When FinTech Competes for Payment Flows[*]

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Abstract

We study the impact of FinTech competition in payment services when banks rely on consumers' payment data to obtain information about their credit quality. Competition from FinTech payment providers disrupts this information spillover to the credit market, reducing the bank's profit and the quality of its loans. Consumers with weak bank affinity benefit from FinTech competition (financial inclusion improves), whereas consumers with strong bank affinity may instead be worse off. Information from payment data flows back into the credit market if FinTech firms either directly make loans or sell consumer data to the bank, or if consumers themselves port their data to the bank. All three regimes improve the quality of loans, although their effects for bank profit and consumer welfare are ambiguous. Our results highlight the important and complex trade-off between consumer welfare and the stability of banks following FinTech competition in payment.

Keywords: FinTech, BigTech, payment, competition, banks, credit market

JEL Classification: D43, G21, G23, G28

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Abstract

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1   Introduction

Payment is an essential part of all economic transactions. The payment market is large: McKinsey (2019) estimates that global payments revenue was $1.9 trillion in 2018. Traditionally, banks have dominated the payment space, but have faced intense competition from FinTech firms around the world in recent years.[1] In the United States, technology giants such as Google, Amazon, Apple, Facebook, and Microsoft have entered the payments space. In China, mobile payments for consumption alone (made through processors such as Ant Financial and WeChat PayAlipay) account for about 16% of GDP (see Bank for International Settlements (2019)). M-Pesa in Kenya is used by about three-quarters of households (see Jack and Suri (2014)). In addition, regulations such as Payment Services Directive 2 in Europe (which requires banks provide customers' account information, upon their consent, to third-party payment providers in a standardized format) have spurred FinTech entry into the payment space.

Banks offer a bundle of services to consumers. For example, in addition to handling payments, banks make loans to businesses and individuals. We argue that payment data generate an information externality, and are useful in predicting consumer default. When consumers adopt a FinTech firm for payment processing, data on their account usage is lost to a bank, and adversely affects the riskiness of the bank's loans. That is, by directly competing with banks in offering cheaper electronic payments, FinTech entrants disrupt information flow and have a material impact on the credit market. Starting with this observation, in this paper we explore the implications of FinTech competition in payments for consumer welfare, bank profit, and the quality of bank loans.

Specifically, we construct and solve a model in which a bank is a monopolist in lending, but competes with two identical FinTech firms for payment processing. The bank and the FinTech firms have the same payment technology. The FinTech firms engage in Bertrand competition and offer payment services at a price normalized to zero. The bank strategically prices payment services to maximize its profit. Consumers are heterogeneous in three independent attributes: a value for unmodeled bank services that we label "bank affinity," credit quality (i.e., the likelihood they will repay a loan), and their reservation interest rate for a loan. A bank that processes payments for a consumer knows her credit quality. Otherwise,

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[1]We call incumbents in the payment space "banks;" in practice, this includes large banks such as JP Morgan and Citibank as well as credit card companies such as Visa and MasterCard. We call the entrants into the payment space "FinTech;" entrants comprise a diverse set of businesses from startups to small online banks to "Big Tech" firms such as Alibaba, Tencent, Amazon, and Apple.

the bank only has a prior belief over it. Throughout, we analyze the problem from three different viewpoints: the bank (which maximizes its total profit from payment services and loans), the consumers (who maximize their total surplus), and a bank regulator (who cares about the quality of loans made by the bank).

We start by formally analyzing the value of payment data in the loan market. It is immediate that, when a bank is informed about the consumer's credit quality, its profit on a loan is higher than when it is uninformed. More surprisingly, we find plausible conditions under which, ex ante, the consumer, too, benefits from the bank being informed and being able to price the loan appropriately. The quality of bank loans, of course, is higher when the bank is informed than when it is not.[2]

In our model, FinTech competition materially affects both the loan market and the payment processing market, and the impact is heterogeneous across consumers. Some consumers who were previously unbanked now use a FinTech firm to process payments.[3] These consumers benefit from FinTech competition by gaining access to electronic payments, a form of financial inclusion. In addition, some consumers switch from the bank to a FinTech firm for payment processing due to the lower price. The bank thus loses credit information about those consumers who switch, which implies that the quality of loans declines. The profit of the bank also decreases. Finally, consumers with strong bank affinity stay with the bank, unswayed by FinTech competition. The overall welfare consequences for consumers depend on the distribution of the bank affinity. If this distribution has an increasing hazard rate, all consumers are better off. However, if it has a decreasing hazard rate, consumers with a high bank affinity are worse off, because the bank's price for payment services actually increases as a result of FinTech competition.[4]

Our baseline model assumes that once payment data are diverted from the bank, they are inaccessible in the credit market. In reality, some FinTech firms actively use payment data as input for direct lending, and some sell such data to banks. Furthermore, regulations such as GDPR (General Data Protection Regulation) in Europe suggest that consumers

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[2]To be precise, the distribution of loan quality by an informed bank first-order stochastically dominates the corresponding distribution for an uninformed bank.

[3]The World Bank (2018) reports that "Globally, about 1.7 billion adults remain unbanked — without an account at a financial institution or through a mobile money provider."

[4]Theoretically, Chen and Riordan (2008) show that when consumer valuations have a decreasing hazard rate, the price of a good is higher under duopoly than monopoly. In a model with random consumer utilities, Gabaix et al. (2016) show that firms' markups increase in the number of firms if the distribution of consumer valuations has "fat tails." Empirically, in a different but analogous context, Sun (2019) shows that in response to the entry of low-cost Vanguard index funds, funds sold with broker recommendations (i.e., likely with captive customers) increased their fees.

should have more direct control of their data. Motivated by these facts, we then examine three data regimes, in each of which consumers' payments data can be used in the credit market: FinTech firms making loans, FinTech firms selling data to the bank, and consumers choosing to port their data to the bank. In particular, our data sales regime is consistent with the widespread practice that banks and FinTech firms are forming partnerships, with banks providing capital and FinTech firms providing the user interface.

In each of these regimes, the lender (whether the bank or a FinTech firm) is informed about a consumer's repayment probability, so loan quality is at its highest. Bank profits unequivocally decrease when FinTech firms make loans, as compared to the case in which FinTech firms only process payments. The results on bank's profits under FinTech data sales or consumer data portability are mixed. In these cases, a bank can share in the surplus generated by having credit information about consumers, but the incentives of a consumer to use the bank for payment services are weaker, so the net effect on the bank's profit is ambiguous.

All three data regimes have an ambiguous impact on consumer welfare. As before, consumer welfare depends on whether the bank affinity distribution has an increasing or decreasing hazard rate. Perhaps a more surprising result is that, under certain conditions, letting consumers own and port data as needed may decrease consumer welfare. Intuitively, the mere option of porting data essentially forces all consumers to do so because of unraveling: consumers with high credit quality would port their data, so a consumer who applies for a loan without revealing her payment data is inferred to be a low-credit borrower.

An important premise of our analysis is that payment data contain valuable information about credit quality. Payment and credit are tightly linked because, as argued by Black (1975), observing the flows in an account allows the bank to better understand a consumer's incomes and expenses, and hence their credit quality. This premise has strong empirical support. Puri, Rocholl, and Steffen (2017) investigate determinants of consumer credit defaults at German Savings Banks between 2004 and 2008. They report that relationship customers have default rates that are 40 basis points lower (on an unconditional average default rate of 60 basis points overall) than new customers. Even simple affinity such as having a savings or checking account are economically significant in reducing defaults. Similarly, Agarwal, Chomsisengphet, Liu, Song, and Souleles (2018) examine credit card debt and suggest that information about changes in the behavior of a customer's other accounts at the same bank helps predict the behavior of the credit card account over time. On business loans, Mester, Nakamura, and Renault (2007) examine monthly data on the transaction accounts of Cana-

dian commercial borrowers. They establish that the accounts are informative about credit risk, and that changes in these accounts leads to a monitoring response from the lender. Recently, Hau, Huang, Shan, and Sheng (2019) show that the transaction data of online vendors enable Ant Financial to grant credit to vendors, in particular those who are less likely to have access to bank credit. On a related note, McKinsey (2019) states that "payments generate roughly 90 percent of banks' useful customer data."

The results in our paper are derived from a simple and stylized model, but are nevertheless useful in interpreting the rich and nuanced discussion about FinTech competition. For example, in developed economies such as the United States and Europe, FinTech entrants are often viewed as "disruptive," as they tend to compete for roughly the same set of consumers who are already bank customers. In our model, this means that most consumers in these economies have fairly strong bank affinity. FinTech entrants in developed economies are hence unlikely to materially erode the dominance of banks. On the other hand, in developing economies such as China and Africa, where banks are less accessible to consumers, FinTech entrants are widely believed to tap into an incremental market and increase financial inclusion. In our model, the unbanked consumers benefit unambiguously from FinTech entry in payment. The success of mobile payments in China, Kenya, and some other developing countries illustrates this point (see, e.g., Jack and Suri (2014), Karlan, Kendall, Mann, Pande, Suri, and Zinman (2016), and Vives (2019)).

Moreover, our model illustrates a payment-led growth path by FinTech firms into other areas of financial services, a route taken by Ant Financial, Vodafone M-Pesa, and Paypal, among others. The payment-led business path is related to, but distinct from, those of peer-to-peer (P2P) lending platforms such as Lending Club and Prosper as well as online lenders such as Quicken Loans.[5]

Finally, our results highlight an important and complex trade-off faced by regulators: consumer welfare versus the stability of banks. In the eyes of a bank regulator, who mostly cares about the health of the banking system, FinTech entrants pose a threat by reducing banks' profits and increasing the riskiness of banks' loan portfolio. In the eyes of a competition regulator, who ultimately cares about consumer welfare, FinTech competition enhances financial inclusion and keeps the bank's market power in check. It is a subtle balance to strike, but it is worth noting that the opposing effects come from two distinct subgroups

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[5]Morse (2015) reviews the P2P literature up to 2015. Recent empirical papers on P2P lending, crowfunding, and online lenders include Iyer, Khwaja, Luttmer, and Shue (2016), Hildebrand, Puri, and Rocholl (2017), Buchak, Matvos, Piskorski, and Seru (2018), Fuster, Plosser, Schnabl, and Vickery (2018), Vallée and Zeng (2019), Tang (2019), and de Roure, Pelizzon, and Thakor (2019), among others.

of population. Innovations and policies that enable financial inclusion for the unbanked consumers, while recapturing credit information about consumers who switch to FinTech firms, may achieve the best of the two worlds. We show that the data sales regime and the portability regime, albeit imperfect, do strike such a balance. The optimal structure to ensure data flow from payments to the credit market remains an open question.

2   Model

The economy comprises one bank, two homogeneous FinTech firms, and a continuum of ex ante identical consumers with mass one. All parties are risk neutral. There are two financial products in this economy: electronic payment services and consumer loans.[6] The bank offers both loans and payment services, while the FinTech firms are stand-alone payment processors.

Each consumer receives the utility $v > 0$ from access to electronic payment services. We assume that the stand-alone qualities of the payment services from both the bank and the FinTech firms are identical (e.g., the mobile Apps are equally secure and easy to use). However, consumes differ in their affinity with the bank, denoted by b_i, which has a distribution function F with support $(-\infty, \infty)$. Consumer i receives an extra value b_i for using the bank for payment services. This additional utility, which we call bank affinity, may arise from the value attached to other services offered by the bank, or from the cost to a consumer of switching payment services away from the bank. Empirically, bank affinity may be a proxy for a consumer's wealth level, demographic characteristics, or access to finance. For example, depending on the data sample and institutional setting, bank affinity could be stronger among older and wealthier consumers, and those in cities. Bank affinity is also expected to be weaker in developing economies than in developed ones.

A consumer who uses neither the bank nor a FinTech firm for electronic payment services would conduct all transactions in cash, in which case she is referred to as "unbanked" and receives a normalized utility of zero from payment processing.

There are two stages to the game. At date $t = 1$, each consumer chooses either the bank or a FinTech firm to process their payments. This timing reflects the fact that payments are ongoing and a payment processor is typically the result of a long term-decision. At date

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[6]The loan in our model is a proxy for any non-payment financial service on which the bank can benefit from having additional information that it obtains from the consumer's payment data. For example, the product could be an investment management product targeted toward consumers with particular wealth levels.

$t = 2$, a fraction $q > 0$ of consumers need a loan of \$1, and apply for this loan at the bank. Consumers are heterogeneous in their repayment probabilities: if a consumer needs a loan, their repayment probability, θ, is drawn from a continuous distribution G with support $[\underline{\theta}, \bar{\theta}] \subseteq [0, 1]$. The consumer also has a reservation interest rate s for the bank loan, which is drawn from a continuous distribution H, with 0 being the lower bound of the support. The reservation interest rate may be interpreted either as the private value of the good or service to be purchased with the loan or as an unmodeled outside financing source. In the latter case, the bank implicitly faces some competition in the loan market as well. The three cumulative distribution functions F, G, and H have associated density functions f, g, and h respectively. Moreover, consumer i's bank affinity b_i, whether she will need a loan, her repayment probability θ_i, and her reservation interest rate are all independent with each other and across consumers.

At date $t = 2$, if a consumer requests a loan, the bank's information about the repayment probability, θ, depends on whether the consumer is a payment customer. Specifically, if at date $t = 1$ a consumer chooses the bank to process payments, we assume that the bank can perfectly observe θ. The intuition here is that between dates $t = 1$ and $t = 2$, the bank observes all outflows from and inflows into the consumer's account, and thus has in-depth knowledge about her financial health. Conversely, if a consumer chooses a FinTech firm to process her payments at $t = 1$, the bank loses sight of her payment data and is completely uninformed about θ. Based on the bank's information (or lack thereof) about θ, the bank optimally charges the consumer an interest rate r. The consumer accepts this loan if and only if the quoted interest rate is lower than her reservation interest rate.

