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Competing digital monies

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Abstract

We compare three competing digital payment instruments: bank deposits, digital platform tokens and central bank digital currencies (CBDCs). A simple theoretical model integrates the theory of two-sided markets and payment economics. We use the model to assess the impact of a public option such as a fast payment system that makes private payment instruments interoperable, or a CBDC that provides general access to public digital money. We show that both options are essentially equivalent for the industrial organisation of the payment system. We find that, even if they may lead to some degree of disintermediation, both options can contribute to increasing financial inclusion and improving social welfare.

Keywords: payments, CBDC, fast payments, banks, big tech, platforms

JEL classifications: E42, E58, G21, L51, O31.

1 Introduction

After decades of relative stability in the market structure of retail payments, new contenders are now vying to challenge bank deposits as a form of retail money for payments. A first set of contenders are the private tokens of digital platform operators, such as big techs. Players like AliPay and WeChat Pay in China, and M-Pesa in Kenya, already provide closed-loop payment systems for users to transact within a certain digital ecosystem. A second set of contenders are private stablecoins.[1] Growing out of the cryptocurrency sector, stablecoins aim to offer payment and other services in new ecosystems built on blockchains and other forms of distributed ledger technology (DLT). A third set of contenders are a new form of money issued by central banks – central bank digital currencies (CBDCs).[2] Central banks are pursuing CBDCs for different reasons, both for retail use (by households and businesses) and for wholesale use (for transactions between financial institutions).[3] Relatedly, central banks can offer retail fast payment systems (FPS), which allow for instant payments between account holders, using existing bank deposits and, in some cases, non-bank payment service providers (PSPs).

These different monies could have very different economic implications, not least for the industrial organisation of retail payment services. Payment markets could become fragmented in competing "walled gardens", or they could become more efficient, integrated and accessible. The key questions of this paper are: what are the likely implications of these three competing digital monies for the market structure in payments? Moreover, when is it socially optimal to build a public sector infrastructure?

To answer this, we integrate two-sided market theory (see Rochet and Tirole (2002); Jullien and Sand-Zantman (2021)) with payment economics. Based on a theoretical model, we assess the likely impact of three competing digital monies. The goal is to compare the world in which digital means of payment provided by new non-bank digital platforms compete with bank deposits, with or without public sector provision of digital money or payment infrastructures.

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[1]Stablecoins are a type of cryptocurrency that aims to maintain a stable value relative to a specified asset, or a pool or basket of assets (FSB, 2023).

[2]CBDCs can be defined as a form of digital money, denominated in the national unit of account, that is a direct liability of the central bank (BIS, 2020).

[3]Both stablecoins and CBDCs could bring new features like tokenisation, or the recording of claims on real or financial assets that exist on a traditional ledger onto a programmable platform. But there may be important differences in their stability as money, and ability to benefit from network effects. See BIS (2023) and (Carstens and Nilekani, 2024).

In particular, our framework distinguishes between the unique characteristics of bank deposits, platform tokens and CBDCs with respect to their use in different sectors of the economy. This can help to understand the impact of private monies on the payment services industry (see Verdier (2024)) and that of a CBDC – or other central bank-operated systems like FPS – as a public sector infrastructure for innovation (BIS (2021); Shin (2021)).

Our model is necessarily very stylised, capturing only a few key features of each instrument. For example, we model bank deposits as an instrument that is useful in a physical (bricks-and-mortar) market. Digital platform payment tokens are a competing instrument that is useful within a specified digital (online) market.[4] In this simple model, we abstract from cryptocurrencies and stablecoins.[5] We consider that some consumers prefer the physical market, and others prefer the digital market. (We do not go into the reasons for these different preferences). CBDCs are modelled as an instrument that is, by construction, interoperable, and thus useful for transactions in both the physical and digital market.[6] Retail FPS are, similarly, a public infrastructure that allows for real-time transactions in both the physical and digital market, thus enforcing interoperability.

Three key results come out of our model. First, when the payment systems are not interoperable (a situation with walled gardens), access to accounts (financial inclusion) and trade volumes are inefficiently low. Second, when a fast retail payment system ensures interoperability between payment systems, financial exclusion disappears at the cost of some degree of disintermediation. Incumbent intermediaries lose market share to non-bank PSPs. Moreover, and somewhat surprisingly, merchant fees tend to increase because the demand for services provided by intermediaries becomes less elastic.[7] Finally, we show an equivalence result between CBDCs

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[4]One could understand this as e-commerce and the type of closed ecosystems offered by large technology (big tech) companies. It would also apply to the aborted Libra (later: Diem) stablecoin proposal of Facebook (Meta).

[5]Cryptocurrencies are used in practice mostly for speculation at current, and the proposed use cases are constantly changing, even in the statements by their proponents. For instance, Bitcoin was initially pitched as a "peer-to-peer electronic cash system" (Nakamoto, 2008), and has since been touted as an investment product, store of wealth ("digital gold") and much more. Stablecoins were initially introduced to address the problem of price volatility in cryptocurrencies, tying their value to central bank-issued currencies (especially the US dollar), but have since been touted as the onramp and offramp of money into and out of the crypto ecosystem, a means for cross-border payments and much more. See Arner et al. (2019) and Cantú et al. (2025).

[6]We assume that the CBDC is issued by the central bank, but that private intermediaries offer retail payment services – i.e. a two-tiered system. This is realistic, as all currently live CBDCs, and most of those under consideration, do indeed feature private intermediaries to interact with clients. See Branch et al. (2025).

[7]Akoguz et al. (2025) study how data interoperability affects competition and welfare in the finance sector. They show that sharing customer data stimulates competition for credit but may indeed increase the prices of payment services.

and retail fast payment systems. Both help to achieve a superior outcome to the laissez-faire approach, ensuring that different payment instruments are interoperable.

