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Competition for retail deposits between commercial banks and non-bank operators: a two-sided platform analysis

Paolo Siciliani

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Abstract

Commercial banks' mainstream business model, which is reliant on a stable supply of retail deposits, continues to be challenged by new and innovative sources of non-bank competition. This paper examines the implications of one such source: a substitute for commercial banks' personal and saving accounts that provides a safer money storage option thanks to access to a central bank's balance sheet. I model competition for retail deposits between a bank and a non-bank payment service operator by adopting the two-sided platform framework to capture the payment functionality between consumers and merchants under various configurations. I show that banks' mainstream business model is most vulnerable when consumers perceive the two service providers as close substitutes; they have the option to sign up with both service providers; their distribution of deposit is skewed; and they are not allowed to make payments across platforms.

Key words: Two-sided platforms, retail deposit, non-bank payment service operator, central bank digital currency.

JEL classification: D43, G21, L50, L20, L15.

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(1) Bank of England. Email: paolo.siciliani@bankofengland.co.uk

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Publications and Design Team, Bank of England, Threadneedle Street, London, EC2R 8AH
Telephone +44 (0)20 7601 4030 email publications@bankofengland.co.uk

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1. Introduction

Substitutes for commercial banks' personal current and saving accounts pose potential threats to the mainstream business model of commercial banks which hinges on the availability of a plentiful supply of retail deposits which provides the cheap and stable source of funding that underpins their net interest margin (NIM) profitability.[1] One of the ways this competition threat could materialise is if consumers were given the option to store their money at the central bank, either directly in the form of central bank digital currencies (CBDC). In addition to a safer storage facility, consumers could keep the convenience of seamlessly making payments and balance transfers. This paper analyses the competition outcome between a bank and a non-bank operator by adopting a two-sided platform framework, used to model the strategic interaction between different payment systems operators whose business model is to match merchants and retail customers on their two separate platform sides.

This paper is related to the literature on competition among two-sided platforms.[2] In particular, it focuses on firms' pricing strategies to bring both sides on board (in our case, consumers and merchants participating in a payment system). Utilities of agents on either side depend on their expectations regarding the number of agents on the other side. If fulfilled these expectations generate cross-group network benefits that are underpinned by membership externalities (as in Armstrong, 2006), whereby agents on either side value the ability to be matched with agents on the opposite side (in our case, in order to be able to make a payment).[3] These are externalities to the extent that agents fail to internalise the fact that their decision to join the network will make it more compelling for agents on the opposite side to do the same, which in turn amplifies through a feedback loop the benefit from joining in the first place. The role of the intermediating platform is to internalise these cross-group externalities by subsidising adoption. Specifically, the side that exerts the largest cross-group benefit tends to be the main beneficiary, whereas agents on the opposite side tend to be charged high fees in order to cross-subsidise adoption on the opposite side.

With respect to payment schemes, consumer membership is typically subsidised through high merchant fees. This is why in the context of credit card associations, members who sign up

[1] Roengpitya et al. (2017) show how this retail model has become more popular in the aftermath of the Great Financial Crisis.

[2] For a recent literature review, see Belleflamme and Peitz (2017).

[3] Membership externalities differ from usage externalities where the benefits are dependent on the intensity of usage from agents on the opposite side (as in Rochet and Tirole, 2003). This paper ignores usage externalities thus implicitly assuming that consumers and merchants want to be able to execute non-cash transactions most of all, regardless of the specific number of transaction carried out. Rochet and Tirole (2006) developed a model that combines both usage and membership externalities.

merchants agree to pay an interchange fee to those members who sign up cardholders. Many papers have investigated firms' incentives to set interchange fees,[4] and competition authorities around the globe have largely taken the view that they are excessively high. As a result, interchange fees nowadays tend to be capped at levels that reflect underlying costs.[5] We do not assess the role of interchange fees, as we model competition among proprietary platforms, rather than associations.

Following the seminal contributions of Caillaud and Jullien (2003), Rochet and Tirole (2003 and 2006), and Armstrong (2006), the literature analysing competition among two-sided platforms has mostly been couched in terms of symmetric firms with respect to underlying costs. This mainstream approach is probably motivated by the consideration that the main research question has been about the pricing strategies adopted by firms to reach a critical mass of agents on both sides to avert the onset of pessimistic expectations regarding the size of the network and, thus, the corresponding cross-group network benefits.[6] Hence, the literature has modelled various sources of agents' preference heterogeneity such as differing network benefits, stand-alone valuations and brand preferences.[7]

This paper models consumer preference heterogeneity in two ways. First, consumers are assumed to be split between those with a high deposit balance and those with a small one under undifferentiated competition. Second, they are assumed to have heterogeneous brand preferences which are modelled under the Hotelling linear framework. In each case we investigate the competition outcomes under single-homing, multi-homing and interoperability. Under single-homing, agents affiliate with only one platform, whereas under multi-homing they have the option to sign up with both platforms. Under interoperability, agents can make payments across platforms, that is, with an agent not belonging to the same platform.

Besides the network benefits arising from the possibility of executing transactions with members of the other side, customers also draw non-network-related benefits from the deposit-taking functionality. In this respect, this paper models competition between asymmetric platforms, given that, as discussed in more detail below, the non-bank operator has a marginal cost advantage thanks to the fact that the cost of deposit remuneration would be borne by the

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[4] See, for example, Schmalensee (2002), Rochet and Tirole (2002), Wright (2003, 2004), and Guthrie and Wright (2007).

[5] See, for example, European Commission, The interchange fees regulation, available at http://ec.europa.eu/competition/publications/factsheet_interchange_fees_en.pdf.

[6] In this respect, see also Hagiu (2006), Weyl (2010) and Halaburda and Yehezkel (2016).

[7] Julien and Pavan (2016) introduce heterogeneity not only in terms of agents' stand-alone valuation of the new network product, but also with respect to the beliefs that agents hold regarding the distribution of fellow agents' stand-alone valuation, in order to model uncertainty across agents regarding the belief that the new platform will succeed in reaching a critical mass.

central bank.[8] This fixed non-network benefit due to deposit remuneration is modelled as tied to the identity of the network platform, due to the assumption that consumers must hold enough balances to execute the volume of transactions channelled through each platform. This specification simplifies the analysis when agents on both sides have the option of multi-homing.

We find that, when platforms are perceived by agents on both sides as undifferentiated, competition to sign up consumers is very strong and the result is that only one platform is active due to the fact that agents on both sides want to patronise the platform that can deliver full network benefits. This is particularly the case when agents are given the option to sign up with both platforms, thanks to the fact that it is easier for the new entrant to sign up consumers notwithstanding the initial disadvantage in terms of network size. In order to soften pricing rivalry on the consumer side, the incumbent platform prefers to allow cross-platform transactions, in particular, when network benefits are strong; whereas the new entrant prefers not to as its aim is to oust the incumbent. Therefore, public intervention to mandate interoperability would favour the incumbent platform.

