

FinTech Disruption, Payment Data, and Bank Information*

Christine A. Parlour[†] Uday Rajan[‡] Haoxiang Zhu[§]

July 11, 2019

Preliminary and Incomplete

*For helpful comments and suggestions, we thank Paolo Fulghieri, Christian Laux, Mario Milone, Gans Narayanamoorthy, Amit Seru, and seminar/conference participants at the Finance Theory Group, Bank of Canada, Goethe University Frankfurt, EPFL/University of Lausanne, University of Hong Kong, Tulane University, University of Amsterdam, Vienna Graduate School of Finance, University of Maryland, University of North Carolina, and the Future of Financial Information Conference.

[†]Haas School of Business, University of California at Berkeley, parlour@berkeley.edu

[‡]Ross School of Business, University of Michigan, urajan@umich.edu

[§]MIT Sloan School of Management, zhuh@mit.edu

FinTech Disruption, Payment Data, and Bank Information

Abstract

We study the impact of FinTech competition on a monopolist bank that bundles payment processing and lending. In our model, consumers' payment data contain information about their credit quality, hence valuable to the bank when making loans. Under mild conditions, consumer surplus in the loan market is also higher ex ante if the bank observes their payment data. The bank internalizes the value of this information when pricing its payment services, as do consumers when choosing a payment processor. Competition from FinTech firms specializing in payment services disrupts this information spillover to lending decisions. We show that FinTech competition can reduce or increase the price of payment services charged by banks. Consumers who value bank relationships highly could be worse off, whereas those with low bank relationships benefit from cheaper access to payment services. If FinTech firms also make loans or sell consumer data to the bank, consumers with low bank relationships receive an additional benefit of gaining access to more informed interest rates, whereas consumers with strong bank relationships could suffer from a potentially higher price of payment services. Finally, policies that give consumers complete control of their payment data break the bank's vertical integration of payment and lending, but the welfare impact of such policies is ambiguous and heterogeneous across consumers. Our results highlight the complex consequences of recent regulation such as PSD2 in the EU and the Open Banking initiative in the UK, especially their heterogeneous impact on consumers.

1 Introduction

On January 13, 2018, the Second Payment Services Directive (PSD2) introduced two new legal entities to the EU: Account Information Service Providers (AISPs) and Payment Initiator Service Providers (PISPs). Account information service providers are consumer-facing companies that can log on to a consumer’s various financial accounts and aggregate the information. Payment initiator service providers provide payment services on behalf of the client. To comply with the directive, traditional banks are required to provide customer account information to FinTech firms in a standardized format and to ensure that their systems allow, through APIs, secure access to customers’ depository accounts.

In this paper we study the impact of FinTech competition in payment services on consumer welfare. The starting point of our analysis is that banks offer a bundle of services to consumers. In particular, they process payments for everyday transactions (e.g., paying monthly bills) and also make loans to consumers when they need credit. These two lines of business are tightly related 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. By directly competing with banks in offering cheaper electronic payments, FinTech entrants disrupt this information flow and hence have a material impact on the lending market.

In our model, there is a continuum of consumers. A single strategic bank maximizes the combined profits from two lines of business: electronic payment services and lending. There are two homogeneous competitive FinTech firms that provide electronic payment services at a normalized price of zero. At $t = 1$, the bank and the FinTech firms offer electronic payment services to consumers at different prices. Consumers differ in their bank relationships. In our model, a more valuable bank relationship means that the consumer receives a higher utility for using the bank for payment service. Each consumer chooses the payment service that maximizes their overall expected utility, including the expected utility from a future loan. At $t = 2$, a fraction of consumers receive a liquidity shock and need a loan from the bank. The credit quality of these consumers is also realized at this point. Importantly, the consumer’s credit quality is perfectly observable by the bank if they use the bank for payment services. Thus, consumers who use the bank for payments face an “informed” interest rate that depends on their credit quality, whereas consumers who use a FinTech firm for payments face a uniform “uninformed” interest rate. Each consumer has an outside

option, or reservation interest rate, that proxies for competition in the loan market.

We establish a mild condition under which the ex ante consumer surplus from obtaining a loan from an informed bank is higher than when the bank is uninformed. The intuition is that more creditworthy consumers receive better interest rates on their loans. When the consumer prefers that the bank be informed about her transactions, she has an additional incentive to use the bank's payment services. Likewise, the bank also benefits from observing the consumer's credit quality, and hence would like to attract consumers by offering payment services at a low price. These two incentives jointly determine the bank's optimal price for payment services at $t = 1$, and hence the bank's market share in payment processing.