Our paper contributes to the literature on payment markets, showing how competing digital monies can result in both desirable and undesirable market structure outcomes. Relative to other papers on platforms, CBDCs and FPS (see next section), we offer a compelling, theoretical exploration of the implications of different monies and policies for the industrial organisation of payment markets. Moreover, we give a unique application to a key sector in the economy whose main service (payments) is key to transactions in many other sectors.

The paper is organised as follows. Section 2 briefly reviews the related literature. In order to set the stage for the theoretical discussion, Section 3 discusses private walled gardens and public infrastructures in practice. Section 4 outlines our baseline model. Section 5 discusses payment systems with walled gardens. Section 6 studies the impact of introducing a fast payment system. Section 7 compares with the outcome of a retail CBDC. Section 8 concludes.

2　Related literature

A growing body of literature is helping to inform current policy debates on the future of the digital economy and the monetary system. One strand assesses digital platforms in the monetary system, including competition between platforms and outcomes in terms of market shares, pricing and financial inclusion (Belleflamme et al., 2022, Croxson et al., 2022). This literature shows how platforms can become dominant in certain markets. Some explicitly look at the role of user data in cementing market power (Cong and Mayer, 2022).

Other studies examine competition between different forms of digital money, in particular between CBDCs, stablecoins and cryptocurrencies (Benigno et al., 2019, Cong and Mayer, 2025). Stablecoins, a type of cryptocurrency that aims to keep a fixed rate against sovereign currencies or assets, suffer from shortcomings, particularly around the credibility of asset backing, price stability and liquidity mechanisms (Arner et al., 2019, Kosse et al., 2023, Aldasoro et al., 2024). However, they could become widely used in the future. The growing literature on CBDCs is summarised in Auer et al. (2022), and includes seminal works like Andolfatto (2020), Fernández-Villaverde et al. (2021), Williamson (2022) and Chiu et al. (2023). This work generally looks at

the macroeconomic implications of competing currencies, rather than the industrial organisation outcomes.

Our study combines these perspectives, showing how at least a few such alternatives may compete with one another and what this will mean for payment markets and welfare in the digital economy and monetary system.

We contribute to the literature by explicitly comparing the public and private provision of payment solutions. This echoes a strand of the literature that studies interoperability in payment systems (see Bianchi et al. (2021) for a survey). In our paper, we consider interoperability in a two-sided market. We define interoperability as the ability of consumers of one payment intermediary (either the bank or the digital platform) to make transfers to merchants of the other. As in other papers, we find that interoperability may soften competition for merchants and increase merchant fees. (See Matutes and Padilla (1994), Crémer et al. (2000), Øystein Foros and Hansen (2001), Chen et al. (2009) and Lubbersen and Bolt (2025)).

There is also literature on platform competition and interoperability in the context of CBDC provision. Siciliani (2018) studies competition for retail deposits between asymmetric platforms: incumbent and entrant. He also compares various outcomes according to the assumptions on single-homing, multi-homing and interoperability of platforms. We use a different framework of Hotelling competition, with simultaneous price setting, and fixed fees on the merchant side.[8] Ahnert et al. (2025) also analyse competition between a bank and a platform offering tokens. However, they model a different definition of interoperability. In their paper, the first-best is achieved when merchants can sell everything online, because the matching technology online is perfect. We assume instead horizontal differentiation between trading environments, which implies that the first-best is a mix of brick-and-mortar and online sales. Brunnermeier and Payne (2022) assume that an incumbent platform may choose to restrict the portability of the payment information of its users to an entrant platform and restrict the convertibility of tokens. (See also and Brunnermeier and Payne (2025)).

Relative to these studies, we thus offer a simple model with an explicit focus on competition

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[8]In his paper, the incumbent plays first, sets fixed membership fees on the consumer side and transaction fees on the merchant side. In contrast, in our paper, merchant fees are not competed away and the number of consumers who join either platform depends on the fees charged on the merchant side. Therefore, our model of Hotelling competition between platforms follows a two-sided market logic.

between bank deposits, platform tokens and CBDCs or FPS. This yields important insights on the implications of each.

3   Private walled gardens and public infrastructures in practice

In practice, digital payment innovation has often been driven by large private sector players operating "walled gardens". M-Pesa, launched in 2007 in Kenya by Vodafone and Safaricom, has enabled large gains in expanding access to digital payments, yet quickly became a closed-loop system. Similarly, AliPay, launched in 2009 in China, is very widely used, allowing for free peer-to-peer payments and very low-cost payments to merchants, yet there are fees for making payments outside its ecosystem or withdrawing funds.

To respond to private walled gardens, public authorities have a number of possible tools. One is to enforce interoperability and possibly to regulate access fees. For example, Kenya's Competition Authority decided in 2018 to enforce the interoperability between M-Pesa and other mobile money operators (Feyen et al., 2021). Similarly, the People's Bank of China intervened in 2019 to enforce interoperability between AliPay, WeChat Pay and other providers and to regulate fees. The European Union (EU) introduced the Digital Markets Act (DMA) and Digital Services Act (DSA), which put specific requirements on large digital platforms and gatekeepers in a large range of areas well beyond payments.

Another option is to create public payment infrastructures, such as central bank-operated retail fast payment systems (FPS) or CBDCs. FPS allow for payments in real time between different providers, such as banks and non-bank payment service providers (CPMI (2021), Frost et al. (2024)). In Brazil, the Pix instant payment system, launched in November 2020, offers users the opportunity to make payments, peer-to-peer or to merchants, through a phone number, a quick response (QR) code, or other means. Within a year of its launch, Pix services were offered by over 770 banks and non-bank PSPs, and used by over two thirds of the Brazilian adult population (Duarte et al., 2021). This has risen further since then, to over 90% of the populationm. Peer-to-peer payments are free and payments to merchants cost an average of 22 basis points – compared to 2.1% for credit cards.