The presence of demand-side frictions on the consumer side due to the fact that consumers hold opposing views regarding their preferred platform mitigates the tendencies towards a winner-takes-all outcome driven by network effects, which means that both platforms can coexist. However, the incumbent can still suffer a material loss in revenue and amount of retail deposits under multi-homing. To the extent that merchants still perceive platforms as, essentially, undifferentiated utilities, pricing rivalry works in their favour, thereby reversing the current prevailing pattern whereby they subsidise consumers' use of payment systems. Given that opposing brand-preferences neutralise the incumbency advantage due to network effects, the new entrant can always outspend the incumbent thanks to the fact that it does not pay for the remuneration of deposits. Hence, merchants switch to the new platform which means that the incumbent loses all but the most loyal consumers. In order to avert this debacle, the incumbent bank has a strong incentive to allow cross-platform payments. The new platform is willing to reciprocate in order to soften pricing rivalry on both sides, so that profits are higher for both firms than under multi-homing.

The next section briefly discusses how the new competition threat to commercial banks could materialise and disrupt the traditional commercial bank model. Section 3 develops the models of competition among undifferentiated platforms, whereas section 4 introduces brand preferences on the consumer side. Section 5 concludes.

[8] On the other hand, in our model the new entrant faces a fixed cost to enter the market. For another recent model with asymmetric firms, see Belleflamme and Toulemonde (2016).

2. The potential competition threat to the traditional commercial bank model

Several central banks are exploring the merits of central bank digital currencies (CBDC)[9] and, in particular, the radical idea that the public could be given access to the central bank balance sheet to store their cash holdings in a personal account. In addition, people would also be able to make payments and transfers thanks to the provision by private operators of complementary services such as 'digital wallet' and transaction verification. Hence, the universal disintermediated access to the central bank's balance sheet, combined with the payment service functionalities offered by accredited digital wallet service providers, would provide depositors, both retail and corporate, with a potential substitute for deposit account services offered by commercial banks.[10]

At a minimum, the competition threat posed by the non-bank operator can increase banks' cost of funding, thus squeezing their NIMs, with potential repercussions on the asset side of banks' balance sheet due to the resulting pressure to pass on the cost increase to borrowers through higher lending rates. More radically, though, banks may be subject to an outflow of retail deposits, in particular in a scenario of financial stress,[11] thus forcing them to shift their mix of sources of funding towards alternative wholesale forms of debt with a longer tenor, that is, in order to maintain liquidity adequacy. Under an extreme scenario, the loss of retail deposits would force banks to adopt a 'narrow-banking' business model whereby their lending activity is entirely reliant on non-insured funding from retail and wholesale investors.[12]

This paper is focused on competition for retail deposits and the provision of payment services between a bank incumbent and a non-bank new entrant offering a functional substitute for the bank's personal current account. In doing so, we treat the provision of deposit-taking

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[9] See, for more information, http://www.bankofengland.co.uk/research/Pages/onebank/cbdc.aspx. See also Bech and Garratt (2017) and Fung and Halaburda (2016).

[10] With respect to the availability of overdraft facilities, it wouldn't be unimaginable that the private operators could also provide lines of credit bundled with payment functionalities.

[11] See, Bank for International Settlements (2018; p.16).

[12] See, for example, Marilyne Tolle, Central bank digital currency: the end of monetary policy as we know it?, Bank Underground blog, 25 July, 2016, available at https://bankunderground.co.uk/2016/07/25/central-bank-digital-currency-the-end-of-monetary-policy-as-we-know-it/. See also Remarks by Vítor Constâncio, Vice-President of the ECB, at the Financial Regulatory Outlook Conference organised by the Centre for International Governance Innovation and Oliver Wyman, Rome 9 November 2017, available at https://www.ecb.europa.eu/press/key/date/2017/html/ecb.sp171109.en.html ("..., the use of the blockchain by central banks to create digital currency open to all citizens without limits would be really disruptive. This would be a radical political choice that could end banking as we know it and is therefore unlikely to happen.")

and payment services on a stand-alone basis, meaning that we ignore the fact that banks lend the deposits raised. In other words, we ignore the fact that banks may want to hold on to their retail deposit bases even if the stand-alone profitability is very low or negative. This is so to the extent that retail deposits are still considered to be a valuable source of funding, that is, when compared to the next best alternative such as wholesale unsecured debt.

Similarly, though, stand-alone profitability may not be the paramount guiding principle for the non-bank operator either. For example, as it is common with many online business models, the non-bank operator may rely on alternative sources of revenues based on the monetisation of the data collected through the provision of current account services (for example, by offering targeted advertising or creating a platform to cross-sell other financial products).[13] More generally, internet giants appear to compete by adding services to their bundle of products in order to cement customer loyalty, so that their calculations would look at the incremental value (i.e., over and beyond stand-alone profitability) that the new service would add to the attractiveness of their broader platform. Therefore, although the analysis that follows is premised on the basic principle of (stand-alone) profit maximisation, it does nevertheless shed lights on the extent to which commercial banks can withstand the competition threat from a non-bank new entrant potentially willing to offer current account services as a loss leader.

2. Competition among horizontally undifferentiated platforms

There is a duopoly with one incumbent platform (commercial bank I) and one new entrant (non-bank operator E), both of them have no capacity constraints and the same marginal operating costs which are normalised to zero. There are two different groups of customers: non-competing merchants,[14] labelled M; and consumers, labelled N. Each group is assumed to have unitary mass and we denote with m^i and n^i $(i = I, E)$ the masses of merchants and consumers affiliated to the incumbent's and entrant's platforms. Both categories of customers, M and N, draw benefits from two different functionalities: making payments and accepting deposits.[15]

[13] Of course, it is important to stress how nowadays in the EU there are new rules imposing strict requirements around the need to obtain consent from consumers in order to exploit the data collected on them.

[14] Specifically, as it is standard to assume in the literature, merchants are monopolist sellers from which all consumers wish to buy exactly one unit of product; these products are perceived as equally valuable and as neither substitutes nor complements in their utility function.

[15] On both sides, the corresponding outside options (such paying by cash) are valued at zero.

With respect to the payment function, we only model business-to-consumer (B2C) transactions, which generate cross-group network effects.[16] We make the standard assumption that merchants expect to execute a transaction with each consumer who has joined the same platform on the opposite side. As is also standard in the literature,[17] we assume that these cross-group network effects are linear in the number of members on the opposite side joining the same platform, according to parameter α_j ($j = M, N$).[18] We assume that merchants cannot set different prices based on which platform is used to execute the payment; in other words, merchants are not allowed to nudge consumers into choosing a specific payment platform by offering a discount (or charging a fee for the use of the unwanted payment platform).[19]

With respect to the deposit taking function, we focus only on the consumer side, N, in light of the fact that it is uncontroversial to assume that merchants would prefer to store their cash with the central bank, that is, to the extent that they do not benefit from deposit insurance available to consumers.[20] The deposit taking function entails a fixed utility benefit for consumers, φ^i, which is additive to the common cross-group variable benefit which depends on the total network dimension. Specifically, consumers have common balance d which is remunerated by the two different platforms at rates, r^i. Moreover, the deposit rate offered by the commercial bank platform is discounted at rate $\delta^I \leq \delta^E = 1$, to reflect the consideration that agents may perceive the central bank's balance sheet as a safer store of value in comparison to bank's deposits.[21] Furthermore, the fixed benefit includes a component v, common across

[16] That is, for the sake of simplicity we ignore the existence of intra-group payments such as business-to-business transactions on the merchant side and peer-to-peer payments on the consumer side.

[17] In Hałaburda and Yehezkel (2016) network benefits can reach a saturation point, in that the incremental cross-network benefit when a new user joins the platform declines after a network size threshold.