To evaluate the effect of FinTech competition, we consider a benchmark in which the bank is a monopolist both in lending and in payment services. In this case, consumers who do not wish to incur the cost of electronic payments at the bank remain unbanked. Low cost FinTech competition reduces the market share of banks in payment processing, by attracting consumers with weak bank relationships. The usual intuition suggests that the bank should respond by reducing its price for payment services, but, in fact, under certain conditions, we show that the bank instead *increases* its price. That is, in the face of price competition, the bank may instead choose to extract a higher profit margin from bank-reliant consumers, even though it loses market share in the process. The increased cost of payment services harms consumers who stay with the bank. Conversely, previously unbanked consumers benefit from FinTech competition by gaining access to electronic payment services. Thus, our analysis shows that FinTech competition has a heterogeneous impact on consumers.

Important to our results on heterogeneous welfare impact is the idea that there are innate differences across consumers in terms of their desire to use a bank or their access to a bank. Such differences occur both across countries (such as Sweden vs Kenya) and across users in the same country. Surveys on bank usage and adoption in the U.S., for example, suggest that banks are more attractive for richer and older populations, while technology usage is more prevalent among the highly-educated. In as much as countries and localities differ in their mix of these demographic groups, differential impacts on users will affect the relative welfare across consumers.

Our results in the base model stem from the fact that the bank offers a bundle of services (both payment services and loans), and FinTech firms only compete in a single service (payments). We then consider the implications if FinTech firms actively use consumer data in the lending market, either by expanding into lending themselves or by selling the payment

data to the bank. In both settings, consumers payment data become available in the lending market even if the consumers choose a FinTech firm to process payments. By gaining access to more informed interest rates in the loan market, consumers with weak prior bank relationships generally benefit. On the other hand, consumers with strong prior bank relationships may see their welfare decline if FinTech firms' entry into lending or data sales end up increasing the price of payment services, for the same reason before.

Given the value of consumer payment data, a natural next question is who should own and control such data. We therefore consider a scenario in which consumers fully own their payment data and can freely transfer them. This arrangement closely maps to the spirit of PSD2. Specifically, suppose that a consumer who uses a FinTech firm for payment processing can transfer her payment data to the bank when she needs a loan. We show that the portability of data breaks the integration of payment services and loans. That is, the bank sets its price for payment services without internalizing the value of information in payment data, because such data would in any case be provided by the consumer when needed. We demonstrate that such unbundling of services could be either beneficial or harmful to consumer welfare. The intuition for the latter is twofold. First, because the bank loses consumers to FinTech firms under data portability, it may increase the price for payment services to earn a larger profit margin from a smaller group of bank-reliant consumers. Second, the mere option of transferring data essentially forces all consumers to do so because of unraveling: consumers with high credit quality would offer their data, so a consumer who applies for a loan without revealing their payment data is known to be a low-credit-quality borrower. If consumers prefer to obtain a loan from an uninformed bank to start with, then data portability reduces the expected surplus of all consumers.

A central theme in our analysis is information spillover from payment data to loans. This premise has empirical support. For example, [Puri, Rocholl, and Steffen \(2017\)](#) investigate determinants of consumer credit defaults at German Savings Banks between 2004 and 2008. They report a difference in default rates of 40 basis points (on an unconditional average default rate of 60 basis points overall) between loans to customers who have a relationship with the bank compared to those without. They find that even simple relationships such as having a savings account or a checking account is 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 Canadian 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. [Schenone \(2010\)](#) provides evidence that banks charge lower loan rates to a firm that has undergone an IPO. Her interpretation is that pre-IPO, banks have an informational monopoly on firm-specific information, which allows them to charge higher rates.

The rest of this paper is organized as follows. Section 2 outlines our model, with the main implications on the pricing of payment services in Section 3. Consumer welfare is discussed in Section 4. Section 5 considers the implications of data markets, and Section 6 concludes. All proofs are in the Appendix.

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.¹ 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, consumers differ in their values of “relationship” 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. Empirically, such a bank relationship 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 relationships could be stronger with the old than the young, with the wealthy than the poor, and in the cities than in rural areas.

¹The 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.

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 $t = 2$, 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 distribution G with support contained in $[0, 1]$. The consumer also has a reservation interest rate for the bank loan, which is drawn from a 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 relationship value 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 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.

