for smart contracts.

The digitalization of the economy will continue, which could aggravate competition problems in markets dominated by digital platforms, including the payments market. In general, a CBDC as a basic outside option for payments could discipline the market. A CBDC that is usable for online transactions in particular would also provide an alternative to private digital means of payments, just as cash is an alternative to point-of-sale transactions. To effectively function as an outside option, a CBDC would require certain features as well as a certain critical level of acceptance by merchants and adoption by customers. Further, as a competition tool, a CBDC might be simpler than developing new competition policies in the complex and changing environment of big tech, and simpler than attempting enforcement via lengthy and uncertain legal battles.

Lastly a CBDC might be a tool to promote digital innovation by helping prevent coordination failures and by providing open access to promising general-purpose technologies like programmable money. This aspect is still somewhat speculative as the societal benefits of some of the touted benefits, like smart contracts, remain to be seen. Likewise, more research has to be conducted to identify a need for government intervention.

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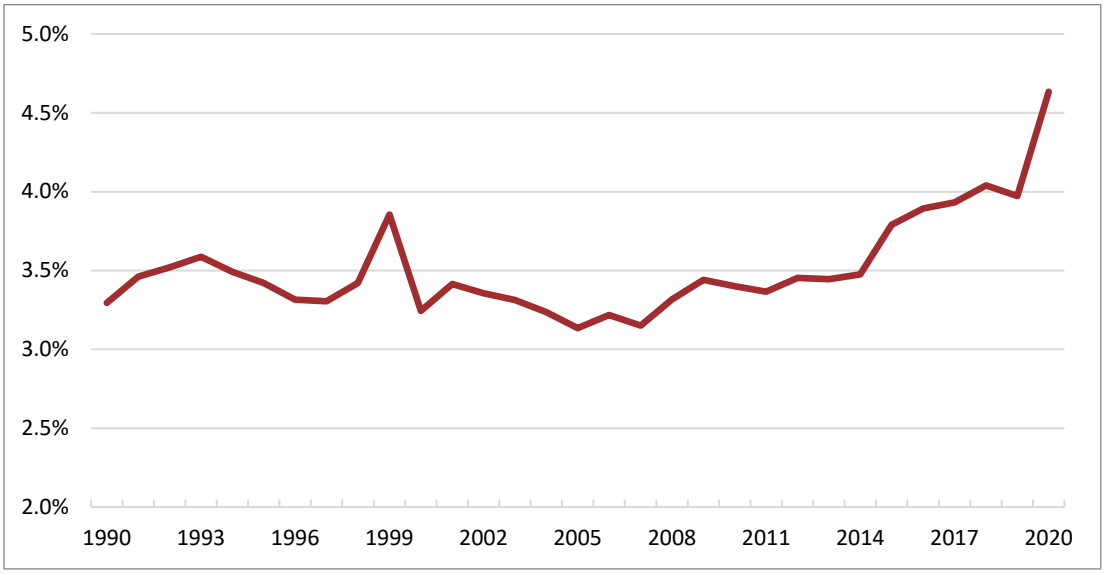
Appendix

Chart A-1: Bank notes in circulation as percentage of nominal gross domestic product



Sources: Statistics Canada and Bank of Canada Last observation: 2020