[18] Following Armstrong (2006), and in contrast to Rochet and Tirole (2003), this parameter does not depend on which platform agents are affiliated with. We believe this is a reasonable assumption to make with respect to what is essentially a commoditised, utility-like service such as making payments.

[19] In the UK, for example, the government has decided to extend the ban on the use of surcharges for all retail payment instruments. See para. 6.13 at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/629988/Implementation_of_the_revised_EU_Payment_Services_Directive_II_response.pdf.

[20] This assumption ignores the possibility that corporate clients may want to keep their deposits with the commercial bank to the extent that this would be important to keep or establish a lending relationship. However, it is worth noting that data on current account performance is normally shared among lenders (i.e., in order to facilitate borrower switching), thus eroding the possibility that the existing current account provider has a competitive advantage based on private information.

[21] A potential extension would be to model heterogeneous risk preferences.

both platforms, which represents the utility consumers derive from having a convenient and secure (in the sense of protected from theft) storage facility for their savings that is redeemable on demand (i.e., liquidity service provision). This component is assumed to be high enough so that every consumer wants to patronise at least one platform.

The two platforms have different pricing instruments depending on the side of the platform.[22] On the consumer side, N, incumbent banks (I) and new non-bank entrants (E) can charge an upfront membership fee p^{i}, which can be negative (i.e., a subsidy). In addition, they can offer deposit rates r^i, with r^E set by the central bank.[23] In the absence of demand-side frictions, the central bank rate must arguably be lower than the other rate set by the commercial bank, as otherwise everyone would opt for the new solution (all else equal) thanks to its superior risk-profile. On the merchant side, M, both platforms charge a unit transaction fee γ^i.

What follows analyse three network regimes: exogenous single-homing, where agents on both sides can only sign up with one platform; endogenous multi-homing, where agents can sign up with both platform; and exogenous interoperability, where agents belonging to a platform are able to execute transactions with agents on the opposite-side belonging to other platform.

2.1 *Single-homing*

As a baseline scenario, let's assume first that the single-homing is the only available option to agents on both sides.[24] Under these circumstances, agents' utilities are given by:

$$\begin{cases} u_M^i = (\alpha_M - \gamma^i)n^i \\ u_N^i = \alpha_N m^i + \varphi^i - p^i \end{cases} \tag{1}$$

where $\varphi^i = v + \delta^i d r^i$.

The first thing to note is that, on the consumer side and in the absence of network benefits, firm I would surely be outcompeted by firm E, that is, given firms' undercutting incentives due to the lack of demand-side frictions. The common fixed component v is competed away, as it is not a differentiating factor between the two platforms. Therefore, for firm I to be able to match the level of utility delivered by firm E, it would ultimately have to set a

[22] The distinction between sides is needed to simplify the model. However, it is defensible in the sense that it is consistent with stylised facts, where consumers are not normally charged transaction fees (at least when using debit cards domestically). Moreover, the few alternatives to the prevailing Free-If-In-Credit pricing model for personal current accounts (PCAs) is where consumers are charged an upfront fee, typically in return for a higher deposit rate. The same design with merchants paying a transaction fee and consumers paying a fixed membership fee is used in Chakravorti and Roson (2006).

[23] We think this is a sensible assumption also with respect to e-money providers who, presumably, will hold consumer (pre-paid) balances in risk-free funds (e.g., deposited at the central bank).

[24] This may be the result of the prevailing use of contract exclusivities by platforms.

combination of price and deposit rate that is loss-making.[25] Firm E has a comparative advantage because it is perceived as a safer store of value (i.e., $\delta^i < 1$) and it does not incur the cost to remunerate deposits at r^E. Therefore, firm E could lower the price down to the point where firm I makes zero profit and still manage to earn a positive operating profit margin (i.e., to recover the fixed entry cost), specifically, by setting $p^E = d\left[r^E + r^I(1-\delta^i)\right]$. Hence, it is imperative for the incumbent platform to retain network benefits at least to some extent.

As explained by Caillaud and Jullien (2003, Proposition 1), when platforms provide undifferentiated and exclusive intermediation services to homogeneous agents, there are multiple equilibria, depending on agents' expectations regarding platforms' respective network sizes, where only one platform is active.[26] In order to improve the predictive power of this class of models, we follow the authors by assuming that the incumbent platform benefits from 'favourable expectations' regarding the size of its network.[27] This approach holds as long as $r^I \geq \frac{r^E}{\delta^I}$; that is, as long as the new platform does not deliver a higher risk-adjusted return. To overcome the incumbency advantage of firm I, firm E must play a 'divide and conquer' (DC) penetration strategy by subsidising consumers first. This entails setting prices low enough as to entice consumers in spite of potential pessimistic expectations regarding firm E's network size (i.e., whereby $m^I = 1$),[28] that is: $p^E < p^I - \alpha_N - d(\delta^I r^I - r^E)$. Having brought consumers on board, firm E can then exploit merchants by extracting all their network benefits -- that is, by setting $\gamma^E = \alpha_M$ -- thanks to the fact that merchants are left with no alternative option but to patronise firm E.

Under these conditions of market contestability,[29] firm I must lower the consumer membership fee in order to deny firm E making a profit under such a DC strategy (i.e., akin to

[25] The commercial bank may still decide to do so in order to raise retail deposits to fund its lending activity to the extent that it would still turn out to be cheaper than relying on other sources of funding such as wholesale debt with a longer tenor.

[26] This corner outcome is considered to be efficient, thanks to the guarantee of full-participation and the fact that agents draw maximum network benefits.

[27] Halaburda and Yehezkel (2016) extend this concept to partial beliefs advantage in a multi-period setup in which the extent of beliefs advantage depends on the market's history. Halaburda et al (2016) investigate under what conditions this incumbency advantage can prevail against a higher quality platform over an infinite period.

[28] It is worth noting that transaction fees cannot be used as instruments to subsidise adoption, given that agents hold pessimistic expectations regarding the size of the entrant's network base. Therefore, only upfront membership fees can be used.

[29] It is worth pointing out that, even without the contestability threat, a monopolistic platform would, at least initially, adopt a penetration strategy where consumers are subsidised, by setting $-p^I + d\delta^I r^I$ just

limit pricing). The expression for firm E's profit is ,[30] $\pi^E = \gamma^E m^E n^E + p^E n^E - F$,[31] where F is a fixed entry cost for the new entrant due to, for example, the need to set up the technological infrastructure and run an advertising campaign to launch the new brand. The limit pricing restraint faced by firm I is therefore given by $p^I \leq \alpha_N - \alpha_M + d(\delta^I r^I - r^E) + F$,[32] which entails a profit for firm I equal to $\pi^I = \alpha_N - d[(1-\delta^I)r^I + r^E] + F$.[33] By setting $r^I = \frac{r^E}{\delta^I}$ the expression for Firm I's profit simplifies to $\pi^I = \alpha_N - \frac{dr^E}{\delta^I} + F$. This expression shows that the lower the fixed entry cost (F), the higher the rate paid by the central bank (r^E) and the lower the relative perception of safety of bank deposits (δ^I),[34] the greater is the squeeze on the incumbent's profitability due to the contestability threat. We note that while the commercial banking model is protected by the favourable expectations in terms of network size (due to the incumbency advantage related to the payment functionality), the new entrant holds the advantage regarding the deposit taking functionality thanks to the reliance on the central bank's balance sheet. Ultimately, for very low values of the fixed entry cost F and high deposit balance d, firm I's profits may turn negative under this defensive pricing strategy.[35]

The common perception that bank deposits are a relatively less safe store of value might induce the emergence of pessimistic expectations against the incumbent firm. Accordingly, with firms' role being reverted, under a DC strategy firm I' membership fee must be set at

above zero in order to prevent the coordination failure where the platform fails, whereas merchants are fully exploited (see Caillaud and Jullien, 2001).