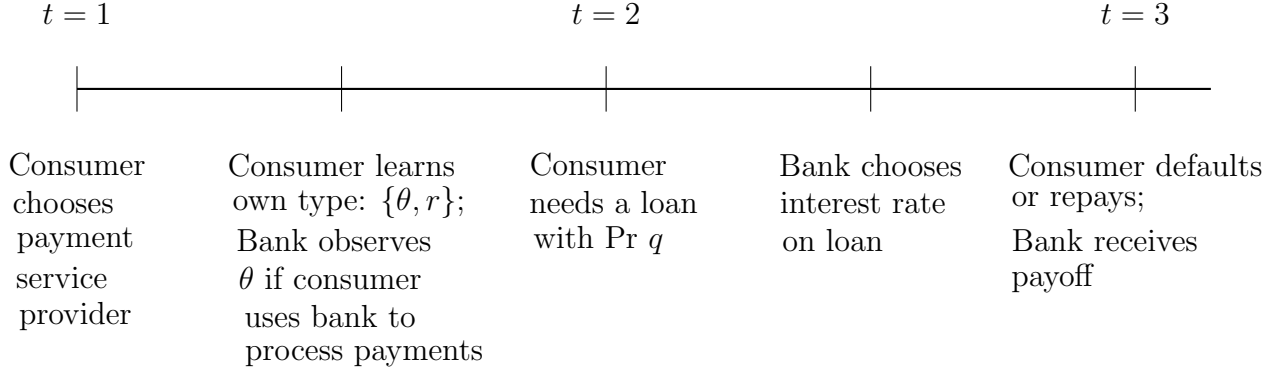


Figure 1: **Timing of Events**

2.1 Information and the Bank's Lending Rates

In our model, all loans have a fixed face value of \$1. The bank's access to a consumer's payment information affects the interest rate the bank offers on the loan. We therefore consider the bank's pricing of loans in two scenarios: the bank is informed or uninformed about θ . The informed bank case and the uninformed bank case are labeled with subscripts I and U , respectively. The bank's cost of funds is normalized to zero.

At the time that the consumer needs a loan, she privately observes her reservation interest rate, 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, 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:

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

Assuming the second-order condition is satisfied, the first-order condition yields the following implicit equation for the optimal interest rate:

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

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

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

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:

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

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

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

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

The second-order condition for optimality is satisfied 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 and so knows θ , the interest rate it charges on the loan, $r_I^*(\theta)$, is implicitly defined by the equation*

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

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

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

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.²

2.2 Bank’s Profit and Consumer Surplus in Loan Market

Next, we consider the bank’s profit and the consumer surplus in the lending market. 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 consumer’s repayment probability.³

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, the expected consumer surplus from the loan (where the expectation is taken over the reservation interest rate) for a consumer is:

$$S_\ell(r, \theta) = \theta \int_r^\infty (x - r)h(x)dx = \theta \left(\int_r^\infty xh(x)dx - r(1 - H(r)) \right), \quad (8)$$

where the subscript “ ℓ ” is a shorthand for loans. The total consumer surplus in the loan market aggregates this quantity across all consumers.

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.

We define the following condition on the convexity of the virtual reservation rate.

Definition 1 (i) *The virtual reservation rate is sufficiently convex at r if $-\frac{V''(r)}{V'(r)} < \frac{h(r)}{1-H(r)}$ for all $r > 0$.*

²Klemperer (1999), Appendix B, provides an interpretation of the virtual valuation of a bidder in an auction as the marginal revenue of the seller.

³Even 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.

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

The inequality in part (i) of the definition requires that the virtual reservation rate is not “too concave” at r . Observe that the right-hand side 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 by 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) *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,*

$$\int_0^1 \pi_I(r_I^*(\theta), \theta) dG(\theta) > \pi_U(r_U^*). \quad (9)$$

(ii) *If the virtual reservation rate is sufficiently convex at each r , the expected 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,*

$$\int_0^1 S_\ell(r_I^*(\theta), \theta) dG(\theta) > \int_0^1 S_\ell(r_U^*, \theta) dG(\theta). \quad (10)$$

(iii) *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 technical intuition behind Proposition 1 is that the bank’s profit is convex in θ under Assumption 1. By Jensen’s inequality, $E[\pi_I(r_I^*(\theta), \theta)] > \pi_I(r_I^*(E(\theta)), E(\theta)) = \pi_U(r_U^*)$. Analogously, if the virtual reservation rate is sufficiently convex at each r , consumer surplus is also convex in θ and hence the consumer prefers an informed bank. 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.

The convexity condition on virtual reservation rates is sufficient for expected consumer surplus to increase when the bank is informed about consumer repayment probabilities. Observe that the condition is stronger than is required, in the sense that expected consumer surplus is higher with the informed bank whenever the condition holds for interest rates in the

range covered by the set $\{r_I^*(\theta)\}_\theta$, rather than for all $r > 0$. Further, there are 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 (ii) nor part (iii) of Proposition 1 apply. In this case, whether consumer surplus increases or decreases when the bank is informed is ambiguous.