At date $t = 3$, the consumer either repays the loan by paying $1 + r$ to the bank, or defaults. For simplicity, in the latter case, we assume that the bank recovers nothing from the consumer. The sequence of events is depicted in Figure 1 below.

3 The Loan Market

3.1 Comparing the Information Regimes in the Loan Market

We begin our analysis at time 2. Suppose a consumer needs a loan at this time. There are two possibilities: either the bank is uninformed about the consumer's repayment probability θ, or the bank is informed and knows θ. The bank's access to a consumer's payment information affects the interest rate the bank offers on the loan (recall that the size of the loan is fixed at \$1). The informed bank case and the uninformed bank case are labeled with subscripts I
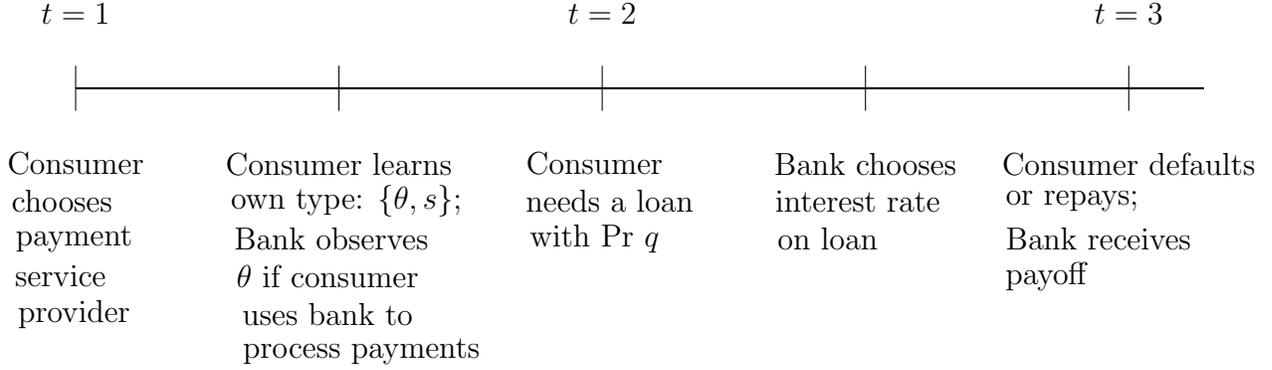
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| $t = 1$ | | $t = 2$ | | $t = 3$ |

Consumer	Consumer learns	Consumer	Bank chooses	Consumer defaults
chooses	own type: $\{\theta, s\}$;	needs a loan	interest rate	or repays;
payment	Bank observes	with Pr q	on loan	Bank receives
service	θ if consumer			payoff
provider	uses bank to			
	process payments			

Figure 1: **Timing of Events**

and U, respectively. The bank's cost of funds is normalized to zero.

3.1.1 Interest Rate Offered by the Bank

At the time that the consumer needs a loan, she privately observes her reservation interest rate r_c, drawn from $H(\cdot)$. Thus, if the bank offers the consumer an interest rate r, she accepts the loan if r is weakly lower than her reservation value r_c, that is, with probability $1 - H(r)$.

If the bank has perfectly observed a consumer's repayment probability θ, the expected profit of the bank from this loan is:

$$\pi_I(r, \theta) = [1 - H(r)](\theta(1 + r) - 1). \tag{1}$$

Assuming that there is a unique interior optimal solution, the first-order condition yields the following implicit equation for the optimal interest rate:

$$r_I^*(\theta) = \frac{1}{\theta} - 1 + \frac{1 - H(r_I^*(\theta))}{h(r_I^*(\theta))}. \tag{2}$$

Here, the first-term $\frac{1}{\theta} - 1$ is the break-even interest rate and the second term $\frac{1 - H(r_I^*(\theta))}{h(r_I^*(\theta))}$ is the optimal mark-up for the strategic bank.

As in auction theory, we can define the "virtual reservation rate" function $V(\cdot)$ as

$$V(r) \equiv r - \frac{1 - H(r)}{h(r)}. \tag{3}$$

Then, the bank's optimal interest rate can be concisely expressed as the rate that satisfies $V(r_I^*(\theta)) = \frac{1}{\theta} - 1$.

By an entirely analogous calculation, if the bank is uninformed about the consumer's repayment probability θ, its expected profit on a loan offered at rate r is:

$$\pi_U(r) = [1 - H(r)]((1+r)E(\theta) - 1), \tag{4}$$

where $E(\theta) = \int_0^1 y dG(y)$ is the mean of θ. Again assuming that there is a unique interior optimal solution, the first-order condition yields an implicit equation for the optimal interest rate:

$$r_U^* = \frac{1}{E(\theta)} - 1 + \frac{1 - H(r_U^*)}{h(r_U^*)}, \tag{5}$$

or $V(r_U^*) = \frac{1}{E(\theta)} - 1$.

A necessary condition for the optimality of the solution is that the second-order condition is satisfied, which is the case if the distribution $H(\cdot)$ is "regular," that is, has an increasing virtual reservation rate. Regularity is satisfied by many common distributions including the uniform and exponential distributions. Going forward, we assume that $H(\cdot)$ is regular.

Assumption 1 *The distribution H is regular; that is, the virtual reservation rate $V(\cdot)$ is strictly increasing.*

Notice that the assumption implies that when the bank is informed about θ, a more creditworthy consumer (i.e., a consumer with a higher θ) is charged a lower interest rate on the bank loan.

The optimal interest rates are summarized in the following lemma.

Lemma 1 *(i) If the bank is informed about θ, the interest rate it charges on the loan, $r_I^*(\theta)$, is implicitly defined by the equation*

$$V(r_I^*(\theta)) = \frac{1}{\theta} - 1. \tag{6}$$

(ii) If the bank does not know θ, the interest rate it charges on the loan, r_U^*, is implicitly defined by the equation

$$V(r_U^*) = \frac{1}{E(\theta)} - 1. \tag{7}$$

Because the bank does not observe the consumer's private reservation interest rate, its "marginal revenue" is not the interest rate r, but is rather $V(r)$; that is, r minus the inverse of the hazard rate that the consumer drops out at r. The break-even rates $\frac{1}{\theta} - 1$ and $\frac{1}{E(\theta)} - 1$ are naturally interpreted as the marginal cost for making the loan. In other words, at the optimal interest rate, the bank's marginal revenue is equal to its marginal cost.[7]

3.2   Outcomes in the Loan Market

Next, we consider three aggregate outcomes in the loan market: the profit of the bank, ex ante consumer surplus, and the quality of bank loans. At a given interest rate, the bank's profit from a loan is given by the expression π_I in equation (1) if it is informed about θ, and by the expression π_U in equation (4) if it is uninformed. Thus, given the optimal interest rate offer, the bank's profit from the loan is $\pi_I(r_I^*(\theta), \theta)$ if it is informed and $\pi_U(r_U^*)$ if it is uninformed. Unsurprisingly, the bank's profit is greater if it is informed about the consumers' repayment probabilities.[8]

Lemma 2 *The bank earns a higher expected profit from lending when it is informed about consumer type, compared to the case in which it is uninformed. That is,*

$$\int_{\underline{\theta}}^{\bar{\theta}} \pi_I(r_I^*(\theta), \theta) dG(\theta) > \pi_U(r_U^*). \tag{8}$$

Consider the ex ante consumer surplus. If a consumer rejects the bank loan, her surplus is normalized to zero. If she accepts the bank loan, her surplus depends on her repayment probability and the interest rate that she receives. Recall that the consumer rejects the loan if her reservation rate is less than r. Then, at a given θ, the expected consumer surplus from the loan (where the expectation is taken over the reservation interest rate) for a consumer is:

$$S_\ell(r, \theta) = \theta \int_r^\infty (x - r)h(x)dx = \theta\left(\int_r^\infty xh(x)dx - r(1 - H(r))\right), \tag{9}$$

where the subscript "ℓ" is a shorthand for loans. The ex ante consumer surplus in the loan market takes a further expectation of $S_\ell(r, \theta)$ over θ.

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[7]Klemperer (1999), Appendix B, provides an interpretation of the virtual valuation of a bidder in an auction as the marginal revenue of the seller.

[8]Even when the bank is informed about θ, by simply charging r_U^* to all consumers, it can earn the same profit as when it is uninformed. If it chooses to deviate from this policy, its profit must strictly increase.

As noted earlier, consumers with high θ values benefit when the bank is informed, and those with low θ values are hurt. Ex ante consumer surplus must trade off these factors. We show that the convexity of the virtual reservation rate is critical in determining whether the ex ante consumer surplus from the bank loan is also greater when the bank is informed about the consumer's repayment probability.

Definition 1   *(i) The virtual reservation rate is* sufficiently convex *at r if* $-\frac{V''(r)}{V'(r)} < \frac{h(r)}{1-H(r)}$.

(ii) Conversely, if the above inequality is violated, the virtual reservation rate is sufficiently
   concave *at r.*

The inequality in part (i) of the definition essentially requires that the virtual reservation rate is not "too concave" at r (notice that the condition can sometimes be satisfied even if $V''(r) < 0$; i.e., the virtual reservation rate is concave at r). Observe that the right-hand size is the hazard rate of $H(\cdot)$; that is, it equals the inverse of the mark-up on the loan. The convexity condition is satisfied at each r by some standard probability distributions such as the uniform and the exponential ones, both of which have linearly increasing virtual reservation rates (so $V'(r)$ is a positive constant and $V''(r) = 0$).

Proposition 1   *(i) If the virtual reservation rate is sufficiently convex at each r, the ex-
   pected consumer surplus from the bank loan (where the expectation is taken over θ) is
   greater if the bank is informed about the repayment probability θ, compared to the case
   in which the bank is uninformed. That is,*

$$\int_{\underline{\theta}}^{\bar{\theta}} S_\ell(r_I^*(\theta), \theta)dG(\theta) > \int_{\underline{\theta}}^{\bar{\theta}} S_\ell(r_U^*, \theta)dG(\theta). \tag{10}$$

*(ii) If the virtual reservation rate is sufficiently concave at each r, the expected consumer
   surplus is lower if the bank is informed about θ.*

The intuition behind Proposition 1 is that, if the virtual reservation rate is sufficiently convex at each r, the consumer surplus is also convex in θ. By Jensen's inequality, the consumer then prefers that the bank be informed. In the opposite case of a sufficiently concave virtual reservation rate at each r, the consumer surplus is concave in θ and the consumer prefers not to give her information to the bank. There are also distributions such that the convexity condition on reservation rates is satisfied for some values of r but is violated for other values of r; that is, the assumptions of neither part (i) nor part (ii) of

Proposition 1 apply. In this case, whether consumer surplus increases or decreases when the bank is informed is ambiguous.

Next, we show that the overall quality of bank loans is also greater when the bank is informed. Observe that Lemma 1 implies that $r_U^* \in (r_I^*(\bar{\theta}), r_I^*(\underline{\theta}))$. Thus, when the bank is informed, consumers with a high repayment probability benefit from a lower interest rate. In turn, they accept a loan more often. The converse holds for consumers with a low repayment probability. Let $Q(r \mid \theta) = 1 - H(r)$ be the quantity of loans made at a given interest rate when the information regime is $j \in \{U, I\}$ and the offered interest rate is r. Then, because $r_I^*(\theta)$ decreases in θ, $Q(r_I^*(\theta) \mid \theta) > Q(r_U^* \mid \theta)$ if θ is high, and $Q(r_I^*(\theta) \mid \theta) < Q(r_U^* \mid \theta)$ if θ is low.

The total quantity of loans when the bank is uninformed is $Q_U^* = \int_{\underline{\theta}}^{\bar{\theta}} Q(r_U^* \mid \theta) dG(\theta)$, and the corresponding quantity when the bank is informed is $Q_I^* = \int_{\underline{\theta}}^{\bar{\theta}} Q(r_I^*(\theta) \mid \theta) dG(\theta)$. The cumulative distribution function of loan quality when the bank is uninformed is then $L_U(\theta) = \frac{\int_{\underline{\theta}}^{\theta} Q(r_U^* \mid x) dG(x)}{Q_U^*}$. Similarly, when the bank is informed, the cumulative distribution function of loan quality is $L_I(\theta) = \frac{\int_{\underline{\theta}}^{\theta} Q(r_I^*(x) \mid x) dG(x)}{Q_I^*}$.

We show that L_I first-order stochastically dominates L_U. Given $r_I^*(\theta)$, let $\hat{\theta}$ denote the lowest consumer repayment type such that $H(r_I^*(\theta)) = 1$; that is, when offered the interest rate $r_I^*(\theta)$, no consumers accept the loan, whereas at all lower interest rates, a positive measure of consumers accept the loan. If $H(r_I^*(\underline{\theta})) < 1$, define $\hat{\theta} = \underline{\theta}$.

Proposition 2 *The distribution of loans when the bank is informed, L_I, first-order stochastically dominates the corresponding distribution when the bank is uninformed, L_U. In particular, for all $\theta \in (\hat{\theta}, \bar{\theta})$, we have $L_I(\theta) < L_U(\theta)$.*

Summarizing, compared to the case of an uninformed bank, if the bank is informed about θ: (i) the bank is better off when it is informed about consumer repayment probability, (ii) consumer surplus from loans depends on the distribution of reservation interest rate, and in some cases (such as when the reservation interest rate is uniform or exponential) consumers too are better off, and (iii) the quality of loans issued by the bank is higher, so overall the credit risk faced by the bank is lower.

4   The Payment Processing Market

We now turn to the market for payment services. At time 1, when consumers choose their payment service providers, they do not know if they will need a loan in the future, or

what their repayment probability θ may be.[9] As usual, we assume that consumers know the basic parameters of the economy, including the probability q they will need a loan and the probability distribution over θ. They use this information rationally when choosing a payment service provider.