[30] For the sake of simplicity, apart from the entry fee, F, all costs are assumed to be symmetric and normalised to zero.

[31] It is worth pointing out that the remuneration of balances deposited at the central bank doesn't feature the expression for firm E's profits.

[32] This entails that p^I is the variable of choice for firm I, whereas r^I is, say, set at a specific mark-up against r^E. Alternatively, firm I would have to set a combination of p^I and r^I that satisfies the inequality. Here we also ignore the possibility that pricing instruments may differ in their prominence in the eyes of consumers, due to potential biases that may lead some consumers to focus more on a specific pricing element.

[33] Firm I's profit is given by $\pi^I = \gamma^I m^I n^I + (p^I - dr^i)n^I$.

[34] In this respect, the provision of access to non-bank operators to the central bank's balance sheet might give salience to the attribute of perceived safety, as suddenly there is a safer option available so that consumers start to attach greater value to this quality attribute than they did beforehand.

[35] It is worth noting that the expression for firm E's profit when it lowers its membership fee down to the point where firm I makes zero profit is exactly the opposite of the expression for firm I's profit. This means that when firm I's profit are positive, firm E would have to make a loss in order to drive the incumbent out of the market; that is, unless firm I's defensive strategy is unviable to start with.

$p^I \leq p^E - \alpha_N + d(\delta^I r^I - r^E)$. The limit price that firm E would have to set to deny its rival making a positive profit is thus $p^E \leq \alpha_N - \alpha_M + d[(1-\delta^I)r^I + r^E]$, yielding a profit of $\pi^E = \alpha_N + d[(1-\delta^I)r^I + r^E] - F$.[36]

2.2 Multi-homing

Under multi-homing the option to sign up with more than one platform is available to agents on both sides. Accordingly, agents' utilities are given by:

$$\begin{cases} u_M = \alpha_M - \gamma^I n^I - \gamma^E(1-n^I) \\ u_N = \alpha_N + v + m^I \delta^I d r^I + (1-m^I) d r^E - p^I - p^E \end{cases} \quad if\ \delta^i > \frac{r^E}{r^I} \tag{2}$$

We assume that the fixed utility component v is not multiplicative in the number of accounts held.[37] The use of the weights m^I and $(1-m^I)$ in consumer utilities is based on the assumption that the split of transactions between the two payment options in turn also dictates the split in terms of deposit balances held in the two corresponding accounts. This is because consumers have to hold enough available balances to accommodate the corresponding volume of transactions. Given the lack of transaction fees, the choice is therefore dictated by which platform offers the best risk-adjusted return, and merchants have to accept whichever method of payment consumers prefer to use (i.e., provided they are members of that platform).

Let's assume, as in the previous configuration, that firm I benefits from 'favourable expectations'. The DC penetration strategy of firm E would be to first offer a small upfront subsidy (i.e., $p^E \leq 0$) to drive membership on the consumer side even without network benefits. In other words, under multi-homing it is cheaper for the new entrant to lure consumers to adopt its platform as a 'second-source' option. Secondly, firm E would have to undercut firm I's exploitative transaction fee (i.e., $\gamma^E \leq \alpha_M$) in order to induce merchants to sponsor its platform and drop the incumbent's (i.e., opting for single-homing with firm E). To note that here we implicitly assume that $F \leq \alpha_M$, as otherwise this strategy would not be viable for firm E. Merchants would want to do so in the knowledge that consumers would rather execute transactions through firm E (i.e., although it delivers a lower risk-adjusted return on *tied* balances) than not realise network benefits at all: that is, provided that network benefits more than offset the reduction in terms of risk-adjusted deposit remuneration so that $\alpha_N - d(\delta^I r^I - r^E) \geq 0$. At first scrutiny, the incumbent's response should be to match this strategy by just about subsidising consumer membership and undercutting its rival on the merchant side up

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[36] Firm E's profit under this scenario are higher than firm I's under the previous opposite scenario when $\frac{F}{d} \leq r^I - (\delta^I r^I - r^E)$, whereas consumer membership fees are higher when $\frac{F}{d} \leq r^I - 2(\delta^I r^I - r^E)$.

[37] Indeed, it could be argued that this fixed utility component could even be lower to the extent that there could be higher transactions costs in having to split savings across multiple storage facilities.

to the point where the revenue raised through the transaction fee can no longer cover the fixed entry cost F, which would correspond to firm I's profit since it no longer has to remunerate deposits at all.

However, this outcome would be odd since consumers would be worse off than under single-homing. In other words, if consumers manage to coordinate on single-homing with firm E,[38] they would at least be earning r^E. The entrant could then charge the maximum transaction fee which would be competed away through membership subsidies up to $\alpha_M - F$. Firm I's response would in turn be to match the corresponding level of consumer utility to induce single-homing on the consumer side in favour of its platform. However, this outcome would be unstable to the extent that coordination among consumers may break down when individual consumers opportunistically sign up with firm E in order to bag the subsidy twice. To prevent this, the incumbent can choose to match that level of utility through a combination of membership fee and deposit rates that deny the possibility for merchants to opt for single-homing in favour of firm E's platform in order to drive consumer choice of payment platform, that is, by setting r^I so that $\alpha_N - d(\delta^I r^I - r^E) \leq 0$, which yields $\mathrm{r}^\mathrm{I} \geq \frac{\alpha_\mathrm{N}}{\delta^\mathrm{I}\mathrm{d}} - \frac{\mathrm{r}^\mathrm{E}}{\delta^\mathrm{I}}$. Accordingly, the limit membership price can be found by solving the following inequality:

$$\alpha_N + (\alpha_M - F) + dr^E \leq \alpha_N - p^I + \delta^i d\left(\frac{\alpha_\mathrm{N}}{\delta^\mathrm{I}\mathrm{d}} - \frac{\mathrm{r}^\mathrm{E}}{\delta^\mathrm{I}}\right) \tag{3}$$

which yields $p^I \leq \alpha_N + F - \alpha_M - 2dr^E$. Firm I's profit is correspondingly $\pi^I = (\alpha_N - dr^E)\left(1 - \frac{1}{\delta^I}\right) + F - dr^E$, which is lower than under single-homing. This lower profit is due to the higher contestability threat under multi-homing that stems from the fact that the incumbency advantage related to network effects is weaker. When this pricing strategy is not viable, firm E will displace the incumbent. It is interesting to note how, according to Eq. (3), under multi-homing the incumbent delivers consumer utility through a higher deposit rate rather than a lower membership fee. This is due to the fact that the fixed benefit related to deposit