CBDCs have been the subject of intense research and development efforts in many countries.

Some central banks in emerging market economies have launched pilots (e.g. in China and Peru). At the time of writing, three central banks (in The Bahamas, Jamaica and Nigeria) had launched a live retail CBDC. Generally, private sector banks and non-bank PSPs provide retail services in these CBDC systems. To date, both peer-to-peer payments and merchant payments have zero fees, with the possibility of introducing low, non-zero fees in the future. Meanwhile, several central banks in advanced economies (e.g. in Switzerland) have progressed in work on a wholesale CBDC, or tokenised reserves. In the euro area, the European Central Bank (ECB) is progressing in its work on a digital euro, looking at both retail and wholesale use cases.

Retail CBDCs share several similarities with FPS (Aurazo et al., 2024). The key difference is that FPS facilitate the transfer of claims on private intermediaries, whereas CBDCs are a claim on the central bank (Auer et al., 2023). They can thus be conceived of as a form of digital cash.[9]

4 Model

We aim to build a simple model of the market for digital payments. Thus, we extend the models of Armstrong (2006), Rochet and Tirole (2006) and Verdier (2024) to study competition between two intermediaries offering payment services: a bank (b) and a platform (p). Our framework enables us to analyse whether public infrastructures such as a central bank-operated fast payment system or a central bank digital currency may improve total user surplus compared to the case in which payment systems are separated by walled gardens.

4.1 Payment intermediaries

Two payment intermediaries, indexed by j, compete to offer payment services to consumers and merchants: a bank ($j = b$) and a platform ($j = p$). Consumers and merchants are placed along a Hotelling line (Hotelling, 1929), which captures their taste differences.[10] The intermediaries offer differentiated services that will be relatively more or less attractive to consumers with different tastes. The bank is located at point 0 on the Hotelling line, where there is a physical

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[9]CBDCs may offer further functionalities such as programmability and offline payments. These could become relevant in the future, but go beyond the scope of this paper.

[10]We adopt the terminology used in the payment industry: sellers are also called "merchants". Similarly, buyers are also called consumers.

market, and the platform is located at point 1, where there is a digital market (which could represent e-commerce or an ecosystem of tokenised assets). The intermediaries incur no costs. Consumers need to open an account with an intermediary to make payments. The bank offers a payment instrument that is accepted by "brick and mortar" retailers, whereas the platform offers an online payment instrument.

In all of our analysis, we maintain several simplifying assumptions.

- all merchants "single-home" in the sense that they choose exactly one trading mode: b for "brick and mortar" or p for online. The number of merchants who select b is denoted by N_S. We also assume that the market is covered on the seller side. The number of online merchants is therefore $(1 - N_S)$.

- potential gains from trade between any couple (merchant, consumer) are always positive, so consumers trade with all the merchants they have access to through the payment system.

- consumers pay no fees, but incur a transport cost if they open an account with an intermediary. Some consumers may decide to open no account, in which case they are excluded from the financial system. We assume that transport costs are high enough so that no consumer opens an account with both intermediaries.

- Merchants pay a fixed fee to the intermediary with whom they open an account and also incur transport costs.

4.2 Buyers

There is a continuum population of consumers who are uniformly distributed on the Hotelling line. They may open an account through intermediary $j = b$ located at point 0 or $j = p$ located at point 1, or none. Consumers incur linear transport costs t_B per unit of distance when they "travel" to open an account.[11] The number of consumers who open an account with intermediary j is denoted N_B^j, where the index B stands for "buyers".

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[11]Transport costs are understood here to refer to users' need to adapt to a payment service that does not coincide exactly with their preference – some users will have a taste for digital-only interactions, while others may prefer physical interaction in the market.

Consumers do not pay any fee to open an account, nor do they pay any transaction fee.[12] We assume that each consumer trades with each "accessible" seller. Therefore, with walled gardens, a consumer who has an account with the bank trades with physical merchants, whereas a consumer who has a platform account trades online. Consumers who do not open any account only trade with physical merchants. With an FPS or a CBDC, a consumer trades with all merchants.[13]

Each transaction generates a surplus α that is divided in proportions r and $1 - r$ between consumers and merchants, where $r \in (0, 1)$ represents the relative bargaining power of consumers. (A higher r means that the consumer can capture more of the surplus). The trading possibilities depend on the organisation of the payment system. In the case of walled gardens, online trading is only possible for consumers who have opened an account with the platform. Physical trades can only be paid for by bank deposits. With an FPS or a CBDC, consumers also trade with merchants affiliated with the other intermediary, but the total surplus of a transaction is reduced by a factor $q < 1$ to capture the loss of ancillary services provided by the intermediary.[14]

Therefore, a consumer located at point x on the Hotelling line can open an account with the bank, and obtain utility:

$$u_B^b = r\alpha N_S - t_B x, \tag{1}$$

or open an account with the platform and obtain utility:

$$u_B^p = r\alpha(1 - N_S) - t_B(1 - x). \tag{2}$$

We make the following assumption:

$$(H_1) : \alpha < t_B. \tag{3}$$

Assumption H_1 implies that multihoming (opening accounts with both intermediaries) is too

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[12]This is in line with observed practice: for both in-store and online purchases, banks and digital platforms generally charge fees to merchants, through a merchant discount rate (MDR), and do not charge fees on consumers. In this analysis, we abstract from rewards or benefits to users, as with credit card points or cash-back to consumers.

[13]We motivate this assumption by the interoperability services offered by fast payment systems, such as Pix in Brazil, which has allowed new providers like Nubank and the non-bank Mercado Pago to offer interoperable payment services with incumbent banks.