If the consumer chooses the bank as a payment processor, the bank learns the repayment type of the consumer. Conversely, if the consumer chooses a FinTech payment provider, the bank remains uninformed about their repayment type. The fact that the bank earns a higher profit from lending if it is informed about the consumer type makes it willing to compete more aggressively in the payment processing market. On the other hand, if a consumer earns a higher (lower) expected surplus with an informed bank in the loan market than with an uninformed bank, then the consumer is more (less) willing to tolerate a higher payment processing fee charged by the bank.

Table 1 summarizes the ex ante expected profit and surplus of the bank and a generic consumer from the bank loan. We refer to a customer who uses the bank to process their payments as a "relationship" customer, whereas a customer who is either unbanked or uses some other payment processing service is referred to as an "other" customer.

Customer Type	Bank Profit	Consumer surplus
Relationship	$E[\pi_I(r_I^*(\theta), \theta)]$	$E[S_\ell(r_I^*(\theta), \theta)]$
Other	$\pi_U(r_U^*)$	$E[S_\ell(r_U^*, \theta)]$

This table shows the expected bank profit and expected consumer surplus from a bank loan for relationship consumers (whose repayment probability is known to the bank) and other consumers (whose repayment probability is unknown to the bank). In each case, the expectation is taken over the repayment probability θ.

Table 1: **Expected bank profit and consumer surplus from a bank loan**

We normalize to zero the cost to both the bank and the FinTech firms of providing payment processing services. Thus, in our model, the FinTech firms do not possess a technological advantage over the bank. Rather, we focus on how the pricing and provision of financial services change after the entry of the FinTech firms.

Recall that consumer i derives a benefit b_i if they use the bank to process payments, where $b_i \sim F$, with support from $-\infty$ to $+\infty$. (The infinite support simplifies the algebra by ensuring interior solutions, but is otherwise unimportant.) The distribution of the bank benefit, or the affinity of the bank, has a critical effect on consumer welfare when FinTech

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[9]In practice, consumers have some idea of their credit quality, but as long as they cannot perfectly predict their credit quality, our results will still carry through.

firms are present. We therefore first discuss the motivation for this distribution, and then proceed with the rest of the analysis.

4.1   The Bank Affinity Distribution

An important economic assumption in our framework is that agents differ in their preference for banks. By a bank, we mean any financial entity that provides a bundle of financial services that are based on transaction accounts. Thus, in our interpretation a bank could be exclusively online, or a more traditional brick and mortar enterprise. By contrast, a FinTech firm (as we are using the term) corresponds to a service that can act as a stand-alone consumer payments processor or as part of a Big Tech conglomerate.

The bank affinity distribution is likely to change slowly across time, so can be empirically estimated. In practice, we expect bank affinity distributions to differ across countries. Consider two polar cases: Sweden and Kenya. In Sweden, a consortium of banks created "Swish," a debit-push system that requires a bank account and a national ID. This system has been widely adopted. Given its ease and ubiquity, it is difficult to operate outside the Swedish banking system. Thus, we expect the bank affinity distribution in Sweden to have a large mass of consumers with very high b values. By contrast, the M-Pesa system, a non-bank based mobile money transfer system that dominates the Kenyan landscape, corresponds to an economy in which a lot consumers have very low b values. In Kenya, having a transaction account at a bank is relatively expensive and inconvenient, compared to this stand-alone value transfer.

In addition to cross-country difference, there are important intra-country differences in bank affinity as well. Industry surveys from the U.S. indicate that the propensity to use banks is closely related to demographic characteristics such as age, education, and technological sophistication. For example, a recent American Bankers Association document says that 53% of millenials "don't think that their bank offers anything unique."[10] Further, the propensity to adopt digital tools varies substantially by age and education, based on the proportion of people in different groups in the U.S. who own a smart phone.[11] In addition, households with very low income or in remote areas may not have sufficient access to banks, compared to households with higher wealth levels or in large cities. Our bank affinity variable is a proxy for all these levels of heterogeneity.

Throughout the rest of the paper, we impose the following condition on the bank affinity

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[10]See https://www.aba.com/Tools/Documents/Millennials-Banking-Infographic.pdf.
[11]See http://www.pewinternet.org/fact-sheet/mobile/.

distribution F and its associated density f.

Assumption 2 *The hazard rate of the bank affinity distribution is not too low; specifically,* $\frac{f(b)}{1-F(b)} > -\frac{f'(b)}{2f(b)}$ *for all b.*

Observe that the right-hand side of the inequality in Assumption 2 is weakly negative if the density function f is weakly increasing, and so the assumption is immediately satisfied in such cases.

We first establish a general result on the optimal price for the bank, based on the value of acquiring a consumer and on the consumer's other options. This formulation is necessarily abstract because it encompasses a number of cases discussed throughout the paper. Nevertheless, the formulation is useful because the structure of the bank's profit-maximizing problem is similar across all these cases.

The consumer acquisition value for the bank comprises both the price paid by the consumer for the bank's payment services, p, and the expected incremental profit to the bank from the bundling of loans and payment services. Let α denote the latter term; that is, the expected incremental profit from a loan made to a payment services consumer. In all the cases we analyze in the paper, the amount α is independent of p, the price for payment services.

Any consumer who uses electronic payment services, whether provided by the bank or by a FinTech firm, obtains a benefit $v > 0$. This benefit captures the advantage of electronic payment services over a cash alternative. The benefit is the same for using the bank or a FinTech firm. That is, the bank and the FinTech firm have the same technology for payment services, and provide the same quality.

In addition, a consumer anticipates that if they need a loan at a later point of time, the bank will be informed about their repayment probability θ if they choose the bank as a payment processor, but will remain uninformed about θ otherwise. In choosing a payment processor, the consumer must therefore take into account that their expected consumer surplus from a loan will vary across these two cases.

Suppose the bank chooses a price p for its payment services. Note that our notion of price here includes both explicit account fees as well as implicit fees that are imposed through minimum balance requirements, with the bank capturing the spread between deposit and lending rates. A consumer who chooses the bank as a payment processor obtains v and their bank affinity b, and pays the bank p. In addition, the consumer must take into account any effect on the consumer surplus from the loan, to determine their overall utility from choosing

the bank. The consumer's overall utility from choosing the bank is therefore

$$v + b - p + qE[S_\ell(r_I^*(\theta), \theta)], \tag{11}$$

where the last term is the ex ante surplus to the consumer in the loan market if they choose the bank for payment services, and the expectation is taken over the consumer's ex post repayment type θ that the consumer herself does not observe ex ante.

Conversely, if the consumer does not choose the bank, in the payment services market, they obtain some utility from an alternative choice, either remaining unbanked (which yields a utility of zero) or choosing a FinTech firm as a payment processor. In our base case, we assume the bank is uninformed about the consumer's repayment type when it makes a loan, so the consumer obtains a surplus $qE[S_\ell(r_U^*, \theta)]$ from the loan. In subsequent extensions of the model, we explore data regimes in which the FinTech firm may either sell data to the bank or the consumer may voluntarily yield their data to the bank. In these cases, the bank is informed about consumer repayment type, so the consumer still obtains a surplus $qE[S_\ell(r_I^*(\theta), \theta)]$ from the loan. Importantly, the consumer's total surplus from payment processing and the loan in all these scenarios is independent of the bank's price for payment services, p.

Observe that the consumer's utility from choosing a bank declines linearly in p. Therefore, at any price p chosen by the bank, there will exist some threshold consumer $\hat{b}(p)$ who is exactly indifferent between using the bank as a payment processor and the best alternative option. Trivially, all consumers with $b > \hat{b}(p)$ will choose the bank, and all consumers with $b < \hat{b}(p)$ will choose the alternative.

As we show in the various cases below, the objective function of the bank can in general be written as:

$$\psi(p) \;=\; (1 - F(\hat{b}(p)))(p + \alpha) + k, \tag{12}$$

where $\hat{b}'(p) = 1$ and α and k are constants that do not depend on p. We therefore state the bank's optimal price for payment services in terms of this generic profit function.

Lemma 3 *Suppose that the bank's profit function can be written as $\psi(p) = (1 - F(\hat{b}(p)))(p + \alpha) + k$, where $\hat{b}'(p) = 1$ and α and k do not depend on p. Assume that the function $\psi(p)$ has a unique interior maximum. Then, the bank's optimal price for payment services, p^*,*

satisfies the first-order condition

$$\frac{1 - F(\hat{b}(p^*))}{f(\hat{b}(p^*))} = p^* + \alpha. \tag{13}$$

The second-order condition is satisfied under Assumption 2.

This lemma allows us to explain the intuition for the results that follow on the bank's pricing of payment services in different cases. The right-hand side of equation (13) is linear and increasing in p. The left-hand side depends on the hazard rate of the distribution of the bank affinity.

We next discuss a benchmark case, in which only the bank offers payment services.

4.2 Only the Bank Offers Payment Services

Suppose the bank is a monopolist in the payment processing market, i.e., FinTech entry has not yet happened. Conditional on p, a consumer who has a bank affinity of b_i earns an expected surplus $v + b_i - p + qE[S_\ell(r_I^*(\theta), \theta)]$ if she chooses the bank for payment processing, and a consumer surplus $qE[S_\ell(r_U^*, \theta)]$ if she remains unbanked. Therefore, in this case, the threshold consumer indifferent between choosing the bank and remaining unbanked satisfies

$$\hat{b}(p) = b_m(p) \equiv p - v - q \underbrace{\left(E[S_\ell(r_I^*(\theta), \theta)] - E[S_\ell(r_U^*, \theta)] \right)}_{\Delta_{S_\ell}}. \tag{14}$$

Given p, a fraction $1 - F(b_m)$ of consumers choose the bank for payment processing. The bank's total expected profit, from both lines of business (i.e., payment services and loans), is

$$\begin{aligned} \psi_m(p) &= (1 - F(b_m)) \left(p + qE[\pi_I(r_I^*(\theta), \theta)] \right) + F(b_m)q\pi_U(r_U^*) \\ &= (1 - F(b_m)) \left(p + q \underbrace{\left(E[\pi_I(r_I^*(\theta), \theta)] - \pi_U(r_U^*) \right)}_{\Delta_\pi} \right) + q\pi_U(r_U^*). \end{aligned} \tag{15}$$

Here, Δ_π is the additional profit the bank earns in expectation when it is informed about the consumer's repayment probability, compared to the case that it is uninformed. The terms π_I and π_U refer to the bank's expected profits from lending, and do not depend on p. Therefore, $\psi_m(p)$ has the form $(1 - F(\hat{b}))(p + \alpha) + k$ assumed in Lemma 3.

From Lemma 3, it follows that the bank's optimal price, p_m^*, satisfies the implicit equation

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$\frac{1-F(b_m(p_m^*))}{f(b_m(p_m^*))} = p_m^* + q\Delta_\pi$. Consumers with a bank affinity $b \geq b_m(p_m^*) \equiv p_m^* - v - q\Delta_{S_\ell}$ choose the bank for payment services, while those with $b < b_m(p_m^*)$ remain unbanked.

4.3 Competition with FinTech Payment Providers

Now, we consider a bank in competition with FinTech payment providers. As the FinTech firms are homogeneous, they engage in Bertrand competition with each other, and so charge a zero price for payment processing services. Thus, a consumer who switches to a FinTech firm obtains a surplus equal to v from payment processing and $qE[S_\ell(r_U^*, \theta)]$ from obtaining a bank loan. If the consumer uses cash, her surplus is $qE[S_\ell(r_U^*, \theta)]$. As $v > 0$, all consumers will choose an electronic payment service provider in this case; that is, no consumer remains just a cash user.

4.3.1 Bank Profit

Consumers have rational expectations about the loan market at date 2, and are therefore aware of the benefit of having a relationship with the bank. If the bank sets the price of payment services to be p, then a consumer's expected surplus from using the bank's payment service remains $v + b_i - p + qE[S_\ell(r_I^*(\theta), \theta)]$, and her expected surplus from using a FinTech for payments is $v + qE[S_\ell(r_U^*, \theta)]$. Thus, the threshold consumer indifferent between using the bank and a FinTech firm for payments satisfies

$$\hat{b}(p) = b_c(p) \equiv p - q\Delta_{S_\ell}. \tag{16}$$

The bank's total profit may therefore be written as

$$\psi_c(p) = (1 - F(b_c))(p + q\Delta_\pi) + q\pi_U(r_U^*), \tag{17}$$

which is again of the form $\psi(p) = (1 - F(\hat{b}(p)))(p + \alpha) + k$ assumed in Lemma 3. It follows that the bank's optimal price for payment services, p_c^*, satisfies the implicit equation $\frac{1-F(b_c(p_c^*))}{f(b_c(p_c^*))} = p_c^* + q\Delta_\pi$. Consumers with a bank affinity $b \geq b_c(p_c^*) \equiv p_c^* - q\Delta_{S_\ell}$ choose the bank as a payment processor, and those with $b < b_c(p_c^*)$ choose a FinTech firm.

The following proposition characterizes outcomes after FinTech entry, compared to the case of the bank being the only payment services provider. Let $b_m^* = b_m(p_m^*)$ and $b_c^* = b_c(p_c^*)$ be the threshold consumer who, in equilibrium, is indifferent between using the bank and not for payment services, in the two respective cases.

Proposition 3 *Comparing a bank that competes with FinTech payment providers with a bank that is a monopolist in offering payment services:*

(i) *The bank's market share decreases with FinTech entry; that is, $b_m^* < b_c^*$.*

(ii) *If the bank affinity distribution F has an increasing (a decreasing) hazard rate throughout, the bank's optimal price for payment services is lower, with $p_c^* < p_m^*$ (higher, with $p_c^* > p_m^*$).*

(iii) *The bank's profit is lower; that is, $\psi_c(p_c^*) < \psi_m(p_m^*)$.*

It is unsurprising that the bank's market share in the payment services market falls with the entry of FinTech firms. Essentially, for the bank to retain the monopolist market share when facing FinTech competition, it has to reduce the price for payment services by such a large amount that it is no longer optimal to try and maintain that market share. Similarly, it is intuitive that the bank's profit falls after FinTech entry.