[38] The possibility for consumers to adopt a common strategy whereby they are collectively better off could be improved in the future thanks to the mass adoption of so-called "aggregators", that is, online shopping assistants that can offer bespoke price comparisons to consumers based on their consumption profiles. See, for example, Wired, To change how you use money, Open Banking must break banks, 17 October, 2017, available at http://www.wired.co.uk/article/open-banking-psd2-regulation-banking. Another solution is "collective switching", whereby consumers explicitly form a group to extract better terms from utility service providers. See, for example, BBC News, British Gas owner Centrica warns about poor trading, 23 November, 2017, available at http://www.bbc.co.uk/news/business-42092169 ("British Gas has lost 823,000 domestic customer accounts, nearly 6%, since the end of June. … Centrica said 650,000 of the customer accounts it had lost were as a result of so-called "collective switching", where large groups of households join forces with a new provider to get the best deal.")

remuneration is used as a tying device in order to deny firm E the move of strategically cornering the merchant side in order to steer consumer choice of payment platform.[39]

2.3 Interoperability

So far we have implicitly assumed that the two platforms are not interoperable, that is, transactions could only be executed within platforms. It is perfectly plausible, though, to imagine that the new platform can be seamlessly integrated with the existing bank payment infrastructure thanks to the access to the central bank's settlement infrastructure, which would enable the new operator to plug directly into the payment systems used by the commercial bank.[40] Under this scenario, firm E will no longer have to compensate agents on both sides for the expected loss of network benefits. Therefore, firm I no longer benefits from the ensuing incumbency advantage, which implies that pricing rivalry becomes more intense.

Specifically, in order for firm I to be able to deter entry, it must set any combination of its three pricing instruments so that the following three conditions are satisfied: *i)* $\gamma^I \leq \gamma^E$; *ii)* $-p^I + \delta^I dr^I \geq -p^E + dr^E$; and *iii)* $p^I + \gamma^I \geq F$. The first two expressions refers to agents' utilities on, respectively, the merchants and the consumers' side, whereas the last one corresponds to the zero profit constraint for firm E. To fix things, let's assume that firm I sets $\gamma^I = 0$. This in turn forces firm E to set $p^E = F$ in order to at least cover its fixed cost of entry. Therefore, firm I can set p^I just below F and $r^I = \frac{r^E}{\delta^I}$, yielding a profit of $F - \frac{r^E}{\delta^I} d$.

This level of profit is lower than under single-homing (equal to $\alpha_N - \frac{dr^E}{\delta^I} + F$), in that the incumbent firm can no longer claim the network benefits on the consumer side, α_N. However, firm I's profit under interoperability can be higher than under multi-homing if $\alpha_N - 2dr^E > 0$, that is, when consumer cross-group network effects related to the payment functionality are twice as important as deposit remuneration.

Therefore, under these circumstances, the incumbent bank would have an incentive to allow payments across platforms, that is, as long as achieving interoperability does not impose a

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[39] With respect to the UK context, this proposition suggest that banks would steer away from the free-if-in-credit (FIIC) business model prevailing for PCAs, whereby consumers are not charged an upfront fee but are offered a very low rates on credit balances.

[40] This is exactly what will happen in the UK where, as a result of the Bank of England's review of the RTGS, non-bank e-money operators will gain access to this critical infrastructure which is instrumental in being able to obtain direct access to payment systems as well: see http://www.bankofengland.co.uk/publications/Documents/news/2017/048.pdf.

cost that dissipates the incremental profit extracted.[41] Of course, firm E would always hold opposite views given the winner-takes-all nature of the competition outcomes under undifferentiated competition. This view implies that if the setting up of interoperability requires the collaboration of both operators, the new non-bank entrant may prefer to deny interoperability in order to trigger tougher pricing rivalry under multi-homing and thus improve its chances of displacing the incumbent bank. Hence, from a policy perspective, an intervention aimed at mandating interoperability would tend to tilt the balance in favour of the incumbent bank.

2.4 Extension with heterogeneous deposit balances

The assumption that consumers have all the same balance is unrealistic. The typical distribution of deposits is skewed, with the vast majority of retail depositors holding small balances and a small minority of them with high balances. Accordingly, let's assume that a proportion $\beta \in (\frac{1}{2}, 1)$ of consumers have low deposits, labelled d_l, with the rest holding high deposits, labelled d_h. Let's further make the simplifying assumption that the deposit amount does not affect the volume of payments, so that merchants are indifferent on what type of consumers they sell to. In what follows we revisit the outcomes under single-homing, multi-homing and interoperability with deposit heterogeneity.

2.4.1 Single-homing

The partition between consumers with high and low deposits means that firm E has the option to target one particular segment in the execution of the DC penetration strategy. This in turn opens the possibility that firm I adopts either an accommodative or aggressive stance, where in the former case the two firms each preside over a specific consumer segment, rather than escalating pricing rivalry in order to deter entry. We search for subgame perfect equilibria, meaning that firm E will assume that firm I will end up choosing the course of action that yields the higher profit conditional on firm E's decision to enter.

However, firm I would have no choice but to adopt an aggressive stance in case firm E targeted the d_l segment first. This is because firm I anticipates that if this larger segment of

[41] Doganoglu and Wright (2006, Section 4) analyse platforms' incentive to agree on interoperability when they are restricted to set membership prices on both sides. They find that platforms may lack the incentives to do so because profits under multi-homing are higher, thanks to the fact that without transaction fees on the merchant side, they lose the incentive to undercut each other in order to corner that side, as this would not generate incremental revenue given that all merchants opt for multi-homing. This finding is based on Caillaud and Jullien (2003, Proposition 11).

consumers switched to the new platform, all merchants would have to follow suit in order to be able to execute transactions with the majority of agents on the opposite side. Therefore firm I would lose the revenue source from the merchant side. Furthermore, for the same reasons outlined at the beginning of this section 2.1, merely charging d_h consumers for deposit taking would not be a viable business proposition for firm I, given that in the absence of network benefits it would have to make a loss in order to at least match the level of fixed utility delivered by the rival platform, let alone a level of utility above the total utility delivered by the other platform inclusive of all the network benefits.

Therefore, firm E would have to target the d_h segment first in order to have a possibility of eliciting an accommodative response from firm I. However, firm I would still have no alternative but to adopt an aggressive stance as long as $r^I \geq \frac{r^E}{\delta^I}$. This is because the penetration price that firm E would have to offer to entice d_h consumers to switch includes a compensation for the lost interests rates $d_h(\delta^I r^I - r^E)$ which would make it even more compelling for d_l consumers to switch to firm E too, thus forcing firm I to deter this strategy.

Therefore, in light of the fact that firm I always opts for an aggressive response, firm E must target the consumer segment which yields the lowest profit for firm I, thus making it more difficult for firm I to deter firm E through the same limit-pricing strategy as outlined in the configuration with only one level of deposits. It turns out that this means firm E always targets the d_l segment first. Specifically, firm E targets d_l consumers by setting $p^E < p^I - d_l(\delta^I r^I - r^E)$, which entails a profit $\pi^E = \alpha_M + p^I - d_l(\delta^I r^I - r^E) - F$. Firm I must then lower its price to deny a positive profit to firm E. This limit-pricing strategy entails $\pi^I = F - d_l[r^E + r^I(\beta - \delta^I)] - d_h r^I(1-\beta)$, which by setting $r^I = \frac{r^E}{\delta^I}$ simplifies to $\pi^I = F + (d_h - d_l) r^E \frac{\beta}{\delta^I} - d_h \frac{r^E}{\delta^I}$.