[14]This can be interpreted to include bank credit or credit card points and rewards for deposits, and information on available products for the platform.

costly for all buyers. The third option is therefore to open no account at all (financial exclusion).[15] The utility of this third option is normalised to zero. The indifference condition between the first and the third option determines the number of consumers who open a bank account:

$$N_B^b = \frac{r\alpha N_S}{t_B}. \tag{4}$$

Similarly, the indifference condition between the second and the third option determines the number of consumers who open an account with the platform:

$$N_B^p = \frac{r\alpha(1 - N_S)}{t_B}. \tag{5}$$

4.3 Sellers

A continuum population of merchants may sell products in the physical market or in the digital market. They are uniformly distributed along the Hotelling line and incur transport costs t_S per unit of distance if they open an account with one of the intermediaries, located at the extremities of the Hotelling line.

Merchants pay fixed fees f^j to open an account with intermediary j and do not pay any variable fee for payment transactions. The difference between the platform fee and the bank fee is denoted $\Delta f = f^p - f^b$. Merchants also obtain a fixed utility $v_0 > 0$ of having access to banking services, which we assume to be sufficiently large such that their market is covered in equilibrium (although the market for consumers may not be fully covered).

A merchant who chooses brick and mortar trade attracts the N_B^b consumers who have a bank account. Therefore, the net utility of a merchant located at point x on the Hotelling line who sells in the physical market is:

$$u_S^b = v_0 + (1 - r)\alpha N_B^b - t_S x - f^b. \tag{6}$$

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[15]These financially excluded ("unbanked") buyers are unserved by both the bank and the platform. This share may be higher in emerging market and developing economies where transport costs are particularly high.

If he or she joins the platform to sell in the digital market, he or she derives a utility:

$$u_S^p = v_0 + (1-r)\alpha N_B^p - t_S(1-x) - f^p. \tag{7}$$

The indifference condition between these two options determines the number N_S of merchants who choose physical trading:

$$t_S(2N_S - 1) = f^p - f^b + (1-r)\alpha(N_B^b - N_B^p), \tag{8}$$

that is:

$$N_S = \frac{1}{2} + \frac{1}{2t_S}[f^p - f^b + (1-r)\alpha(N_B^b - N_B^p)].$$

Finally, we make a second assumption:

$$(H_2): t_B t_S > r(1-r)\alpha^2,$$

to ensure the concavity of profit functions and the existence of an interior equilibrium in which sellers single-home. This assumption implies that the product of transport costs for buyers and sellers is greater than the product of the maximum surpluses that consumers and merchants can obtain from making transactions.

5 The equilibrium with walled gardens

5.1 Timing of the game

We model competition in the economy with walled gardens as a game between the two intermediaries with the following timing:

- Each intermediary $j = b, p$ announces their fee f^j to sellers.

- Merchants decide on their trading mode $j = b, p$, and open an account with the corresponding intermediary.

- Consumers choose whether to open an account with the bank, the platform or none.

- Consumers trade with all merchants that accept their payment instrument.

5.2 The Nash equilibrium

The Nash equilibrium of this game is obtained when each intermediary selects a fee that maximises its profit while taking the fee of its competitor as given. Neglecting operating costs, the profit functions are

$$\pi^b = f^b N_S,$$

for the bank, and

$$\pi^p = f^p(1 - N_S)$$

for the platform. Under assumptions H_1 and H_2, this game has a unique equilibrium that is easily characterised. In fact, using equations (4) and (5) that determine the numbers of consumers who open an account with the bank and the platform, we can transform (8) into an equation relating the number of physical merchants N_S to the merchant fees. We obtain an affine relationship:

$$N_S = \frac{1}{2} + A_0(f^p - f^b), \tag{9}$$

where

$$A_0 = \frac{t_B}{2[t_B t_S - r(1-r)\alpha^2]},$$

and $A_0 > 0$ from assumption (H2). Proposition 1 gives the equilibrium of competition between intermediaries in a walled gardens economy.

Proposition 1. *Under assumptions H_1 and H_2, the walled garden economy has a unique equilibrium (denoted by upper indices G) characterised by:*

$$N_S^G = \frac{1}{2}, \tag{10}$$

$$N_B^b = N_B^p \equiv N_B^G = \frac{r\alpha}{2t_B}, \tag{11}$$

$$f^b = f^p \equiv f^G = t_S - \frac{r(1-r)}{t_B}\alpha^2. \tag{12}$$

Proof. The profit functions of the two intermediaries are

$$\pi^b = f^b N_S,$$

12

for the bank, and

$$\pi^p = f^p(1 - N_S)$$

for the platform. The first order conditions for an interior Nash equilibrium are thus

$$\frac{\partial \pi^b}{\partial f^b} = A_0(f^p - 2f^b) + \frac{1}{2} = 0,$$

for the bank, and

$$\frac{\partial \pi^p}{\partial f^p} = A_0(f^b - 2f^p) + \frac{1}{2} = 0$$

for the platform. The assumption H_2 ensures that the profit functions of the intermediaries are concave with respect to prices. By combining the two first-order conditions, we obtain the results stated in Proposition 1. Moreover, the assumption H_2 ensures that all merchants prefer to single-home in equilibrium rather than multi-home. □

5.3 Welfare analysis

Social welfare equals the total surplus generated by the transactions undertaken by consumers and merchants less the transport costs. The N_B^b consumers who have an account with the bank trade with N_S merchants and the N_B^p consumers who have an account with the platform trade with $(1 - N_S)$ merchants. Thus the total volume of trade is

$$V = N_B^b N_S + N_B^p(1 - N_S),$$

and social welfare equals:

$$W = v_0 + \alpha[N_B^b N_S + N_B^p(1 - N_S)] - \frac{t_S}{2}[N_S^2 + (1 - N_S)^2] - \frac{t_B}{2}[(N_B^b)^2 + (N_B^p)^2]. \tag{13}$$