However, as part (ii) of Proposition 3 shows, competition for payment services does not necessarily imply that all consumers will pay lower prices. If the bank affinity distribution F has an increasing hazard rate, prices are indeed reduced for all consumers by competition. This outcome conforms to our usual intuition that competition benefits consumers.

However, with a decreasing hazard rate of F, there will be "winners" and "losers" among customers when FinTech firms enter. Consumers who choose a FinTech firm for payment services are better off, relative to the economy with a monopolist bank. Those with weak bank affinity (b_i close to zero) were previously unbanked, and can now switch from using cash to using a FinTech firm for payments. Consumers with slightly higher bank affinity were paying the bank p_m^* and can now obtain the same payment service at zero cost from a FinTech firm. On the other hand, consumers who have strong bank affinity are disappointed that their costs for payment services have in fact increased, but they have no choice but to stay with the bank for convenience reasons.[12]

The intuition for our result on the price of payment services can be understood from Figure 2. In each of the monopoly and competitive cases, the inverse hazard rate for the threshold consumer equals $p + q\Delta_\pi$, which is represented by the solid blue line. Consider part (a) of this figure, which represents the case of an increasing hazard rate (or, equivalently, a decreasing inverse hazard rate $\frac{1-F}{f}$). Here, $b_c(p) = p - q\Delta_{S_\ell} = b_m(p) + v > b_m(p)$. As $\frac{1-F}{f}$

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[12]Distributions with increasing hazard rates include the uniform and exponential distributions. For some parameter values, the Weibull distribution has a decreasing hazard rate.
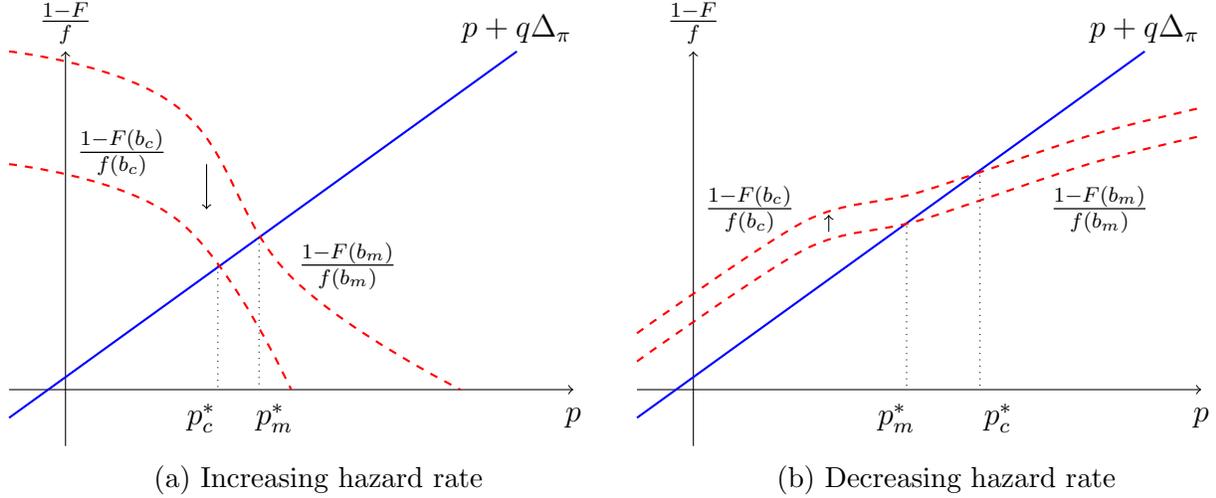
(a) Increasing hazard rate (b) Decreasing hazard rate

Figure 2: **Bank's pricing of payment services**

is decreasing, we have $\frac{1-F(b_c(p))}{f(b_c(p))} < \frac{1-F(b_m(p))}{f(b_m(p))}$. This is indicated on the figure by a downward shift of the dashed red curve in figure (a). The result is that the price falls to p_c^*.

Part (b) of the figure shows the case with a decreasing hazard rate. Here, $\frac{1-F}{f}$ is increasing, so the red dashed lines have an upward slope. Further, as $b_c(p) > b_m(p)$ for each p, the entry of the FinTech firms shifts the dashed red curve $\frac{1-F(b_m)}{f(b_m)}$ upward. The result is an increase in the price to p_c^*. This intuition echoes Chen and Riordan (2008), who compare duopoly and monopoly prices in a model in which consumers have private valuations for each of the two providers of the good (see their Corollary 1 in particular).

4.3.2 Consumer Welfare

The overall welfare of each consumer has two components. First, if the consumer uses a payment service, either from a FinTech firm or the bank, they derive a utility v from this use. In our base model, a consumer who uses a FinTech firm pays zero for this use, so their net surplus from payment services is also v. A consumer who uses a bank pays a price p but also obtains their bank affinity b, for a net surplus from payment services of $v + b - p$. In addition, at time 1, the consumer obtains an expected benefit equal to $qE[S_\ell]$ from the bank loan, where S_ℓ as before depends on whether the bank is uninformed or informed about the consumer's repayment probability.

After the FinTech firms enter, the consumer's overall expected welfare at time 1 is:

$$
W_c = \begin{cases}
v + qE[S_\ell(r_U^*, \theta)] & \text{if the consumer uses a FinTech firm} \\
v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)] & \text{if the consumer uses the bank for payments.}
\end{cases}
$$

When the bank is a monopolist, the consumer surplus of an unbanked consumer is just $W_m = qE[S_\ell(r_U^*, \theta)]$, whereas that of a banked customer is $W_m = v + b - p_m^* + qE[S_\ell(r_I^*(\theta), \theta)]$.

A consumer's expected welfare therefore depends on their bank affinity. Table 2 shows the ex ante expected consumer welfare conditional on bank affinity b. As Proposition 3 shows, $b_c^* > b_m^*$, so the middle group is nonempty. For each group, we tabulate the consumer welfare in the case of a monopolist bank (W_m), in the case of FinTech competition (W_c), and the difference, $W_c - W_m$.

	$b < b_m$	$b \in [b_m^*, b_c^*]$	$b > b_c^*$
W_m	$qE[S_\ell(r_U^*, \theta)]$	$v + b - p_m^* + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_m^* + qE[S_\ell(r_I^*(\theta), \theta)]$
W_c	$v + qE[S_\ell(r_U^*, \theta)]$	$v + qE[S_\ell(r_U^*, \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$
$W_c - W_m$	v	$p_m^* - b - q\Delta_{S_\ell}$	$p_m^* - p_c^*$

W_m is the expected consumer welfare of a consumer with bank affinity b when the bank is the only provider of payment services, and W_c is the expected welfare of the consumer when FinTech firms compete with the bank in providing payment services.

Table 2: **Expected consumer welfare when only the bank provides payment services and with bank-FinTech competition**

Note that consumers with bank affinity $b < b_m^*$ always benefit from the entry of FinTech firms. These consumers are unbanked when the bank is a monopolist, and rely only on cash for transactions. FinTech entry expands inclusivity by incorporating these consumers into the financial system.

The shape of the bank affinity distribution, through its effect on the bank's price for payment services, has a critical effect on consumer welfare.

Proposition 4

(i) *If the bank affinity distribution $F(b)$ has an increasing hazard rate everywhere, then FinTech competition increases the welfare of each consumer.*

(ii) *If the bank affinity distribution $F(b)$ has a decreasing hazard rate everywhere, then FinTech competition increases the welfare of consumers with bank affinity $b < p_m^* - q\Delta_{S_\ell}$, and decreases the welfare of consumers with bank affinity $b > p_m^* - q\Delta_{S_\ell}$.*

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Given our comments in Section 4.1 on factors underlying the bank affinity distribution, the welfare effects of FinTech competition in payment services are likely to be heterogeneous both across countries and across different demographic groups in the same country. To the extent that different countries may fall into different cases in Proposition 4, a common policy such as PSD2 may have heterogeneous welfare effects. Because these welfare implications operate through the price channel, the direction of the net effect can in principle be determined from observed prices for payment services.

4.3.3 Quality of Bank Loans

As Proposition 3 shows, in equilibrium the bank has a higher market share when it is a monopolist in payment services, compared to the case in which it competes with FinTech firms on this dimension. Recall that the distributions over consumer repayment probability θ and bank affinity b are independent. Therefore, for each value of θ, in the loan market the bank is informed about a proportion $1 - F(b_k^*)$ of consumers, where $k \in \{m, c\}$ indicates whether the bank is a monopolist or competes with FinTech firms, and is uninformed about a proportion $F(b_k^*)$. This observation, combined with Proposition 2, implies that the distribution of bank loan quality under monopoly first-order stochastically dominates the corresponding distribution under competition. With a slight abuse of notation, let L_m^* denote the cumulative distribution function of the quality (θ) of accepted loans under monopoly, and L_c^* the corresponding distribution under competition.

Proposition 5 *The equilibrium distribution of bank loans when the bank has a monopoly on payment services, L_m^*, first-order stochastically dominates the corresponding distribution when there is FinTech competition for payment services, L_c^*.*

Thus, even in situations in which consumers benefit from FinTech entry, a fundamental policy tradeoff arises. The quality of loans made by the bank depends on the information it has about borrowers. When borrowers choose a FinTech firm for payment services, the bank loses information on these borrowers that is useful for predicting their default. Thus, the interest on bank loans is no longer as informative about credit quality. In addition, the quality of loans made by the bank worsens, which means that the assets of the bank are now riskier.

The change in the riskiness of bank assets has implications both for regulators and the bank's counterparties in financial market transactions. A regulator must recognize that the financial system as a whole is now riskier because the bank has worse information. While in

normal market conditions the difference may be seen as incremental, in stress scenarios the loans made by a bank may default at higher than expected rates. Similarly, counterparties of the bank now need to recognize the higher default risk in the bank's assets, and price transactions with the bank by taking this into account. We stress that these negative effects of FinTech competition happen because payment data away from the bank are assumed inaccessible in the credit market in our base model. Next, we examine a few ways by which such data flow back into the lending process, as well as the consequences.

5   Data Markets

As pointed out by Admati and Pfleiderer (1990), information can be used by its possessor in at least two ways. First, it can be used to design a financial product, and second, it can be sold directly. In this spirit, we consider two uses of consumer data by FinTech firms: they may use such data to make consumer loans, and they may sell the data to the bank. Finally, we consider a situation in which consumers own their own data and can easily transfer the data to the bank when they need a loan.

Some of our results in this section depend on whether the ex ante social surplus from the lender being informed about the consumer's repayment probability is positive; that is, on whether $\Delta_{S_\ell} + \Delta_\pi > 0$. We identify a sufficient condition on the consumer's reservation interest rates for this total surplus to be positive.

Lemma 4 *Suppose that* $-\frac{V''(r)}{V'(r)} < \frac{h(r)}{1-H(r)}(1+V'(r))$ *for all* $r > 0$. *Then,* $\Delta_\pi + \Delta_{S_\ell} > 0$, *i.e.,* *that is, the total surplus from the loan is higher when the lender is informed about consumer repayment probabilities.*

Observe that as long as $V'(r) > 0$, the condition in the statement of the lemma holds whenever the virtual reservation rate is sufficiently convex (recall Definition 1, part (i)), which is intuitive as Δ_π must be non-negative in all cases. Thus, whenever $\Delta_{S_\ell} > 0$, it follows that the sum $\Delta_\pi + \Delta_{S_\ell}$ is also strictly positive.

5.1   FinTech Lending

Consider a FinTech firm that (just like a bank) can also lend to consumers for whom it processes payments. Examples of FinTech firms moving into the lending space include Paypal and Square, which began as payment processors and now offering loans through Paypal

Credit and Square Capital, as well as Ant Financial, which began as AliPay and then expanded into a wide variety of financial services.

Suppose the FinTech firms have exactly the same screening abilities as banks.[13] That is, both the bank and the FinTech lenders are informed about the repayment probability of consumers whose payments they process. An entity that does not process the consumer's payments remains uninformed about the repayment probability, and so potentially suffers from adverse selection. Therefore, neither the bank nor a FinTech firm is willing to lend to a consumer whose payments they do not process, and hence to obtain a loan a consumer goes back to their payment processor.

Ex ante, the expected profit per consumer to a FinTech firm from lending is $qE[\pi_I(r_I^*(\theta), \theta)]$. Anticipating this profit at date 2, Bertrand competition drives the FinTech firms to set a price of payment services equal to $-qE[\pi_I(r_I^*(\theta), \theta)] < 0$. A negative price may be interpreted here as the FinTech firms offering incentives such as Amazon gift cards to consumers who sign up with them.[14] In this case, the FinTech firms price payment services below cost, and recover zero profits by using consumer data in lending. Therefore, consumers explicitly pay the bank for payment services (through, for example, minimum balance requirements and deposit rates that are below lending rates for the bank), whereas they implicitly pay the FinTech firms and the bank by letting them use the payment data without reimbursement.

A consumer's expected surplus from using the FinTech for processing payment is thus $v + qE[S_\ell(r_I^*(\theta), \theta)] + qE[\pi_I(r_I^*(\theta), \theta)]$, and her expected surplus for using the bank for processing payment is $v + b - p_l^* + qE[S_\ell(r_I^*(\theta), \theta)]$, where p_l^* is the bank's price of payment services. Note that the bank affinity b is earned only if the consumer uses the bank as a payment processor. Thus, a consumer will choose the bank to process payments if and only if $b \geq b_l^* \equiv p_l^* + qE[\pi_I(r_I^*(\theta), \theta)]$. If the consumer uses cash for payment instead, her net utility is $qE[S_\ell(r_U^*, \theta)]$. The net utility from the FinTech firm is higher if $v + q(\Delta_{S_\ell} + E[\pi_I(r_I^*(\theta), \theta)]) > 0$. This condition is relatively mild, and we assume that it holds throughout; i.e., we assume that even if $\Delta_{S_\ell} < 0$, the utility from electronic payment service, v, and the bank's expected profit on a loan when it is informed about the consumer, $E[\pi_I(r_I^*(\theta), \theta)]$, are sufficiently large.