It is worth noting that by setting $d = \beta d_l + (1-\beta) d_h$ (i.e., so that there is the same amount of deposits overall) firm I's profit falls by an amount equal to α_N (i.e., the entire network benefits from the consumer side) compared to the outcome under single-homing but without deposit heterogeneity. This is because under the current partition, d_l consumers can shift the merchant side M with them, which therefore allows them to extract more of the network benefits generated by the prevailing platform. Therefore, in the presence of a skewed distribution of deposits, the ability of firm I to fend off the threat from a new platform relying on access to the balance sheet of the central bank is materially diminished under the single-homing configuration.

2.4.2 Multi-homing

As in section 2.2, firm I must tie in consumers to its payment platform by offering a deposit rate high enough so as to compensate them for the loss of network benefits. This way merchants lose the ability to nudge consumers into switching to the new platform by coordinating on the single-homing option with firm E. The difference is that this pricing strategy must be targeted at d_l consumers, which, as with the previous configuration under single-homing, makes it more costly. Firm I has to set a lower price $p^I \leq \alpha_N + F - \alpha_M - 2d_l r^E$ and offer a higher deposit rate $r^I \geq \frac{\alpha_N}{\delta^I d_l} - \frac{r^E}{\delta^I}$, so that profit is certainly lower when $d = \beta d_l + (1-\beta)d_h$.

2.4.3 Interoperability

In contrast to the previous two configurations, under interoperability nothing changes compared to the exposition in section 2.3. This is because there is no need to compensate d_l consumers for the loss of network benefits. Therefore, the incumbent platform has stronger incentive to seek interoperability under a skewed deposit base.

In summary, when platforms are perceived by agents on both sides as undifferentiated, pricing rivalry will be very intense with winner-takes-all outcomes driven by cross-group network effects related to the payment functionality. This is particularly the case when the multi-homing option is available to agents on both sides, given that the incumbency advantage due to the favourable expectations regarding the network size is undermined. When network effects on the consumer side are particularly strong, that is, compared to the fixed benefits from the deposit-taking functionality, the two operators will hold opposite views regarding the willingness to allow interoperability, whereby agents can execute transactions with opposite ones belonging to a different platform. Whilst the incumbent bank would want to secure interoperability, the non-bank new entrant would oppose it in order to drive harsher pricing rivalry in the hope of displacing the incumbent. Therefore, under these circumstances, any decision taken by a public authority acting as an arbitrator to settle such a dispute might be highly contentious. Finally, the ability of the incumbent bank to deter the new non-bank entrant is undermined when the distribution of deposits is skewed, with a majority of consumers holding low balances. In the next section we show how the presence of demand-side frictions due to heterogeneous brand preferences on the consumer side can mitigate to some extent the harshness of pricing rivalry among platforms so that both platforms can coexist in the market.

3. Competition among horizontally differentiated platforms

So far we have assumed that consumers are indifferent between the two platforms and so decide which one to join primarily on the basis of the delivered network benefits, which are based on a common marginal benefit parameter, and the corresponding risk-adjusted return on deposits. However, it is plausible to imagine that consumers may intrinsically prefer a specific platform. On the one hand, preferences for the non-bank new platform may be driven by a taste for new things (i.e., 'early adopters') or a particularly strong risk aversion which tends to favour the central bank's option as a store of deposits (i.e., they have a lower δ^I). On the other hand, some consumers may be more conservative in nature (i.e., 'late adopters') or particularly concerned about cyber risk and thus prefer to stay with the incumbent bank rather than switching to an unfamiliar fintech firm.

To account for these differing views, we adapt our model by adding heterogeneous brand preferences through a classic Hotelling spatial framework whereby the two platforms are located at the opposite ends of a unit interval along which consumers are uniformly distributed, so that they face a linear 'transport' cost to travel to firms' locations. Specifically consumers are identified according to a parameter $x \in [0,1]$ which is uniformly distributed across the unit interval. In this setup, merchants remain indifferent between the two platforms, since they just want to reach consumer and pay low transaction fees.

Firms I and E are located, respectively, at 0 and 1. A consumer located at x incurs a cost of τx when buying from firm I and a cost of $\tau(1-x)$ when buying from firm E, where τ is a positive parameter measuring the disutility induced by having to join a platform that is some distance away (i.e., on the linear preference space) from the location of the consumer in question.

In what follows we examine three regimes: *i)* competitive bottlenecks, whereby agents on one side exogenously select single-homing and those on the other side exogenously select multi-homing; *ii)* endogenous multi-homing; and *iii)* interoperability.

3.1 Competitive bottlenecks

We first adopt the 'competitive bottleneck' framework developed by Armstrong (2006, Section 5). Specifically, we assume that consumers sign up only with one platform whereas merchants always opt for multi-homing. Accordingly, the location of the consumer who is indifferent between the two platforms – in that she derives the same level of utility – is given by:[42]

$$n^I = \frac{1}{2} + \frac{\alpha_N(m^I - m^E) - (p^I - p^E) + (\varphi^I - \varphi^E)}{2\tau} = 1 - n^E \qquad (4)$$

The assumption that merchants always opt for multi-homing in order to maximise their coverage entails that their decision to join a platform is taken independently from the decision to join the other one. In other words, merchants will join a platform as long as the utility derived from the platform in question is not negative. Therefore, platforms do not compete for

[42] Specifically, the indifference/cut-off point is obtained by solving the following equation with respect to x: $\alpha_N m^I + \varphi^I - p^I - \tau x = \alpha_N m^E + \varphi^E - p^E - \tau(1-x)$. Consumers located at the left of the solution are with firm I, and vice versa.

merchants at all, but instead extract all of the merchants' network benefits by setting $\gamma^I = \gamma^E = \alpha_M$. In other words, merchants are captured by both platforms given the assumption that they always choose to join both of them. Complete multi-homing on the merchant side in turn means that network benefits are not a differentiating factor for consumers, as each platform can deliver full coverage on the merchant side.[43] Therefore, consumers decisions as to which platform to pick is very much like in a classic (one-sided) Hotelling spatial setting, with the only difference being that platforms compete away some of the rent extracted from the merchant side in order to sign up consumers.

Therefore, under this configuration both platforms can be active and split the consumer side. Specifically, firms' profits are given by:

$$\pi^I = (\alpha_M + p^I - r^I d)\left[\frac{1}{2} - \frac{(p^I - p^E) + (\varphi^I - \varphi^E)}{2\tau}\right] \text{ and} \tag{5a}$$

$$\pi^E = (\alpha_M + p^E)\left[\frac{1}{2} + \frac{(p^I - p^E) - (\varphi^I - \varphi^E)}{2\tau}\right] - F \tag{5b}$$

As in the previous section, firms' profit functions differ in two respects: although the variable cost corresponding to the remuneration of deposits in not incurred by firm E (but by the central bank), it faces a fixed cost of entry. To simplify the notation let's assume that firm I sets $r^I = \frac{r^E}{\delta^I}$, so that the $\Delta\varphi$ component disappears from the quantity expressions in the square brackets. By solving the system of first order conditions, $\frac{\partial \pi^i}{\partial p^i} = 0$,[44] equilibrium prices and quantities are given by:

$$p^I = \tau - \alpha_M + \frac{2r^E d}{3\delta^I} \text{ and } p^E = \tau - \alpha_M + \frac{r^E d}{3\delta^I} \tag{6a}$$

$$n^I = \frac{3\tau - \frac{r^E d}{\delta^I}}{6\tau} = 1 - n^E \text{ and } m^I = m^E = 1 \tag{6b}$$

Both firms use all the rents extracted from the merchant side to lower prices on the consumer side. Under the standard assumption that $\tau > \alpha_M$,[45] both prices are certainly positive. Firm I sets a higher membership price due to the marginal cost asymmetry in terms of deposit remuneration. Both prices rise when competition on the consumer side becomes less intense (i.e., when τ increases), and firm I's market share of consumers grows as a result, although its market share is always smaller than that of firm E.