Using Proposition 1, we see that at the equilibrium of the walled garden economy, the volume of trade is

$$V^G = \frac{r\alpha}{2t_B} \tag{14}$$

and social welfare equals

$$W^G = v_0 + \frac{r(2 - r)\alpha^2 - t_B t_S}{4t_B}. \tag{15}$$

The equilibrium that results from competition between intermediaries separated by walled gardens is characterised by financial exclusion. In fact, there is a proportion

$$1 - N_B^b - N_B^p = 1 - \frac{r\alpha}{t_B} > 0$$

of consumers who do not have access to electronic payment systems. The volume of trade is low, as consumers can only trade physically or online, but not both. We show now that with the same technologies (i.e. assuming that interoperability is not feasible) a central planner could increase welfare above the level reached in the walled garden equilibrium.

Proposition 2. *If interoperability is not technically feasible, social welfare is maximised for* $N_S = \frac{1}{2}$, *and* $N_B^p = N_B^b = \frac{\alpha}{2t_B}$, *which corresponds to a volume of trade*

$$V^* = \frac{\alpha}{2t_B},$$

higher than the equilibrium value. Similarly, financial exclusion is reduced but not eliminated. The proportion of buyers who have no access to the payment system in the welfare optimum is reduced to $(1 - \frac{\alpha}{t_B})$, *which is, however, still positive by assumption* H_1.

Proof. This follows immediately after differentiating formula (13), which gives the expression of social welfare with respect to N_S, N_B^b and N_B^p. We obtain:

$$\frac{\partial W}{\partial N_S} = \alpha(N_B^b - N_B^p) - t_S(2N_S - 1) = 0,$$

$$\frac{\partial W}{\partial N_B^b} = \alpha N_S - t_B N_B^b = 0,$$

and

$$\frac{\partial W}{\partial N_B^p} = \alpha(1 - N_S) - t_B N_B^p = 0.$$

This linear system has a unique solution $N_S = \frac{1}{2}, N_B^p = N_B^b = \frac{\alpha}{2t_B}$. It is easy to check that the Hessian matrix of W has eigen values of $-2t_S < 0$ (simple) and $-t_B < 0$ (double). This proves that W is concave and thus that the above first order conditions indeed characterise the maximum of W. $\square$

6 The equilibrium with a fast payment system

Another way to reduce financial exclusion is for the authorities to introduce a new technology, in the form of a central bank-operated fast payment system (FPS) that provides digital payments services to all buyers. This offers the possibility of interoperability between the bank, the platform and a new type of intermediary, namely (non-bank) payment service providers (PSPs). PSPs offer consumers with payment services of lower quality $q < 1$ than incumbents but for negligible fees and no transport costs.[16] As a result, the FPS allows buyers to purchase items in both locations. We now analyse the new equilibrium between the incumbent intermediaries.

6.1 Buyers

With an FPS, consumers have access to all merchants, but with a loss of ancillary services when they pay a merchant who has an account with a different intermediary. This implies that in that case, the gains from trade are multiplied by a factor $q < 1$. Buyers have three options:

- open an account with the bank, in which case their utility is

$$r\alpha[N_S + q(1 - N_S)] - t_B x,$$

- open an account with a non-bank PSP, giving utility

$$rq\alpha,$$

- or open an account with the platform, giving utility

$$r\alpha[qN_S + (1 - N_S)] - t_B(1 - x).$$

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[16]These payment services are instant, low-cost and accepted in both the physical and digital environment, which is highly convenient for buyers. But buyers may not have access to other financial services (eg credit, insurance) nor other benefits from credit cards or digital platform tokens, like buyer protections, reward points, etc.

Indifference between the first two expressions gives the number of buyers who open an account with the bank:

$$N_B^b = \frac{r(1-q)\alpha N_S}{t_B},$$

while indifference between the last two expressions gives the number of buyers who open an account with the platform:

$$N_B^p = \frac{r(1-q)\alpha(1-N_S)}{t_B}.$$

6.2 Sellers

Sellers only have two options. They can open an account with the bank, in which case they obtain utility

$$v_0 + (1-r)\alpha[N_B^b + q(1-N_B^b)] - t_S x - f^b,$$

or with the platform, and obtain:

$$v_0 + (1-r)\alpha[N_B^p + q(1-N_B^p)] - t_S(1-x) - f^p.$$

The indifferent seller determines the number N_S of sellers who open an account with the bank. After using the above expressions of N_B^b and N_B^p and simplifying, we obtain an equation similar to equation (9):

$$N_S = \frac{1}{2} + A_1(f^p - f^b),$$

where

$$\frac{1}{A_1} = 2[t_S - \frac{r(1-r)(1-q)^2\alpha^2}{t_B}],$$

with $A_1 > 0$ from (H2) and $(1-q)^2 < 1$.

6.3 The Nash equilibrium with an FPS

Proposition 2 characterises the equilibrium with an FPS.

Proposition 3. *Under assumptions H_1 and H_2, the equilibrium with an FPS (denoted by upper index F) is characterised by:*

$$N_S^F = \frac{1}{2}, \tag{16}$$

$$N_B^b = N_B^p \equiv N_B^F = \frac{r\alpha(1-q)}{2t_B}, \tag{17}$$

$$f^b = f^p \equiv f^F = t_S - \frac{r(1-r)}{t_B}(1-q)^2\alpha^2. \tag{18}$$

Moreover, all consumers have access to an electronic payment instrument.