We show that competition in lending further erodes the bank's market share in payments,

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[13]Our assumption therefore contrasts with the set-up in Milone (2019), in which technological lenders are more efficient than traditional lenders at extracting information from hard data, whereas the latter are better at acquiring soft information.

[14]Recall also that we have set the marginal cost of offering payment services to zero. If this marginal cost is sufficiently positive, then the net price offered by the FinTech firms would be positive.

as well as its overall profit. However, the consumer welfare effects again depend on whether the bank's price for payment services increases or decreases with FinTech competition in lending. Finally, in this case the lender (whether the bank or the FinTech firm) is always informed about the repayment type of the consumer, so the distribution of loans in the economy strictly improves to L_I.

Proposition 6 *Suppose that FinTech firms offer payment services and also make loans to consumers, and that $\Delta_{S_\ell} + \Delta_\pi > 0$. Then, compared to the case in which FinTech firms do not make loans (the case in Section 4):*

(a) *The market share of the bank is strictly lower (i.e., $b_l^* > b_c^*$), and its profit is also strictly lower.*

(b) *The effect on consumer welfare depends on the bank affinity distribution. Specifically,*

    (i) *If the bank affinity distribution F has an increasing hazard rate, then the bank's price for payment services decreases (i.e., $p_l^* < p_c^*$), and all consumers are strictly better off.*

    (ii) *If the bank affinity distribution F has a decreasing hazard rate, there are two possible cases. If the bank's price for payment services decreases (i.e., $p_l^* < p_c^*$), then all consumers are strictly better off. However, if the bank's price for payment services increases (i.e., $p_l^* > p_c^*$), then consumers with bank affinity $b < p_c^* + qE[\pi_I(r_I^*(\theta), \theta)]$ are strictly better off and those with bank affinity $b > p_c^* + qE[\pi_I(r_I^*(\theta), \theta)]$ are strictly worse off.*

(c) *The distribution of consumer loans in the economy (whether the lender is the bank or a FinTech firm) is equal to L_I^*, and attains its highest loan quality.*

Part (a) of Proposition 6 is intuitive. If the bank is no longer the only provider of credit, consumers have weaker incentives to give their payment business to the bank in case they need a loan. So the bank loses business in both lines and loses profits. For part (b), consistent with our previous results on welfare in Section 4.3.2, FinTech entry into lending may have a differential welfare effect across consumers. Table 3 compares the surplus of consumers if FinTech firms enter the lending business (W_l) to the surplus when FinTech firms offer only payment services but not loans (W_c).

Consumers with a low bank affinity (including those who are brought into the financial system when FinTech firms start to offer payment services) are strictly better off. However,

	$b < b_c^*$	$b \in [b_c^*, b_l^*]$	$b > b_l^*$
W_c	$v + qE[S_\ell(r_U^*, \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$
W_l	$v + qE[S_\ell(r_I^*(\theta), \theta)] + qE[\pi_I(r_I^*(\theta), \theta)]$	$v + qE[S_\ell(r_I^*(\theta), \theta)] + qE[\pi_I(r_I^*(\theta), \theta)]$	$v + b - p_l^* + qE[S_\ell(r_I^*(\theta), \theta)]$
$W_l - W_c$	$q\Delta_{S_\ell} + qE[\pi_I(r_I^*(\theta), \theta)]$	$-b + p_c^* + qE[\pi_I(r_I^*(\theta), \theta)]$	$p_c^* - p_l^*$

W_c is the expected welfare of a consumer with bank affinity b when FinTech firms compete with the bank in providing payment services but do not offer loans, and W_l is the expected welfare of the consumer when FinTech firms also offer loans.

Table 3: **Effects of FinTech lending on consumer welfare**

the effect on consumers with a high bank affinity ($b > b_l^*$ in Table 3) depends on whether the bank's price for payment services increases or decreases when FinTech lending begins, and therefore on whether the affinity distribution $F(\cdot)$ has an increasing or decreasing hazard rate.

Finally, part (c) of Proposition 6 is also intuitive. Because the credit provider is also the payment provider, the lender (regardless whether it is the bank or a FinTech firm) is always informed. Hence, the loan quality is the highest possible (in the sense of first-order stochastic dominance).

5.2 FinTech Sale of Data

Next, we consider FinTech sale of data. FinTech firms do not directly lend to consumers, but instead sell consumer payment data to the bank at $t = 2$ when consumers' liquidity shocks are realized. For simplicity, we assume that FinTech firms sell consumers' payment data indiscriminately, that is, at the same price regardless of θ. At this point, the bank is a monopolist purchaser of the data, and the FinTech firm is a monopolist seller. We assume that the price for the data is set by Nash bargaining between the bank and the FinTech firm. This cooperative relationship is realistic because the FinTech firms may not wish to incur the cost of acquiring a bank license and hence coming under banking regulation.

Denote by $w \in [0, 1]$ the bargaining power of the bank, so that the bargaining power of the FinTech firm is $1 - w$. Let d be the price for the data. If the bargaining is successful, the bank's expected profit increases by $\Delta_\pi - d$, and the profit of the FinTech firm increases by d. If the bargaining breaks down, each party obtains zero. The resulting price therefore maximizes $(\Delta_\pi - d)^w \, d^{1-w}$.

Lemma 5 *If the FinTech firm can sell consumer transaction data to the bank, the bank purchases data on any FinTech consumer that applies for a loan, at a price $d^* = (1 - w)\Delta_\pi$.*

What is the effect of data sales on the pricing of payment services? In expectation, a FinTech firm earns $q(1-w)\Delta_\pi$ on each consumer it attracts in the payment services market. Therefore, Bertrand competition between the FinTech firms for consumers pushes down their price for payment services to $-q(1-w)\Delta_\pi$.

Thus, if the bank charges p for payment services, a consumer who chooses the bank obtains a total surplus $v + b - p + qE[S_\ell(r_I^*(\theta), \theta]$. A consumer who chooses a FinTech firm obtains $v + q(1-w)\Delta_\pi + qE[S_\ell(r_I^*(\theta), \theta]$. Hence, the threshold consumer indifferent between the FinTech firms and the bank has affinity $b_s(p) = p + q(1-w)\Delta_\pi$. Let p_s^* denote the price the bank charges for payment services in equilibrium, and denote $b_s^* = b_s(p_s^*)$. The bank's market share in the payment services market is then $1 - F(b_s^*)$.

Table 4 shows the expected consumer welfare for a consumer with a given bank affinity b in the base case of no data sales and when FinTech firms sell payment data to the bank. The middle case is written as $b \in [b_c^*, b_s^*]$ because we prove in Proposition 7 below that the bank's market share in payment services shrinks when data sales occur; i.e., that $b_s^* > b_c^*$.

	$b < b_c^*$	$b \in [b_c^*, b_s^*]$	$b > b_s^*$
W_c	$v + qE[S_\ell(r_U^*, \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$
W_s	$v + q(1-w)\Delta_\pi + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + q(1-w)\Delta_\pi + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_s^* + qE[S_\ell(r_I^*(\theta), \theta)]$
$W_s - W_c$	$q\Delta_{S_\ell} + q(1-w)\Delta_\pi$	$-b + p_c^* + q(1-w)\Delta_\pi$	$p_c^* - p_s^*$

W_c is the expected welfare of a consumer with bank affinity b when FinTech firms compete with the bank in providing payment services and do not sell data to the bank, and W_s is the expected welfare of the consumer when FinTech firms sell consumer payment data to the bank.

Table 4: **Effects of FinTech data sales on consumer welfare**

When the bank can purchase consumer payment data, it is informed about consumer repayment probability on all loans, and so the distribution of loans is again L_I^*, as in Proposition 6. Also analogous to Proposition 6, the implications for consumer welfare again depend on the distribution F and on the bank affinity b. The effect on bank profit, however, is ambiguous. On the one hand, the bank benefits from being able to obtain information on consumers with low affinity, $b \le b_s^*$, and those consumers' data were unavailable to the bank without data sales. On the other hand, the bank loses some market share in payment services. The net impact on the bank's profit is thus hard to sign.

Proposition 7 *Suppose FinTech firms can sell consumer payment data to the bank, and that $\Delta_{S_\ell} + (1-w)\Delta_\pi > 0$. Then, compared to the case in which FinTech firms offer payment services but such data sales are prohibited:*

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(a) *The market share of the bank in payment services is strictly lower (i.e., $b_s^* > b_c^*$), and the change in bank profit is ambiguous.*

(b) *The effect on consumer welfare depends on the bank affinity distribution. Specifically,*

   (i) *If the bank affinity distribution F has an increasing hazard rate then there are two cases. If the bank's price for payment services falls (i.e., $p_s^* < p_c^*$), then all consumers are strictly better off. However, if the bank's price for payment services rises (i.e., $p_s^* > p_c^*$), then consumers with bank affinity $b < p_c^* + q(1-w)\Delta_\pi$ are strictly better off and those with bank affinity $b > p_c^* + q(1-w)\Delta_\pi$ are strictly worse off.*

   (ii) *If the bank affinity distribution F has a decreasing hazard rate, then the bank's price for payment services increases (i.e., $p_s^* > p_c^*$), and consumers with bank affinity $b < p_c^* + q(1-w)\Delta_\pi$ are strictly better off whereas those with bank affinity $b > p_c^* + q(1-w)\Delta_\pi$ are strictly worse off.*

(c) *The distribution of bank loans is L_I^*, and attains its highest feasible quality.*

5.3   Consumers Own Their Data

In the previous two subsections, we have analyzed two possibilities in which consumer payment data residing with FinTech firms eventually make their way back to the lending market. In both, it is the FinTech firm that makes the active decision of using the data for lending or selling the data. A natural next question is why not let consumers decide the use of their data. If consumers have full ownership of their payment data and can freely transfer these data, does it make them better off? Our analysis is motivated by PSD2 and GDPR (General Data Protection Regulation, which took effect in the EU in May 2018), and the related EU-wide push toward giving consumers control of their data. We consider a scenario in which a consumer can require her payment processor to transfer an accurate record of her payment data to a third party. We assume such a transfer is costless. To the extent that the regulatory objective of better data protection is to enhance consumer protection and their bargaining power, our setting considers the "best case" scenario for consumers.

More formally, we add a step to the model of the previous section. At $t = 2$, after the consumer realizes her need for a loan, she can ask her payment processor to transfer her payment data to the bank. Of course, this step is nontrivial only if she has chosen a FinTech firm to be her payment processor. Note also that at $t = 2$, the consumer's payment type

θ and her reservation value r are already realized. By the usual unraveling argument, a consumer with a good credit quality (i.e., a high θ) would voluntarily share her payment data with the bank, and this essentially forces all the consumers who need loans to share payment data with the bank.[15]

If consumers can freely transfer their data, they do not need to use the bank to process payments to get any additional consumer surplus on the loan when the bank is informed about their repayment probability. Thus, the decoupling of payments from loans changes the tradeoff when a consumer selects a payment processor. If the consumer uses the bank for processing payments, her expected payoff is $v + b_i - p + qE[S_\ell(r_I^*(\theta), \theta)]$, as before, where p is the bank's price quote on payment services. If the consumer uses a FinTech firm for payments, her expected payoff changes to $v + qE[S_\ell(r_I^*(\theta), \theta)]$, where it is r_I instead of r_U because the consumer's optimal choice of providing data to the bank makes the bank informed. As a third possibility, if the consumer uses neither the bank nor the FinTech firms for payments (i.e., she uses cash), then her expected payoff is $qE(S_\ell(r_U^*, \theta))$. Therefore, if $v + q\Delta_{S_\ell} \geq 0$, then using cash is dominated by using a FinTech firm. We proceed under the assumption that $v + q\Delta_{S_\ell} \geq 0$, so that the consumer uses the bank for payments if $b_i \geq b_d(p) \equiv p$ and uses a FinTech firm if $b_i < p$.

The bank's total expected profit is therefore

$$\psi_d(p) = (1 - F(p))p + qE[\pi_I(r_I^*(\theta), \theta)], \tag{18}$$

where we have used the fact that all consumers who need loans now transfer their payment data to the bank. From Lemma 3, the bank's optimal price for payment services satisfies $p_d^* = \frac{1 - F(p_d^*)}{f(p_d^*)}$.

Now, consider consumer welfare with and without data portability. We exhibit consumer welfare for different levels of bank affinity in Table 5 below. We denote $b_d^* = b_d(p_d^*)$. The difference row shows the increment to welfare on switching from a no data transfer regime to one in which data can be freely transferred.

We characterize equilibrium outcomes of data portability in Proposition 8 below. As with data sales, the bank loses market share in payment services, and its overall profit may increase or decrease. In this case, the bank benefits from obtaining the data of consumers with $b \leq b_c^*$ for free. Once again the distribution of loans is L_I^*, as the bank is informed about consumer repayment type on all consumers.

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[15]This ex post unraveling argument holds regardless of whether the consumers prefer an informed bank or uninformed bank ex ante (i.e., regardless of whether the virtual valuation is sufficiently convex).

	$b < b_c^*$	$b \in (b_c^*, b_d^*)$	$b > b_d^*$
W_c	$v + qE[S_\ell(r_U^*, \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$
W_d	$v + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_d^* + qE[S_\ell(r_I^*(\theta), \theta)]$
$W_d - W_c$	$q\Delta_{S_\ell}$	$p_c^* - b$	$p_c^* - p_d^*$

W_c is the expected welfare of a consumer with bank affinity b when FinTech firms compete with the bank in providing payment services and there is no consumer data portability, and W_d is the expected welfare of the consumer when the consumer can freely port data to the bank.