[43] It is straightforward to see that multi-homing does not make sense for consumers, in that they would merely pay more for a second fee and incur larger 'transport' costs.

[44] It is straightforward to verify that the second order conditions are satisfied.

[45] This assumption is required to prevent tipping outcomes where one platform corners the consumer side, and thus also the merchant side. In other words, the 'dispersion' force due to horizontal differentiation can counterbalance the 'agglomeration' force due to cross-group network benefits (see Belleflamme and Peitz, 2017).

Equilibrium profits are given by:[46]

$$\pi^I = \frac{\left(3\tau - \frac{r^E d}{\delta^I}\right)^2}{18\tau} \text{ and } \pi^E = \frac{\left(3\tau + \frac{r^E d}{\delta^I}\right)^2}{18\tau} - F \tag{7}$$

Correspondingly, the variable operating profit of firm E is higher thanks to the marginal cost advantage.

3.2 Multi-homing

The assumption that merchants must opt for multi-homing is essential to the stability of the previous configuration. If merchants have the option of multi-homing, the outcome described above would not be sustainable. The previous outcome would not hold because of platforms' attempts to 'steer' merchants into single-homing by undercutting the rival's fee and thus inducing consumers to patronise the cheaper platform.[47] From a merchant's perspective, it then makes sense to switch to a platform that slightly undercuts the (commonly charged) monopolistic fee in that, at a minimum, they will still be able to sell to the same number of single-homing consumers,[48] whilst retaining more than the zero quota of network benefits they are currently left with. Furthermore, because every merchant attached to the other (more expensive) platform reaches the same conclusion individually, the undercutting platform will be able to corner the merchant side. This shift by merchants to the less expensive platform will in turn lead consumers who are less loyal to the rival platform (i.e., those who are located close to the cut-off point where the indifferent consumer is located with uniform multi-homing on the merchant side) to switch to the undercutting platform to avoid the resulting loss of network benefits. Knowing that this consumer behaviour will transpire makes switching an even more compelling proposition for merchants to start with.

On the consumer side, the fact that the merchant side is cornered renders irrelevant the option of multi-homing. Multi-homing only makes sense if the current platform does not deliver network benefits. However, in that case multi-homing is always dominated by the option of single-homing with the rival platform. For example, for a consumer attached to firm I, which has lost network benefits (i.e., utility is given by $\varphi^I - p^I - \tau x$), the two alternative options of single-homing on firm E and multi-homing are ranked as follows, respectively: $\alpha_N + \varphi^E - p^E - \tau(1 -$

[46] The corresponding first order conditions are: $\frac{\partial \pi^I}{\partial p^I} = \frac{1}{2} + \frac{p^E - 2p^I + \frac{r^E d}{\delta^I} - \alpha_M}{2\tau} = 0$ and $\frac{\partial \pi^E}{\partial p^E} = \frac{1}{2} + \frac{p^I - 2p^E - \alpha_M}{2\tau} = 0$.

[47] This strategy was first conceptualised in Rochet and Tirole (2003).

[48] This presume that merchants are 'atomistic', i.e., they are individually too small to be able to sway the consumer affiliation decision one way or the other.

$x) > \alpha_N + \varphi^E - p^E - p^I - \tau$.[49] Accordingly, firm I share of single-homing consumers is given by $n^I = \frac{1}{2} - \frac{(p^I - p^E) - (\varphi^I - \varphi^E) + \alpha_N}{2\tau} = 1 - n^E$. Whereas, if firm I succeeds in retaining all the merchants its market share on the consumer side would be $n^I = \frac{1}{2} - \frac{(p^I - p^E) - (\varphi^I - \varphi^E) - \alpha_N}{2\tau} = 1 - n^E$. The only difference is that in the former expression the network benefits on the consumer side reduce firm I's share on the same side, and vice versa in the latter.

The same is true with respect to equilibrium prices, and thus also for equilibrium profits, where in the former scenario firm I has to compensate consumers for the loss of network benefits. The opposite of course applies to firm E. Specifically,[50] by solving the corresponding systems of first order conditions,[51] the revenue raised on the consumer side by firm I with and without network benefits is, respectively, $\frac{\left(3\tau + \alpha_N - \frac{r^E d}{\delta^I}\right)^2}{18\tau}$ and $\frac{\left(3\tau - \alpha_N - \frac{r^E d}{\delta^I}\right)^2}{18\tau}$, with difference equal to $\frac{2\alpha_N\left(3\tau - \frac{r^E d}{\delta^I}\right)}{9\tau}$. Assuming that both revenue amounts above are positive, this is the maximum amount that firm I is willing to spend to subsidise adoption on the merchant side. With respect to firm E, the revenue raised on the consumer side with and without network benefits is, respectively, $\frac{\left(3\tau + \alpha_N + \frac{r^E d}{\delta^I}\right)^2}{18\tau}$ and $\frac{\left(3\tau - \alpha_N + \frac{r^E d}{\delta^I}\right)^2}{18\tau}$, with difference equal to $\frac{2\alpha_N\left(3\tau + \frac{r^E d}{\delta^I}\right)}{9\tau}$.[52] Therefore, firm E can always overspend its rival in order to corner the merchant side. This is so as long as its profits are positive overall, specifically:

$$\pi^E = \frac{\left(3\tau + \alpha_N + \frac{r^E d}{\delta^I}\right)^2}{18\tau} - \frac{2\alpha_N\left(3\tau - \frac{r^E d}{\delta^I}\right)}{9\tau} - F \geq 0 \tag{8}$$

If this condition does not hold, firm E is certainly unprofitable, as the revenue generated on the consumer side without network benefits is lower than the sum of the first two terms in the above expression. If the condition holds - and firm I's equilibrium profit without network

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[49] It is worth observing that the fixed benefit φ^E appears on both sides given that even under multi-homing consumers would have to keep their deposits with firm E to use its platform to make transactions with merchants.

[50] As before, to simplify the notation let's assume that firm I sets $r^I = \frac{r^E}{\delta^I}$, so that the $\Delta\varphi$ component disappears.

[51] When network benefits are capture by firm I, the first order conditions are: $\frac{\partial \pi^I}{\partial p^I} = \frac{1}{2} + \frac{p^E - 2p^I + \frac{r^E d}{\delta^I} + \alpha_N}{2\tau} = 0$ and $\frac{\partial \pi^E}{\partial p^E} = \frac{1}{2} + \frac{p^I - 2p^E - \alpha_N}{2\tau} = 0$; whereas in the opposite case they are: : $\frac{\partial \pi^I}{\partial p^I} = \frac{1}{2} + \frac{p^E - 2p^I + \frac{r^E d}{\delta^I} - \alpha_N}{2\tau} = 0$ and $\frac{\partial \pi^E}{\partial p^E} = \frac{1}{2} + \frac{p^I - 2p^E + \alpha_N}{2\tau} = 0$.