Proof. Comparing the equations that characterise Nash equilibria in the two cases of walled gardens and FPS, we see that the only difference is that the parameter α is multiplied by $(1 - q) < 1$. Thus the Nash equilibrium is unique and given by the same formulas once α is replaced by $\alpha(1 - q)$. In particular, the number of buyers who associate with one of the incumbents is lower, but the rest of the market is covered by non-bank PSPs and the FPS. Moreover, the fees paid by the merchants are **higher** because the demand for each incumbent is less elastic.[17] $\qquad\square$

Comparing with Proposition 1, we see that the introduction of a FPS has several consequences:

- Financial exclusion disappears because all consumers gain access to an electronic payment instrument.

- The market share of the incumbent intermediaries is reduced by a factor $(1 - q)$.

- The fees paid by merchants **increase** because the demand functions become **less** elastic, with $A_1 < A_0$. With compatibility, an intermediary's efforts to attract more merchants benefit its competitor. The latter offers its buyers access to a greater number of compatible merchants. Due to cross-side externalities, this increases the value for merchants of connecting with the competing intermediary. Therefore, compatibility softens the competition for merchants.

We now study the impact of the FPS on social welfare.

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[17]Matutes and Regibeau (1988) or Øystein Foros and Hansen (2001) obtain a similar result. Our assumptions differ, because we consider cross-side compatibility. Here, compatibility is reached through the FPS and there is a market expansion effect on the consumer side, which is caused by the entry of PSPs. If the total size of the market is not fixed, compatibility increases the total quantities and may sometimes lower firms' common equilibrium price (see Katz and Shapiro (1985)).

6.4 Welfare analysis

The first consequence of introducing an FPS is that the volume of trade reaches its maximum level: $V^F = 1$. However, the gains from trade are not fully exploited, since only a fraction N_B of transactions realise the full surplus α, while the remaining fraction realises only the surplus $q\alpha$. Social welfare equals

$$W^F = v_0 + \alpha[N_B + q(1 - N_B)] - \frac{t_S}{4} - t_B(N_B)^2.$$

Using Proposition 2, we can replace N_B by its equilibrium value:

$$W^F = v_0 + \alpha[q + \frac{r\alpha(1 - q)^2}{2t_B}] - \frac{t_S}{4} - \frac{r^2\alpha^2(1 - q)^2}{4t_B}. \tag{19}$$

The comparison with the walled garden economy is easy, since it corresponds to the case where $q = 0$. Therefore

$$W^F - W^G = \alpha q - \frac{r(2 - r)\alpha^2 q(2 - q)}{4t_B} = \alpha q[1 - \frac{r(2 - r)(2 - q)\alpha}{4t_B}].$$

Assumption H_1 states that $r\alpha < t_B$. Moreover $(2 - q)(2 - r) < 4$. Thus $W^F > W^G$. Wrapping up all our results, we obtain the following proposition:

Proposition 4. *The introduction of an FPS has the following consequences:*

1. *Financial exclusion disappears.*

2. *The volume of trade is at its maximum level, but the gains from trade are not fully exploited.*

3. *The shares of consumers who open an account with incumbent intermediaries is reduced.*

4. *The profits of incumbent intermediaries increase, since they charge higher fees to merchants, while they still cover all the market on the merchant side.*

5. *Social welfare is increased.*

7 Central bank digital currency

Another policy option that can reduce the inefficiencies caused by financial exclusion and imperfect competition between intermediaries is to issue a retail CBDC. A retail CBDC is defined as a digital payment instrument, denominated in the national unit of account, that is a direct liability of the central bank, and is open for use by households and businesses. This section discusses several designs that are possible for the CBDC.

7.1 The CBDC is only distributed by incumbent intermediaries

This design is essentially equivalent to a FPS without PSPs, assuming that incumbent intermediaries are required by the central bank to provide fast payment services at no fee for consumers. In this case, all buyers open an account with one of the incumbents, but they have the option between a full service account that offer maximum quality of service but implies transport costs, and a CBDC wallet, that only gives them a lower quality of service q but negligible transport cost. Transport costs are a simple tool to model horizontal product differentiation for ancillary services, while basic payment services are the same for all. Even if this CBDC design is very similar to the FPS analysed above, there are two interesting differences:

1. first, the risk of disintermediation is less acute since incumbent intermediaries keep the management of CBDC deposits, which might be used as reserves or collateral for repurchase agreements or interbank loans.

2. second, the quality of service q becomes a policy variable that can be controlled by the central bank.

In practice, some central banks have envisaged such a system. For example, the Swedish Riksbank has tested the integration of the e-krona network with a point of sale (POS) terminal, and demonstrated that it was possible to update the software on a single POS terminal to support payment processing separate from traditional card payments (see e-Krona Pilot phase 2 report by the Riksbank; Riksbank (2022)). Concretely, this means that any merchant accepting the bank payment instrument would be able to accept the CBDC.

7.2   Integration of the CBDC within an existing FPS

Another possibility has been explored by the Reserve Bank of India (RBI), which is to integrate the CBDC within an existing FPS. This aims to avoid costly duplication of infrastructure. This trade-off is well explained by the RBI: "*An Indian CBDC should be able to utilise the current payments infrastructure like UPI, digital wallets like Paytm, Gpay etc. Interoperability between payment systems contributes to achieving adoption, co-existence, innovation, and efficiency for end users. It would be key to integrate a CBDC into the broader payments landscape of India which would possibly help drive end user adoption (both for the public and merchants). This will obviate the need for the creation of a parallel acceptance infrastructure. RBI would have options in how it plans to achieve interoperability, from the use of established messaging, data, and other technical standards to building technical interfaces to communicate with other systems. Integration between systems through APIs shall allow a light yet secure inter-operable architecture. It will be necessary to ensure the robustness of APIs as well for heightened cyber-security. However, barriers to interoperability would likely exist that cover technical, commercial, and legal aspects. Dialogue with stakeholders would be the key to addressing these. Achieving interoperability is a collaborative process and will require the active involvement of all industry players in the Indian payments landscape*" (RBI, 2022). This integrative solution could enhance competition and the quality of services. One potential drawback could be concentration of all (bank deposit and CBDC) payments in one infrastructure, which could generate additional cyber-risks and other operational risks for central banks.