Table 5: **Consumer welfare before and after the free portability of payment data**

Proposition 8 *Suppose that $\Delta_{S_\ell} + \Delta_\pi > 0$ and $v + q\Delta_{S_\ell} \geq 0$. Then, under free data portability, compared to the case of no portability:*

(a) *The market share of the bank in payment services is strictly lower (i.e., $b_d^* > b_c^*$), and the change in bank profit is ambiguous.*

(b) (i) *If $\Delta_{S_\ell} > 0$, there are two possible cases. If the bank's price for payment services falls (i.e., $p_d^* < p_c^*$), then all consumers are strictly better off. Conversely, if the bank's price for payment services rises (i.e., $p_d^* > p_c^*$), then consumers with bank affinity $b < p_c^*$ are strictly better off and those with bank affinity $b > p_c^*$ are strictly worse off.*

    (ii) *If $\Delta_{S_\ell} < 0 < v + q\Delta_{S_\ell}$, then the bank's price for payment services rises (i.e, $p_d^* > p_c^*$), and all consumers are strictly worse off.*

(c) *The distribution of bank loans is equal to L_I^*, and attains the highest feasible quality.*

Comparing Propositions 7 and 8, we see that FinTech data sales and portability of data have similar implications for the bank's market share, profits, and the loan quality. The difference lies in the consumer welfare. In particular, it is possible that all consumers are worse off under free portability of data, compared to the case without data transfer at all (Section 4). Specifically, the possibility of porting data forces data porting by the unraveling arguments. If consumers ex ante prefer that the bank is uninformed, their expected surplus from the loan market goes down with free portability of data. This possibility reveals a potential unintended consequence of data privacy policies.

6   Concluding Remarks

We have presented a simple model that illustrates the complex effects that can occur when FinTech entrants compete with incumbent banks in payments processing. Our starting point is that a bank learns valuable information about a consumer's credit quality by processing their ongoing transactions. This information externality creates an incentive to bundle payment services and consumer loans. The bank, of course, gains from this information externality. Under mild conditions, consumers also gain from providing their information to the bank because it increases their surplus in the loan market.

We show that FinTech competition in payment processing disrupts this information externality in loan markets. The bank loses market share and profit, and the quality of its consumer loans deteriorates. If FinTech entry reduces the price of the bank's payment services, in net terms all consumers are better off. Somewhat surprisingly, the bank may increase the price of its payment services, in which case consumers with a high bank affinity are worse off. The heterogeneous impact on consumer welfare is an interesting trade-off.

A more important trade-off from a macroprudential point of view is between consumer welfare and the stability of banks. On the one hand, FinTech competition provides low-cost electronic payment services to the unbanked households, which tend to be the least resilient to adverse economic shocks. On the other hand, due to lost credit information in payment data, banks face a higher likelihood of delinquencies on their loan books.[16] A natural questions is whether the best of the two worlds may be achieved simultaneously by introducing a market for data.

We subsequently analyze three regimes of a data market: FinTech firms directly making loans, FinTech firms selling information to the bank, and consumers themselves choosing to provide the bank with their own information. In each of these cases, the overall loan quality is improved relative to the base case in which diverted consumer payment data are inaccessible in credit market. Thus, recapturing consumer payment data one way or another largely mitigates the concern that FinTech competition increases the riskiness of the bank's loan portfolio.

The effect on bank profit, however, differs across the three regimes of the data market. If FinTech firms directly make loans, it is unambiguously detrimental to bank profit. If the bank buys consumer data from FinTech firms or if consumers port data themselves, the impact

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[16]It is important to remember that, by affecting the bank's pricing of payment services and its market share, FinTech competition affects the proportion of bank income from payments and from loans. This factor too affects the riskiness of the bank overall.

on bank profit remains ambiguous. On the one hand, the bank shares the surplus generated by using payment information when granting loans. On the other hand, consumers have less incentive to choose the bank for payment services because the data are made available in the loan market anyway. Consumer welfare also sees ambiguous changes. In particular, we caution that policies that give consumers the *option* to port data essentially *force* them to port data.

We have made two simplifying assumptions in our analysis that can be relaxed in future work. The first is that the FinTech firms are competitive and earns zero expected profit. In our model, if FinTech firms make a positive profit in lending or selling consumer data to banks, these profits are competed away in the form of below-cost payment services. In a different model, Ellison (2005) shows that if firms sell a "base good" and an "add-on" good, undercutting the rival on a base good may not be appealing for sellers if doing so attracts customers who are less willing to buy the add-on good. If our model were extended such that a consumer's value for payment services is correlated with her credit quality or reservation interest rate, we suspect that FinTech payment providers can also earn positive profits for exactly the same intuition (reducing the price for payment services may end up attracting customer types who are undesirable from a lender's perspective). Another channel to obtain positive profits is if the FinTech (or Big Tech) firms exploit network effect or their market power over consumer interface, which may lead to competitive concerns (see Bank for International Settlements (2019) and Vives (2019) for more discussion of this point).

The second assumption that could be relaxed is that FinTech firm's information about consumers' credit quality only comes from payment data. In reality, Big Tech firms have gathered more granular information that banks do not have. For example, Berg, Burg, Gombovic, and Puri (2019) show that consumers' digital footprint contains information about default that is complementary to credit scores. Frost, Gambacorta, Huang, Shin, and Zbinden (2019) find that Mercado Libre's use of borrower characteristics improves the prediction of credit quality above and beyond the credit bureau score. A richer model could feature this inherent information advantage of Big Tech, balanced by the bank's inherent advantage of having low-cost funding by depositors.

A Proofs

A.1 Proof of Lemma 1

(i) Suppose the bank is informed about θ. The first-order condition in r is

$$-h(r)(\theta(1+r) - 1) + (1 - H(r))\theta = 0, \tag{19}$$

which, after a little rearranging, yields $V(r(\theta)) = \frac{1}{\theta} - 1$.

The second-order condition is

$$-h'(r)(\theta(1+r) - 1) - 2h(r)\theta \ < \ 0. \tag{20}$$

The first-order condition implies that $1 + r - \frac{1}{\theta} = \frac{1-H(r)}{h(r)}$. Substitute this into the second-order condition. The second-order condition now reduces to the expression $V'(r) = 2 + \frac{(1-H(r))h'(r)}{h(r)^2} > 0$; that is, the virtual valuation is strictly increasing. This implies that the interest rate that satisfies the first-order condition is a local maximum. Under the assumption that the optimal solution is unique and interior, we also have a global maximum.

(ii) The proof is similar to the proof of part (i), with $E(\theta)$ substituted for θ when the bank is uninformed about consumer type. ∎

A.2 Proof of Lemma 2

We show that the bank's profit function π_I is convex in θ. Observe that by the envelope theorem, given the optimal interest rate $r_I^*(\theta)$ we have $\frac{d\pi_I(r_I^*,\theta)}{d\theta} = \frac{\partial \pi_I}{\partial \theta} = (1 - H(r_I^*(\theta)))(1 + r_I^*(\theta))$. Thus,

$$\frac{d^2\pi_I}{d\theta^2} \ = \ \frac{d}{dr_I^*}\left(\frac{d\pi_I}{d\theta}\right)\frac{dr_I^*}{d\theta} = \left(-(1+r_I^*)h + 1 - H\right)\frac{dr_I^*}{d\theta}. \tag{21}$$

Now, the first-order condition for optimal interest rate in equation (19) implies that $\frac{1-H}{h} = 1 + r - \frac{1}{\theta} < 1 + r$, so that $1 - H - h(1 + r_I^*) < 0$. Further, as $V'(r) > 0$, from the condition $V(r) = \frac{1}{\theta} - 1$, it follows that r_I^* is strictly decreasing in θ, so that $\frac{dr_I^*}{d\theta} < 0$. Hence, $\frac{d^2\pi_I}{d\theta^2} > 0$; that is, $\pi_I(r_I^*)$ is strictly convex in θ.

From the respective first-order conditions for profit-maximization, it follows that $r_U^* = r_I^*(E(\theta))$. Therefore, from Jensen's inequality, we have $E(\pi_I(r_I^*(\theta), \theta)) > \pi_U(r_U^*)$. ∎

A.3   Proof of Proposition 1

(i) Given the equation for consumer surplus from the bank loan, (9), we have

$$\frac{dS_\ell}{d\theta} = \int_r^\infty (x-r)h(x)dx - \theta(1-H(r))\frac{dr}{d\theta} > 0, \tag{22}$$

$$\frac{d^2 S_\ell}{d\theta^2} = \underbrace{-2(1-H(r))\frac{dr}{d\theta}}_{>0} + \underbrace{\theta h(r)\left(\frac{dr}{d\theta}\right)^2}_{>0} - \theta(1-H(r))\frac{d^2 r}{d\theta^2}. \tag{23}$$

In the second derivative, the third term is not signed in general. But we can substitute in:

$$\frac{dr}{d\theta} = -\frac{1}{\theta^2 V'(r)}, \tag{24}$$

$$\frac{d^2 r}{d\theta^2} = \frac{1}{V'(r)}\left[\frac{2}{\theta^3} - V''(r)\left(\frac{dr}{d\theta}\right)^2\right] = \frac{1}{V'(r)}\left[\frac{2}{\theta^3} - V''(r)\frac{1}{\theta^4 V'(r)^2}\right]. \tag{25}$$

Then, $\frac{d^2 S_\ell}{d\theta^2}$ simplifies to

$$\frac{d^2 S_\ell}{d\theta^2} = \frac{1}{\theta^3}\left[\frac{h(r)}{V'(r)^2} + \frac{(1-H(r))V''(r)}{V'(r)^3}\right]. \tag{26}$$

Thus, S_ℓ is convex in θ if and only if the right hand side is positive, or

$$V''(r) > -\frac{h(r)}{1-H(r)}V'(r), \tag{27}$$

which is the convexity condition in part (i) of Definition 1.

(ii) When S_ℓ is convex in θ, noting that $r_U^* = r_I^*(E(\theta))$, it follows from Jensen's inequality that $E[S_\ell(r_I^*(\theta), \theta)] > E[S_\ell(r_U^*, E(\theta))]$. ∎

A.4   Proof of Proposition 2

Let ℓ_U and ℓ_I respectively be the loan densities when the bank is uninformed and when it is informed.

Step 1: We show that ℓ_I crosses ℓ_U once, and from below.

First, observe that, when the bank is uninformed, the quantity of loans at a given θ is $Q(r_U^* \mid \theta) = 1 - H(r_U^*)$ for each $\theta \in [\underline{\theta}, \bar{\theta}]$. Therefore, the loan density $\ell_U(\theta) = \frac{Q_U(r_U^*|\theta)}{\int_{\underline{\theta}}^{\bar{\theta}} Q_U(r_U^*|\theta)dG(\theta)}$

is constant for all $\theta \in [\underline{\theta}, \bar{\theta}]$.

Next, observe that, when the bank is informed, $r_I^*(\theta)$ is strictly decreasing in θ over the region $[\hat{\theta}, \bar{\theta}]$, where $\hat{\theta} \geq \underline{\theta}$. This follows from the first-order condition $V(r_I^*(\theta)) = \frac{1}{\theta} - 1$. The RHS is strictly decreasing in θ, and as the virtual valuation $V(\cdot)$ is strictly increasing, a higher value of θ implies a strictly lower interest rate $r_I^*(\theta)$. Therefore, the quantity of loans at a given θ when the bank is informed, $Q_I(r_I^*(\theta) \mid \theta) = 1 - H(r_I^*(\theta))$, is strictly increasing in θ. Therefore, the density of loans $\ell_I(\theta) = \frac{Q_I(r_I^*(\theta)|\theta)}{\int_{\underline{\theta}}^{\bar{\theta}} Q_I(r_I^*(\theta)|\theta)dG(\theta)}$ is strictly increasing in θ for $\theta \in [\hat{\theta}, \bar{\theta}]$.

Now, as ℓ_U and ℓ_I are each densities, it follows that $\int_{\underline{\theta}}^{\bar{\theta}} \ell_U(\theta)d\theta = \int_{\underline{\theta}}^{\bar{\theta}} \ell_I(\theta)d\theta = 1$. As ℓ_I is strictly increasing in θ and ℓ_U is constant in θ, it must be that ℓ_I crosses ℓ_U exactly once, and from below.

Step 2: L_I first-order stochastically dominates L_U.

Let θ_0 be the value of repayment probability θ at which $\ell_I(\theta) = \ell_U(\theta)$. Observe further that $L_I(\hat{\theta}) = 0 \leq L_U(\hat{\theta})$. Therefore, it is immediate that for all $\theta \in (\underline{\theta}, \theta_0]$, we have $L_I = \int_{\underline{\theta}}^{\theta} \ell_I(x) < L_U = \int_{\underline{\theta}}^{\theta} \ell_u(x)dx$. Similarly, when $\theta \in [\theta_0, \bar{\theta})$, we have $1 - L_I = \int_{\theta}^{\bar{\theta}} \ell_I(x) > 1 - L_U = \int_{\theta}^{\bar{\theta}} \ell_U(x)$, which implies that $L_I(\theta) < L_U(\theta)$. Thus, $L_I(\theta) < L_U(\theta)$ for all $\theta \in (\hat{\theta}, \bar{\theta})$, so that L_I first-order stochastically dominates L_U. ∎

A.5 Proof of Lemma 3

Given the profit function $\psi(p)$, the first-order condition is:

$$1 - F(\hat{b}) - f(\hat{b}) \frac{d\hat{b}}{dp} (p + \alpha) = 0. \tag{28}$$

As $\frac{d\hat{b}}{dp} = 1$, this condition reduces to:

$$1 - F(\hat{b}(p)) - f(\hat{b}(p)) (p + \alpha) = 0 \tag{29}$$

$$\frac{1 - F(\hat{b}(p))}{f(\hat{b}(p))} = p + \alpha. \tag{30}$$

From equation (29), the second-order condition for profit-maximization is

$$-f(\hat{b}(p)) - f(\hat{b}) \frac{d\hat{b}(p)}{dp} - f'(\hat{b}(p))(p + \alpha) < 0. \tag{31}$$

From equation (29), we have $p + \alpha = \frac{1 - F(\hat{b}(p))}{f(\hat{b}(p))}$. Substituting this into equation (31) and setting $\frac{d\hat{b}(p)}{dp} = 1$, the condition reduces to the inequality assumed in Assumption 2. ∎

A.6   Proof of Proposition 3

(i) Suppose the bank's market share goes up after FinTech competition; i.e., that $b_m^* > b_c^*$. This means that some consumer, say consumer i, does not use a monopolist bank but uses the bank when it faces competition.