[52] Given the assumed restriction in terms of pricing instrument on the merchant side, the subsidy can take a per-transaction form.

benefits, which is equal to $\pi^I = \frac{\left(3\tau - \alpha_N - \frac{r^E d}{\delta^I}\right)^2}{18\tau}$, is non-negative - equilibrium prices and quantities are given by:

$$p^I = \frac{3\tau - \alpha_N + 2\frac{r^E d}{\delta^I}}{3} \text{ and } p^E = \frac{3\tau + \alpha_N + \frac{r^E d}{\delta^I}}{3} \tag{9a}$$

$$n^I = \frac{1}{2} - \frac{\alpha_N + \frac{r^E d}{\delta^I}}{6\tau} = 1 - n^E \text{ and } m^E = 1 = 1 - m^I \tag{9b}$$

This outcome differs radically from the previous one under the 'competition bottleneck' configuration, in that here the cross-group subsidy is reverted to the benefit of merchants who lack brand preferences. Also here the incumbent firm is displaced to a far larger degree, mainly because of the marginal cost asymmetry in the remuneration of deposits.

3.3 Interoperability

As in sections 2.3 and 2.4.3, interoperability neutralises the competition effects of network benefits. Therefore, although pricing rivalry on the merchant side is still very high, it no longer makes sense to subsidise their patronage. This also means that merchants have no incentive not to opt for multi-homing. Hence, firms will just not earn any revenue on that side. On the consumer side, competition reverts to the classic one-sided Hotelling outcome thanks to the fact that multi-homing prevails on the merchant side. Accordingly, equilibrium prices, quantities and profits given by:

$$p^I = \tau + \frac{2r^E d}{3\delta^I} \text{ and } p^E = \tau + \frac{r^E d}{3\delta^I} \tag{10a}$$

$$n^I = \frac{1}{2} - \frac{r^E d}{6\tau\delta^I} = 1 - n^E \text{ and } m^E = m^I = 1 \tag{10b}$$

$$\pi^I = \frac{\left(3\tau - \frac{r^E d}{\delta^I}\right)^2}{18\tau} \text{ and } \pi^E = \frac{\left(3\tau + \frac{r^E d}{\delta^I}\right)^2}{18\tau} - F \tag{10c}$$

It is interesting to note that consumer membership prices are lower compared to the previous configuration for consumers attached to firm E, and vice versa with respect to firm I,[53] whereas the aggregate transport costs incurred by consumers are certainly lower under this configuration thanks to the fact that a lower number of consumers who prefer the incumbent have to sign up with the less preferred new entrant.[54] The incumbent is clearly better off under this regime compared to the previous one under endogenous multi-homing, which entails that it has strong incentives to seek interoperability. Firm E has an incentive to reciprocate when $\alpha_N{}^2 - 6\alpha_N\left(\tau - \frac{r^E d}{\delta^I}\right) > 0$, that is when network effects on the consumer side are strong and brand preferences are low compared to the fixed benefit consumers derive from the

[53] As shown by comparing the expressions in Eq. (9a) with the corresponding ones in Eq. (10a).

[54] Given that the expression for n^I in Eq. (10b) is greater than the corresponding one in Eq. (9b).

remuneration of deposits. Intuitively, these are conditions which would tend to intensify pricing rivalry on the consumer side under endogenous multi-homing, whereby firm E, having cornered the merchant side, compete hard to sign up consumers who would have preferred to stay with the incumbent's platform otherwise. Therefore, it is in the best interest of the non-bank new platform to reciprocate interoperability in order to avert descending into a price war, but instead split the consumer side more evenly with the bank incumbent platform. Therefore, under these circumstances, interoperability should emerge voluntarily, that is, without the need for public intervention. This is in stark contrast to the incentive structure under undifferentiated competition where, contrary to the current configuration, a winner-takes-all outcome would prevail irrespective of interoperability, so that the new entrant prefers the regime where the incumbent profits are minimised.

In summary, when consumers hold opposing preferences regarding their platform of choice both platforms can coexist in the market. Nevertheless, under the more realistic scenario where merchants are not obliged to select multi-homing, the incumbent bank is marginalised in that it can only retain the most loyal consumers and is force to exit the market for the provision of payment services. As a corollary, the prevailing pricing structure whereby merchants subsidise consumer use of payment systems is reverted, with platforms competing hard to corner the merchant side through subsidies. Banks can avert this doomed fate by allowing interoperability in payment services, which softens pricing rivalry on both sides and lead to less punitive partition on the consumer side. Luckily for them, the non-bank new entrant may well have an incentive to cooperate in setting up interoperability when pricing rivalry on the consumer side under endogenous multi-homing is likely to be very intense. Under interoperability, merchants also no longer subsidise consumers use of payment services, thanks to the fact that they are indifferent about which platform they patronise.[55]

4. Conclusions

Retail banks' mainstream business model, which is reliant on a stable supply of retail deposits, might come under threat as a result of the emergence of a new substitute for commercial banks' personal and saving accounts that provides a safer money storage option thanks to access to a central bank's balance sheet. This paper assesses competition between a bank and a non-bank operator running two-sided platforms that allow payments between consumers and merchants (besides providing their own deposit-storage facilities) under three configurations: exogenous single-homing, endogenous multi-homing and interoperability. In

[55] With respect to the UK context, this outcome tends to suggest that banks would have to abandon the prevailing FIIC business model for PCAs whereby consumers are currently not charged an upfront fee.

line with the extant literature, when platforms are perceived as undifferentiated by agents on both sides, pricing rivalry is intense and only one platform can be active. The ability of the incumbent bank to fend off the competition threat from the non-bank operator is lower when multi-homing is an option. This is particularly the case when the distribution of deposits skewed towards a majority of depositors with relatively low balances. When consumers value the ability to make payments particularly strongly (i.e., compared to the remuneration of deposits), the incumbent bank is better off under interoperability. Under undifferentiated competition, the prevailing pricing structure whereby consumer access to payments systems is subsidised by merchants is maintained.

Alternatively, when consumers have split preferences regarding the non-bank new entrant, they end up being the ones who subsidise merchants when the option of multi-homing is available, that is, thanks to the fact that the latter are in principle indifferent between the two platforms. Indeed, the incumbent bank can be totally crowded out on the merchant side, thus being left with only a minority of very loyal customers who strongly dislike the new platform (e.g., perhaps because they are concerned about cyber risk). Therefore, the incumbent greatly prefers to compete under interoperability where the extent of merchant subsidisation is capped to zero transaction fees so that they all opt for multi-homing. Therefore, the incumbent can hold on to a larger number of consumers and both platforms can charge a higher membership fee thus making higher profits, which tends to suggest that the non-bank new entrant would be willing to cooperate on allowing interoperability.

In conclusion, perhaps counterintuitively, the risk that banks could be exposed to a large deposit outflow as a result of the entry of a new platform relying on access to the central bank's balance sheet can be mitigated by the presence of demand-side frictions due to opposing brand preferences. These must be sufficiently high, though, as to neutralise the incumbency advantage due to the presence of network effects on the consumer side, thus weakening the tendency towards a winner-takes-all outcome that can beset competition among two-sided platforms. Furthermore, platform coexistence is facilitated when both platforms are willing to allow seamless payments across them, or when public intervention imposes interoperability in the absence of cooperation.

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