7.3   CBDC and disintermediation

An important point, already discussed above, is that a CBDC is modelled here not to provide the full extent of ancillary services provided by incumbent intermediaries. This is captured in our model by assuming that the gains from trade are reduced by a factor $q < 1$ when they are mediated by a PSP rather than by the CBDC rather than by the bank or the platform. This parameter q is influenced by the design of the CBDC, and can be viewed as a policy variable. The trade-off for public authorities is between disintermediation (which increases for a higher q) and financial inclusion (more buyers and sellers benefiting from a higher quality of service). This is related to the view that a CBDC could crowd out not only bank deposits but also

platform tokens (and perhaps other private instruments).

In fact, in our simple model, increasing q is always good for social welfare.[18]

Proposition 5. *An increase in q has two effects on social welfare: it increases the quality of service for the fraction of payments managed by PSPs, but it decreases the fraction of payments managed by intermediaries. In our specification, the net impact is always positive.*

Proof. The equilibrium value of W^F is given by equation (19). The derivative of this expression with respect to q is:

$$\frac{dW^F}{dq} = \alpha[1 - \frac{r\alpha(1-q)(2-r)}{2t_B}].$$

Now $r\alpha < t_B$ by assumption H_1 and $(1-q)(2-r) < 2$. This implies that

$$\frac{dW^F}{dq} > 0.$$

$\square$

Other trade-offs could also affect the future design of CBDCs. One concern is the potential for disintermediation, or bank runs to CBDCs during periods of banking distress. This negative welfare effect could be overcome by setting limits on CBDC holdings, like those being considered by the ECB and other central banks (Bidder et al. (2024)). Modelling the impact of these measures on industrial organisation could be another fruitful area for future research.

8   Conclusion

This paper has modelled a world of competing digital payment instruments: bank deposits, digital platform tokens and central bank digital currencies (CBDCs). We have shown that if consumers' tastes differ, banks and platforms may carve up the market to extract rents from merchants through fees, which may not be socially optimal. Introducing a retail fast payment system (FPS) can be similar to a CBDC, and can increase financial inclusion and social welfare.

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[18]Of course, this welfare gain has to balanced with the possible costs incurred by the central bank when improving the quality of the payment service, as well as indirect costs of disintermediation, which are not modeled here. Competition with PSPs could disrupt bank lending activities by reducing their ability to learn from payment data about consumer creditworthiness, with ambiguous effects on social welfare (Parlour et al. (2022)).

However, surprisingly, it can make the demand for incumbent services **less** elastic and therefore increase equilibrium merchant fees.

In our very simple set-up, a retail CBDC is essentially equivalent to a FPS. This suggests that introducing a retail CBDC might not be a top priority for countries where an efficient FPS is already in place.[19]

Our model is a simple and flexible tool that can be extended to many different possible designs. Nonetheless, even in the simple form presented here, it holds lessons for current debates on the future of the monetary system. In particular, it shows one means by which CBDCs or FPS could increase welfare and help to achieve an improved market structure, relative to a laissez-faire approach.

Of course, the model abstracts some key issues around the interaction of competing monetary instruments in practice, and the business model of banks and other private payment service providers in various systems. We leave these important questions to the policy discussion and future research.

References

T. Ahnert, P. Hoffmann, and C. Monnet. Payments and privacy in the digital economy. Journal of Financial Economics, 169, 2025.

E. C. Akoguz, T. Roukny, and T. Vadasz. The interoperability of financial data. Discussion paper, KU Leuven, 2025.

I. Aldasoro, P. Mehrling, and D. Neilson. On par: a money view of stablecoins. Journal of Financial Market Infrastructures, 11(4):47–64, 2024.

D. Andolfatto. Assessing the impact of central bank digital currency on private banks. The Economic Journal, 131, 09 2020.

M. Armstrong. Competition in two-sided markets. The RAND Journal of Economics, 37(3): 668–691, 2006.

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[19]Our paper does not go into depth on the possibility of tokenised deposits or unified ledgers.

D. Arner, R. Auer, and J. Frost. Stablecoins: Risks, potential and regulation. Bank of Spain Financial Stability Review, 2019.

R. Auer, J. Frost, L. Gambacorta, C. Monnet, T. Rice, and H. Shin. Central bank digital currencies: Motives, economic implications, and the research frontier. Annual Review of Economics, 34:697–721, 2022.

R. Auer, G. Cornelli, and J. Frost. Rise of the central bank digital currencies. International Journal of Central Banking, October, 2023.

J. Aurazo, H. Banka, J. Frost, A. Kosse, and T. Piveateau. Central bank digital currencies and fast payment systems: rivals or partners? BIS Papers, 151, 2024.

P. Belleflamme, M. Peitz, and E. Toulemonde. The tension between market shares and profit under platform competition. International Journal of Industrial Organization, 81, 2022.

P. Benigno, L. M. Schilling, and H. Uhlig. Cryptocurrencies, currency competition, and the impossible trinity. Working Paper 26214, National Bureau of Economic Research, 2019.

M. Bianchi, M. Bouvard, R. Gomes, A. Rhodes, and V. Shreeti. Mobile payments and interoperability: Insights from the academic literature. Working paper, 2021.

R. M. Bidder, T. P. Jackson, and M. Rottner. CBDC and banks: Disintermediating fast and slow. Deutsche Bundesbank Discussion Paper No. 15/2024, 2024.

BIS. Central bank digital currencies: foundational principles and core features. Technical report, Bank for International Settlements, 2020.