When the bank is the only provider of payment services, consumer i does not use the bank if and only if

$$v + b_i - p_m + qE[S_\ell(r_I^*(\theta), \theta)] < qE[S_\ell(r_U^*, \theta)], \tag{32}$$

or

$$b_i < p_m - v - q\Delta S_\ell. \tag{33}$$

When the bank faces FinTech competition, consumer i uses the bank if and only if

$$v + b_i - p_c + qE[S_\ell(r_I^*(\theta), \theta)] \geq v + qE[S_\ell(r_U^*, \theta)], \tag{34}$$

or

$$b_i \geq p_c - q\Delta S_\ell. \tag{35}$$

These two conditions require $p_c < p_m - v$, that is, the bank must lower the price sufficiently upon FinTech competition.

The first-order conditions in the two cases are

$$0 = \psi_c'(p_c) = 1 - F(p_c - q\Delta_{S_\ell}) - f(p_c - q\Delta_{S_\ell})(p_c + q\Delta_\pi), \tag{36}$$

$$0 = \psi_m'(p_m) = 1 - F(p_m - q\Delta_{S_\ell} - v) - f(p_m - q\Delta_{S_\ell} - v)(p_m + q\Delta_\pi). \tag{37}$$

Note that the function $\psi'(p_m)$ is non-increasing in p_m for the second-order condition to hold. Since $p_m > v + p_c$ by the conjecture, replacing p_m by a smaller value $v + p_c$ in the $\psi'(p_m)$ expression will make it larger, that is,

$$0 = \psi_m'(p_m) \leq \psi_m'(v + p_c) = 1 - F(p_c - q\Delta_{S_\ell}) - f(p_c - q\Delta_{S_\ell})(p_c + v + q\Delta_\pi) \tag{38}$$

$$= -f(p_c - q\Delta_{S_\ell})v < 0, \tag{39}$$

which is a contradiction (in the last equality we have substituted in the first-order condition $\psi'_c(p_c) = 0$). Therefore, although FinTech competition can reduce the bank's price for payment services, it does not reduce it so much that the bank ends up gaining market share.

(ii) Let p^*_c be the bank's optimal price under competition. Then, from the first-order condition in equation (36), it follows that

$$\frac{1 - F(b_c(p^*_c))}{f(b_c(p^*_c))} = p_c + q\Delta_\pi. \tag{40}$$

In what follows, note that $b_m(p^*_c) = b_c(p^*_c) - v < b_c(p^*_c)$. Suppose the hazard rate $\frac{f(b)}{1-F(b)}$ is strictly increasing over the region $b \in [b_m(p^*_c), b_c(p^*_c)]$. Then, the inverse hazard rate $\frac{1-F(b)}{f(b)}$ is strictly decreasing for b in this range. Therefore, it follows that

$$\frac{1 - F(b_m(p^*_c))}{f(b_m(p^*_c))} > p_c + q\Delta_\pi. \tag{41}$$

That is, $\psi'_m(p) > 0$ when evaluated at $p = p^*_c$. Therefore, it must be that $p^*_m > p^*_c$.

Next, suppose the hazard rate $\frac{f(b)}{1-F(b)}$ is strictly decreasing over the region $b \in [b_m(p^*_c), b_c(p^*_c)]$. Then, the inverse hazard rate $\frac{1-F(b)}{f(b)}$ is strictly increasing for b in this range. Therefore, reversing the argument from (i), it follows that

$$\frac{1 - F(b_m(p^*_c))}{f(b_m(p^*_c))} < p_c + q\Delta_\pi. \tag{42}$$

That is, $\psi'_m(p) < 0$ when evaluated at $p = p^*_c$. Therefore, it must be that $p^*_m < p^*_c$.

(iii) Observe that, at the same price p, we have $b_m(p) < b_c(p)$. Thus, fixing the price p, the bank's revenue from payment services is higher when it is a monopolist. In addition, as $\Delta_\pi > 0$, the bank's overall profit from loans is also higher when it is a monopolist. Therefore, it follows that $\psi_m(p) > \psi_c(p)$. Hence, at the optimal price when the bank competes in the payment services market, we have $\psi_m(p^*_c) > \psi_c(p^*_c)$.

Now, profit maximization when the bank is a monopolist implies that $\psi_m(p^*_m) \geq \psi_m(p^*_c)$. Hence, it must be that $\psi_m(p^*_m) > \psi_c(p^*_c)$. ∎

A.7   Proof of Proposition 4

(i) Suppose that $F(b)$ has an increasing hazard rate. From Proposition 3, it follows that $p^*_c < p^*_m$.

Consider the effect on the welfare of consumers with different values of b. From Table 2, $W_c - W_m = v$ for consumers with $b < b_m$. Hence, these consumers benefit from FinTech competition. Similarly, consumers with $b > b_c^*$ experience an increase in welfare equal to $p_m^* - p_c^* > 0$.

Finally, consider consumers in the range $b \in [b_m^*, b_c^*]$. These consumers experience a change in welfare equal to $p_m^* - (b + q\Delta_{S_\ell})$. Observe that $b \leq b_c^*$ implies that $b + q\Delta_{S_\ell} < p_c^* < p_m^*$, so the change in their welfare is positive. Intuitively, these consumers were using the bank for payment services when it was a monopolist, but switch to the FinTech firm when there is competition in this market. If these consumers had remained with the bank, they would have experienced an increase in welfare equal to $p_m^* - p_c^* > 0$. By revealed preference, the FinTech firm must provide an increase at least as large, else they would not have switched to it.

Hence, all consumers experience an increase in welfare when $F(b)$ has an increasing hazard rate.

(ii) Suppose that $F(b)$ has a decreasing hazard rate. From Proposition 3, it follows that $p_c^* > p_m^*$ in this case.

Here, it is immediate from Table 2 that the change in welfare after FinTech competition arrives is $v > 0$ for consumers with $b < b_m^*$ and $p_m^* - p_c^* < 0$ for consumers with $b > b_c^*$.

Consider consumers with $b \in [b_m^*, b_c^*]$. As $p_c^* > p_m^*$, it no longer follows that $b + q\Delta_{S_\ell} < p_m^*$. Instead, if $b < p_m^* - q\Delta_{S_\ell}$, these consumers experience an increase in welfare, whereas if $b > p_m^* - q\Delta_{S_\ell}$, these consumers see a decrease in welfare. The interpretation is that in the latter case, the consumers switch reluctantly to a FinTech firm because the bank has raised its price for payment services from p_m^* to p_c^*. ∎

A.8 Proof of Proposition 5

Recall from Proposition 2 that the quantity of loans issued to a given θ when the bank is informed about θ is $Q(r_I^*(\theta) \mid \theta)$, and the quantity when the bank is uninformed is $Q(r_U^* \mid \theta)$. Now, for each θ, the mass of loans under monopoly is $Q_m(\theta) = (1 - F(b_m^*))Q(r_I^*(\theta) \mid \theta) + F(b_m^*)Q(r_U^* \mid \theta)$. The corresponding quantity under competition is $Q_c(\theta) = (1 - F(b_c^*))Q(r_I^*(\theta) \mid \theta) + F(b_c^*)Q(r_U^* \mid \theta)$. Thus, the density of loans over θ in competition regime $k \in \{m, c\}$ is $\ell_k = \frac{Q_k(\theta)}{\int_{\underline{\theta}}^{\bar{\theta}} Q_k(\theta)dG(\theta)}$.

Recall that $Q(r_I^*(\theta) \mid \theta)$ is strictly increasing in θ, and $Q(r_U^* \mid \theta)$ is constant in θ. As the respective weights on $Q(r_I^*(\theta) \mid \theta)$ are constant over θ, it follows that Q_c and Q_m are

each strictly increasing in θ. This implies that ℓ_c and ℓ_m in turn are each strictly increasing. Notice also that $Q(r_I^*(\theta) \mid \theta) - Q(r_U^* \mid \theta)$ is strictly increasing in θ.

Now, we have $r_I^*(E\theta) = r_U^*$. Hence, $Q(r_I^*(E\theta) \mid E\theta) = Q(r_U^* \mid E\theta)$, with $Q(r_I^*(\theta) \mid \theta) < Q(r_U^* \mid \theta)$ for $\theta < E\theta$, and the inequality being reversed for $\theta > E\theta$. Further, observe that $b_m^* < b_c^*$ implies that $1 - F(b_m^*) > 1 - F(b_c^*)$. Hence, it follows that $Q_m(\theta)$ is steeper than $Q_c(\theta)$, and crosses $Q_c(\theta)$ from below at the point $E\theta$.

Next, we show that ℓ_m crosses ℓ_c only once and from below. If $\int_{\underline{\theta}}^{\bar{\theta}} Q_m(\theta) dG(\theta) = \int_{\underline{\theta}}^{\bar{\theta}} Q_c(\theta) dG(\theta)$, this point is immediate. Suppose not. As ℓ_m and ℓ_c are each strictly increasing and $\int_{\underline{\theta}}^{\bar{\theta}} \ell_j(\theta) dG(\theta) = 1$ for each $j = m, c$, there must exist at least one point θ' at which $\ell_m(\theta') = \ell_c(\theta')$. If $\int_{\underline{\theta}}^{\bar{\theta}} Q_m(\theta) dG(\theta) > \int_{\underline{\theta}}^{\bar{\theta}} Q_c(\theta) dG(\theta)$, then it follows that $\ell_m(\theta) < \ell_c(\theta)$ for each $\theta \leq \theta'$. Thus, there can be only one such point θ'. Hence, $\ell_m(\theta) > \ell_c(\theta)$ for $\theta > \theta'$, so that ℓ_m crosses ℓ_c only once and from below. A similar argument holds if $\int_{\underline{\theta}}^{\bar{\theta}} Q_m(\theta) dG(\theta) < \int_{\underline{\theta}}^{\bar{\theta}} Q_c(\theta) dG(\theta)$.

Now, the argument in Step 2 in the proof of Proposition 2 goes through. Hence, L_m first-order stochastically dominates L_c. ∎

A.9   Proof of Lemma 4

Substitute the value of $\frac{dr}{d\theta}$ from equation (24) into equation (21), to get

$$\frac{d^2\pi_I}{d\theta^2} = -(1 - H(r) - (1+r)h(r))\frac{1}{\theta^2 V'(r)}. \tag{43}$$

Equation (26) is

$$\frac{d^2 S_\ell}{d\theta^2} = \frac{1}{\theta^3}\left[\frac{h(r)}{V'(r)^2} + \frac{(1 - H(r))V''(r)}{V'(r)^3}\right]. \tag{44}$$

Therefore,

$$\frac{d^2\pi_I}{d\theta^2} + \frac{d^2 S_\ell}{d\theta^2} = \frac{h(r)}{\theta^2 V'(r)^2}\left[V'(r)\left(\underbrace{-\frac{1 - H(r)}{h(r)} + (1+r)}_{=\frac{1}{\theta}, \text{ by equation (2)}}\right) + \frac{1}{\theta} + \frac{1 - H(r)}{h(r)}\frac{V''(r)}{\theta V'(r)}\right]. \tag{45}$$

Thus, the second derivative of $\pi_I + S_\ell$ is positive if

$$\frac{V''(r)}{V'(r)} > -\frac{h(r)}{1 - H(r)}(1 + V'(r))\text{for all } r, \tag{46}$$

which is the condition in the statement of the lemma. From Jensen's inequality, it follows that this is also a sufficient condition for $\Delta_\pi + \Delta_{S_\ell} > 0$. ■

A.10 Proof of Proposition 6

(a) When FinTech firms can also offer loans, the bank and each FinTech firms make loans to their own market segments (i.e., the consumer's who chose them for payment processing). In this case, the bank's total expected profit for charging p for payment services is

$$\psi_l(p) = (1 - F(b_l^*))(p + qE[\pi_I(r_I^*(\theta), \theta)]), \tag{47}$$

which is again of the form assumed in Lemma 3. Thus, the optimal price is given by the implicit equation

$$\frac{1 - F(p_l^* + qE[\pi_I(r_I^*(\theta), \theta)])}{f(p_l^* + qE[\pi_I(r_I^*(\theta), \theta)])} = p_l^* + qE[\pi_I(r_I^*(\theta), \theta)]. \tag{48}$$

When FinTech firms offer payment services but do not directly lend, the profit function of the bank, $\psi_c(\cdot)$, is shown in equation (17), and from equation (36), the first-order condition for the bank's price for payment services is:

$$\frac{1 - F(p_c^* - q\Delta_{S_\ell})}{f(p_c^* - q\Delta_{S_\ell})} = p_c^* + q\Delta_\pi. \tag{49}$$

Rewriting the two first-order conditions, using b_c and b_l as variables:

$$\psi_c'(b_c) = 1 - F(b_c) - f(b_c)(b_c + q\Delta_{S_\ell} + q\Delta_\pi) = 0, \tag{50}$$

$$\psi_l'(b_l) = 1 - F(b_l) - f(b_l)b_l = 0. \tag{51}$$

Suppose that $b_l^* = b_\ell(p_\ell^*) \leq b_c^* = b_c(p_c^*)$. Then using the fact that $\psi_l'(\cdot)$ is decreasing, we have

$$0 = \psi_l'(b_l^*) \geq \psi_l'(b_c^*) = 1 - F(b_c^*) - f(b_c^*)b_c^* = f(b_c^*)(q\Delta_{S_\ell} + q\Delta_\pi) > 0. \tag{52}$$

Hence, $b_l^* > b_c^*$ if $\Delta_{S_\ell} + \Delta_\pi > 0$. That is, the bank's market share reduces, compared to the case in which the FinTech firms do not offer loans.

Now, observe that, at the same price p, we have $b_l(p) > b_c(p)$. Thus, fixing the price p, the bank's market share, and hence revenue from payment services, is lower when the FinTech

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firms can also make loans. In addition, the bank loses the loan profit $E(\pi_I)$ on consumers in the range $b \in [b_c(p), b_l(p)]$ and the profit π_U on consumers in the range $b < b_c(p)$. Therefore, it follows that $\psi_c(p) > \psi_l(p)$. Hence, at the optimal price when FinTech firms also make loans, we have $\psi_c(p_l^*) > \psi_l(p_l^*)$. Now, profit maximization when the bank is a monopolist in the loan market implies that $\psi_c(p_c^*) \geq \psi_c(p_l^*)$. Hence, it must be that $\psi_c(p_c^*) > \psi_l(p_l^*)$.

(b) The condition for the bank's optimal payment services price when the bank competes with FinTech firms only in payments is

$$\frac{1 - F(b_c(p_c^*))}{f(b_c(p_c^*))} = p_c^* + q\Delta_\pi, \tag{53}$$

where $b_c(p) = p - q\Delta_{S_\ell}$.

The corresponding condition when FinTech firms also lend is

$$\frac{1 - F(b_l(p_l^*))}{f(b_l(p_l^*))} = p_l^* + qE\pi_I(r_I^*(\theta), \theta), \tag{54}$$

where $b_l(p) = p + qE\pi_I(r_I^*(\theta), \theta) > b_c(p)$.

(i) Suppose F has an increasing hazard rate; then, $\frac{1-F}{f}$ is decreasing. Hence,

$$\frac{1 - F(b_l(p_c^*))}{f(b_l(p_c^*))} < p_c^* + q\Delta_\pi < p_c^* + qE\pi_I(r_I^*(\theta), \theta). \tag{55}$$

Therefore, it must be that $p_l^* < p_c^*$.

Now, it is immediate that consumers in the range $b \geq b_l^*$ benefit from FinTech lending. Their surplus is $v + b - p + qE[S_\ell(r_I^*(\theta), \theta]$, so $p_l^* < p_c^*$ implies that their surplus improves. Consumers in the range $b \in [b_c^*, b_l^*]$ obtain a surplus $v + b - p_c^* + qE[S_\ell(r_I^*, \theta)]$ without FinTech lending, and a surplus $v + q(E[S_\ell(r_I^*, \theta)]) + qE[\pi_I(r_I^*, \theta)]$ with FinTech lending. Observe that by revealed preference $v + q(E[S_\ell(r_I^*, \theta)]) + qE[\pi_I(r_I^*, \theta)] \geq v + b - p_l^* + qE[S_\ell(r_I^*, \theta)] > v + b - p_c^* + qE[S_\ell(r_I^*, \theta)]$. Hence, these consumers too benefit. Finally, consider consumers in the range $b \leq b_c^*$. These consumers obtain $v + qE[S_\ell(r_U^*, \theta)]$ without FinTech lending, and $v + q(E[S_\ell(r_I^*, \theta)] + E[\pi_I(r_I^*, \theta)])$ with FinTech lending. Hence, their surplus changes by $q(\Delta_{S_\ell} + E[\pi_I(r_I^*, \theta)]) > q(\Delta_{S_\ell} + \Delta_\pi) > 0$.

(ii) Next, suppose F has a decreasing hazard rate. A similar argument as above shows that if F has a decreasing hazard rate, p_l^* may be higher or lower than p_c^*. If $p_l^* < p_c^*$, then all consumers strictly benefit from FinTech lending. If $p_l^* > p_c^*$, it follows that consumers with $b > p_c^* + qE[\pi_I(r_I^*, \theta)]$ see a strict reduction in surplus, and those with $b < p_c^* + qE[\pi_I(r_I^*, \theta)]$

see a strict increase in surplus.

(c) When FinTech firms also make loans, each of the bank and the two FinTech firms make loans to consumers who use their services for payment processing. Thus, all loans in the economy are made to consumers whose repayment type θ is known to lenders. The distribution of loans is thus L_I^*, and represents the highest quality of loans that can be made.

∎

A.11 Proof of Lemma 5

The Nash product is $(\Delta_\pi - d)^w \, d^{1-w}$.

The first-order condition for the optimal price is

$$-w\Big(\frac{d}{\Delta_\pi - d}\Big)^{1-w} + (1-w)\Big(\frac{d}{\Delta_\pi - d}\Big)^{-w} \;=\; 0, \tag{56}$$

which directly yields $d^* = (1-w)\Delta_\pi$. It is straightforward to check that the second-order condition is satisfied.

∎

A.12 Proof of Proposition 7

(a) When the bank makes a loan, it obtains a payoff $E[\pi_I(r_I^*(\theta),\theta)] - (1-w)\Delta_\pi$ from FinTech payment consumers, and a payoff $E[\pi_I(r_I^*(\theta),\theta)]$ from bank payment consumers. Thus, the bank's profit may be written as:

$$
\begin{aligned}
\psi_s(p_s) &= (1-F(b_s))\,(p_s + qE[\pi_I(r_I^*(\theta),\theta)]) + F(b_s)q(E[\pi_I(r_I^*(\theta),\theta)] - (1-w)\Delta_\pi) \\
&= (1-F(b_s))\,(p_s + q(1-w)\Delta_\pi) + qE[\pi_I(r_I^*(\theta),\theta)] - q(1-w)\Delta_\pi, \tag{57}
\end{aligned}
$$

where $b_s = p_s + q(1-w)\Delta_\pi$. Hence, from Lemma 3, the bank's optimal price for payment services satisfies the implicit equation:

$$\frac{1 - F(p_s + q(1-w)\Delta_\pi)}{f(p_s + q(1-w)\Delta_\pi)} = p_s + q(1-w)\Delta_\pi. \tag{58}$$

This condition may be re-written as:

$$\psi_s'(b_s) \;=\; 1 - F(b_s) - f(b_s)b_s. \tag{59}$$

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Observe that this has the same form as equation (51), the first-order condition when FinTech firms can make loans. Thus, the argument in the proof of Proposition 6 to show that $b_l^* > b_c^*$ applies, and hence $b_s^* > b_c^*$. That is, the market share of the bank is lower when FinTech firms can sell consumer payment data to the bank.

The bank's profit when it can purchase data from the FinTech firm is:

$$\psi(p_s^*) = (1 - F(b_s^*))\{p_s^* + qE[\pi_I(r_I^*(\theta), \theta)]\} + qF(b_s^*)\{E[\pi_I(r_I^*(\theta), \theta)] - (1 - w)\Delta_\pi\}. \tag{60}$$

The profit when there are no data sales is given by:

$$\psi(p_c^*) = (1 - F(b_c^*))\{p_c^* + qE[\pi_I^*]\} + qF(b_c^*) E[\pi_U^*]. \tag{61}$$

Now, at the same price p, we have $b_s(p) > b_c(p)$. Thus, at a given price, the bank's payment revenue is lower in the no-data-sales regime. Further, compared to the no-data-sales regime, the bank has an increased loan profit of $qw\Delta_\pi$ from consumers in the range $b \leq b_c(p)$, and a decreased loan profit of $q(1 - w)\Delta_\pi$ from consumers in the range $b \in [b_c(p), b_s(p)]$. Thus, it may be that $\psi_s(p) > \psi_c(p)$ or the converse, and the overall effect on bank profit is ambiguous.

(b) The condition for optimal payment services price when the bank competes with FinTech firms only in payments is

$$\frac{1 - F(b_c(p_c^*))}{f(b_c(p_c^*))} = p_c^* + q\Delta_\pi, \tag{62}$$

The corresponding condition when FinTech firms can sell data to the bank is

$$\frac{1 - F(b_s(p_s^*))}{f(b_s(p_s^*))} = p_s^* + q(1 - w)\Delta_\pi. \tag{63}$$

Suppose F has a decreasing hazard rate; then, $\frac{1-F}{f}$ is increasing. Hence,

$$\frac{1 - F(b_s(p_c^*))}{f(b_s(p_c^*))} > p_c^* + q\Delta_\pi > p_c^* + q(1 - w)\Delta_\pi. \tag{64}$$

Now, at any price p such that $\frac{1-F(b_s(p))}{f(b_s(p))} > p + q(1 - w)\Delta_\pi$, we have $\psi_s'(p) > 0$. Therefore, it must be that $p_s^* > p_c^*$. The effects on consumer welfare in different regions of bank affinity now follow from Table 4. This proves part (ii).

Consider part (i). A similar line of argument shows that if F has an increasing hazard rate, p_s^* may be higher or lower than p_c^*. Suppose $p_s^* < p_c^*$. Then, consumers with $b \geq b_s^*$ see their surplus increase by $p_c^* - p_s^*$. Those with affinity $b \leq b_c^*$ see their surplus increase by $q((1-w)\Delta_\pi + \Delta_{S_\ell})$. Finally, those with affinity $b \in [b_c^*, b_s^*]$ see their surplus change by $q(1-w)\Delta_\pi + p_c^* - b$. This quantity is strictly decreasing in b. Further, at the upper bound of the range $[b_c^*, b_s^*]$, i.e., when $b = b_s^*$, the change in surplus is $q(1-w)\Delta_\pi + p_c^* - b_s^* = p_c^* - p_s^* > 0$. Hence, all consumers are better off. If, however, $p_s^* > p_c^*$, then again consumers with $b < p_c^* + q(1-w)\Delta_\pi$ are strictly better off and those with $b > p_c^* + q(1-w)\Delta_\pi$ are strictly worse off.

(c) The bank directly has information about consumer payments for all consumers with $b \geq b_s^*$. It buys data on consumer payments from the FinTech firms for consumers with $b < b_s^*$. Thus, the bank has information on consumer repayment type θ for all consumers. Hence, the distribution of loans is L_I^*, which represents the highest feasible quality of loans.

$\blacksquare$

A.13   Proof of Proposition 8

(a) We show that $b_d^* > b_c^*$, where $b_d^* = b_d(p_d^*)$. That is, the market share of the bank falls when payment data become portable. Observe that $b_d^* > b_c^*$ is equivalent to $p_d^* > p_c^* - q\Delta_{S_\ell}$. Write the two first-order conditions for the optimal bank price under no data portability and data portability respectively:

$$0 = \psi_c'(p_c^*) = 1 - F(p_c^* - q\Delta_{S_\ell}) - f(p_c^* - q\Delta_{S_\ell})(p_c^* + q\Delta_\pi), \tag{65}$$

$$0 = \psi_d'(p_d^*) = 1 - F(p_d^*) - f(p_d^*)p_d^*. \tag{66}$$

Suppose that $p_d^* \leq p_c^* - q\Delta_{S_\ell}$. Since $\psi'(p_d)$ is decreasing in p_d for the second-order condition to hold, we have

$$0 = 1 - F(p_d^*) - f(p_d^*)p_d^* \geq 1 - F(p_c^* - q\Delta_{S_\ell}) - f(p_c^* - q\Delta_{S_\ell})(p_c^* - q\Delta_{S_\ell})$$
$$= f(p_c^* - q\Delta_{S_\ell})q(\Delta_\pi + \Delta_{S_\ell}) > 0, \tag{67}$$

which is a contradiction when $\Delta_\pi + \Delta_{S_\ell} > 0$. Therefore, it must be that $p_d^* > p_c^* - q\Delta_{S_\ell}$, or equivalently $b_d^* > b_c^*$.

Now, at the same price p, we have $b_d(p) > b_c(p)$. Thus, at a given price, the bank's payment revenue is lower in the no-data-portability regime. However, the bank has an

increased loan profit of $q\Delta_\pi$ from consumers in the range $b \leq b_c^*$, and the same profit from consumers in the range $b \geq b_c^*$. Thus, it may be that $\psi_d(p) > \psi_c(p)$ or the converse, and the overall effect on bank profit is ambiguous.

(b) Consider the effects of free data transfer on consumer welfare.

  (i) Suppose that $\Delta_{S_\ell} > 0$. From Table 5, consumers with $b < b_c^*$ experience a change in welfare equal to $q\Delta_{S_\ell} > 0$. Consider consumers in the range $b \in [b_c^*, b_d^*]$. Their change in welfare is equal to $p_c^* - b$. The condition $b_d^* > b_c^*$ is equivalent to $p_d^* > p_c^* - q\Delta_{S_\ell}$. Therefore, it may be that $p_d^* < p_c^*$ or $p_d^* > p_c^*$. In the former case, all consumers are strictly better off with data portability. In the latter case, consumers with $b < p_c^*$ are strictly better off and those with $b > p_c^*$ are strictly worse off.

  (ii) Suppose that $\Delta_{S_\ell} < 0 < v + q\Delta_{S_\ell}$. Here, the condition $v + q\Delta_{S_\ell} > 0$ ensures that consumers with low b values choose a FinTech firm to process payments, rather than just using cash. In this case, $p_d^* > p_c^* - q\Delta_{S_\ell}$ implies that $p_d^* > p_c^*$. Hence, it follows from Table 5 that all consumers are strictly worse off.

(c) The bank directly has information about consumer payments for all consumers with $b \geq b_d^*$. Consumers with $b < b_d^*$ voluntarily reveal their payment data to the bank. Thus, the bank has information on consumer repayment type θ for all consumers. Hence, the distribution of loans is L_I^*, which represents the highest feasible quality of loans. ∎

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