BIS. Central bank digital currencies: an opportunity for the monetary system. Technical report, Bank for International Settlements, 2021.

BIS. Blueprint for the future monetary system: improving the old, enabling the new. Technical report, Bank for International Settlements, 2023.

S. Branch, Y. Cooper, C. Franco, J. Frost, P. Koo Wilkens, Y. Lyu, J. McIntosh, C. Mu, T. Phillip, E. Salinas, L. Ward, T. Walker, and A. Wright. Retail cbdcs in practice: The experience of the SandDollar, e-CNY and JAM-DEX©. SSRN Electronic Journal, 2025. doi: 10.2139/ssrn.5398695.

M. Brunnermeier and J. Payne. Platforms, tokens, and interoperability. Princeton University Economics Department Working Paper, 2022.

M. Brunnermeier and J. Payne. Strategic money and credit ledgers. Princeton University Economics Department Working Paper, 2025.

C. Cantú, J. Frost, and T. Noone. Some perspectives on the regulation of stablecoins. Law Comtemporary Problems, 87, 2025.

A. Carstens and N. Nilekani. Finternet: the financial system for the future. BIS Working Papers, 1178, 2024.

J. Chen, U. Doraszelski, and J. E. Harrington, Jr. Avoiding market dominance: product compatibility in markets with network effects. The RAND Journal of Economics, 40(3): 455–485, 2009.

J. Chiu, S. M. Davoodalhosseini, J. Jiang, and Y. Zhu. Bank market power and central bank digital currency: Theory and quantitative assessment. Journal of Political Economy, 131(5): 1213–1248, 2023.

L. Cong and S. Mayer. Antitrust, regulation, and user union in the era of digital platforms and big data. mimeo, 2022.

L. W. Cong and S. Mayer. Strategic digitization in currency and payment competition. Journal of Financial Economics, 168:104055, 2025.

CPMI. Developments in retail fast payments and implications for rtgs systems. Technical report, Committee on Payments and Market Infrastructures, 2021.

K. Croxson, J. Frost, L. Gambacorta, and T. Valletti. Platform-Based Business Models and Financial Inclusion: Policy Trade-Offs and Approaches1. Journal of Competition Law Economics, 2022.

J. Crémer, P. Rey, and J. Tirole. Connectivity in the commercial internet. The Journal of Industrial Economics, 48(4):433–472, 2000. ISSN 00221821, 14676451.

A. Duarte, J. Frost, L. Gambacorta, P. K. Wilkens, and H. S. Shin. Central banks, the monetary system and public payment infrastructures: lessons from Brazil's Pix. BIS bulletin, 2021.

24

J. Fernández-Villaverde, D. Sanches, L. Schilling, and H. Uhlig. Central bank digital currency: Central banking for all? Review of Economic Dynamics, 41:225–242, 2021. Special Issue in Memory of Alejandro Justiniano.

E. Feyen, J. Frost, L. Gambacorta, H. Natarajan, and M. Saal. Fintech and the digital transformation of financial services: implications for market structure and public policy. BIS Papers, 117, 2021.

J. Frost, P. K. Wilkens, A. Kosse, V. Shreeti, and C. Velásquez. Fast payments: design and adoption. BIS Quarterly Review, 2024.

FSB. High-level recommendations for the regulation, supervision and oversight of global stablecoin arrangements: Final report. Technical report, Financial Stability Board, 2023.

H. Hotelling. Stability in competition. The Economic Journal, 39(153):41–57, 1929.

B. Jullien and W. Sand-Zantman. The economics of platforms: A theory guide for competition policy. Information Economics and Policy, 54(C):S0167624520301244, 2021.

M. L. Katz and C. Shapiro. Network externalities, competition, and compatibility. The American Economic Review, 75(3):424–40, 1985.

A. Kosse, M. Glowka, I. Mattei, and T. Rice. Will the real stablecoin please stand up? BIS Papers, 2023.

V. Lubbersen and W. Bolt. Competition between payment card networks and rebates. Working Paper, 2025.

C. Matutes and A. Padilla. Shared ATM networks and banking competition. European Economic Review, 38(5):1113–1138, 1994.

C. Matutes and P. Regibeau. "Mix and match": Product compatibility without network externalities. The RAND Journal of Economics, 19(2):221–234, 1988. ISSN 07416261.

S. Nakamoto. Bitcoin: A peer-to-peer electronic cash system. SSRN Electronic Journal, 2008. doi: 10.2139/ssrn.3440802.

C. A. Parlour, U. Rajan, and H. Zhu. When fintech competes for payment flows. The Review of Financial Studies, 55(11):4985–5024, 2022.

RBI. Concept note on central bank digital currency. Technical report, Reserve Bank of India, October 2022.

Riksbank. E-krona pilot phase 2. Technical report, Sveriges Riksbank, April 2022.

J.-C. Rochet and J. Tirole. Cooperation among competitors: Some economics of payment card associations. The RAND Journal of Economics, 33(4):549–570, 2002. ISSN 07416261.

J.-C. Rochet and J. Tirole. Two-sided markets: A progress report. The RAND Journal of Economics, 37(3):645–667, 2006.

H. Shin. Central bank digital currencies: an opportunity for the monetary system. Speech at the BIS Annual General Meeting, 2021.

P. Siciliani. Competition for retail deposits between commercial banks and non-bank operators: a two-sided platform analysis. Bank of England Staff Working Paper, 728, 2018.

M. Verdier. Digital payments and bank competition. Journal of Financial Stability, 73, 2024.

S. D. Williamson. Central bank digital currency and flight to safety. Journal of Economic Dynamics and Control, 142:104–146, 2022.

Øystein Foros and B. Hansen. Competition and compatibility among internet service providers. Information Economics and Policy, 13(4):411–425, 2001. ISSN 0167-6245.

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