3 The Payment Processing Market

When consumers choose their payment service providers, they do not know if they will need a loan in the future. Further, should they need a loan, they do not know what their repayment type θ will be. (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.) As usual, we assume that consumers know the basic parameters of the economy, including q , the probability 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.

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

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**

by ensuring interior solutions, but is otherwise unimportant.) The distribution of the bank benefit, or the relationship value of the bank, has a critical effect on consumer welfare when FinTech firms are present. We therefore first discuss the motivation for this distribution, and then proceed with the rest of the analysis.

3.1 The Bank Relationship 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 if it chooses act as a standalone consumer payments processor as articulated under the PSD2 regulations.

The bank relationship distribution is likely to change slowly across time, so can be empirically estimated. In practice, we expect bank relationship 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 relationship 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.

Sweden and Kenya have very different economies, so clearly inter-country comparisons are somewhat strained. There are important intra-country differences in bank relationships 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 millennials “don’t think that their bank offers anything unique.”⁴ Further, the propensity to adopt digital tools varies substantially by age and education, based on the proportion of people in different groups in the US who own a smart phone.⁵ 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 relationship variable is a proxy for all these levels of heterogeneity.

Throughout the rest of the paper, we impose the following condition on the bank relationship distribution F and its associated density f .

Assumption 2 *The hazard rate of the bank relationship 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 incremental profit the bank expects to make on a payment services consumer if it subsequently makes a loan to the same consumer. In all the cases we analyze in the paper, the amount α is independent of p , the price for payment services.

⁴See <https://www.aba.com/Tools/Documents/Millennials-Banking-Infographic.pdf>.

⁵See <http://www.pewinternet.org/fact-sheet/mobile/>.

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. A consumer who chooses the bank as a payment processor obtains v and their bank relationship value 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

$$v + b - p + \text{net expected loan benefit of choosing the bank as a payment processor.} \quad (11)$$

Conversely, if the consumer does not choose the bank, 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. This latter utility is of course 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. Further, observe that $\hat{b}'(p) = 1$.

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

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

where k is a constant that does not depend on p . We therefore state the bank's optimal price for payment services in terms of this generic profit function.

Lemma 2 *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 . Then, the bank's optimal price for payment services, p^* , satisfies the implicit equation*

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

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 relationship value.

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

3.2 Only the Bank Offers Payment Services

First, suppose the bank is a monopolist in the payment processing market, i.e., before Fin-Tech entry. Conditional on p , a consumer who has a bank relationship 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 $qE[S_\ell(r_U^*, \theta)]$. Therefore, in this case, the threshold consumer indifferent between choosing the bank and remaining unbanked satisfies

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

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

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

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 2.

From Lemma 2, it follows that the bank's optimal price, p_m^* , satisfies the implicit equation $\frac{1-F(b_m(p_m^*))}{f(b_m(p_m^*))} = p_m^* + q\Delta_\pi$. Consumers with a bank relationship $b \geq b_m(p_m^*) \equiv p_m^* - v - q\Delta_{S_\ell}$ choose the bank for payment services, while those with $b < b_m(p_m^*)$ remain unbanked.

3.3 Competition with FinTech 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, the consumer surplus from using a FinTech firm for processing payment is the gross value of the service, v . As $v > 0$, all consumers will choose an electronic payment service provider in this case; that is, no consumer remains just a cash user.

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

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

The bank's total profit may therefore be written as

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

which is again of the form $\psi(p) = (1 - F(\hat{b}(p)))(p + \alpha) + k$ assumed in Lemma 2. 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 relationship $b \geq b_c(p_c^*) \equiv p_c^* - q\Delta_{S_\ell}$ choose the bank as a payment processor, and those with $b < b_c(p_c^*)$ choose a FinTech firm.

The following proposition characterizes the comparison between p_c^* and p_m^* . Surprisingly, if the hazard rate of the bank relationship value distribution is decreasing, the bank charges a higher price for payment services when FinTech competition is present.

Proposition 2 *The bank's market share decreases with FinTech entry; that is, $b_m^* < b_c^*$. Further, the bank's optimal price for payment services when it competes with FinTech providers, p_c^* , is strictly lower (higher) than its price when it is a monopolist, p_m^* , if the bank relationship distribution F has an increasing (a decreasing) hazard rate throughout.*

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.

The main takeaway from Proposition 2 is that competition for payment services does not necessarily imply that all consumers will pay lower prices. If the bank relationship 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 relationships (b_i close to zero) were previously unbanked, and can now switch from using cash to using a FinTech firm for payments. Others (with slightly higher bank relationship values) 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 high bank relationship values 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.

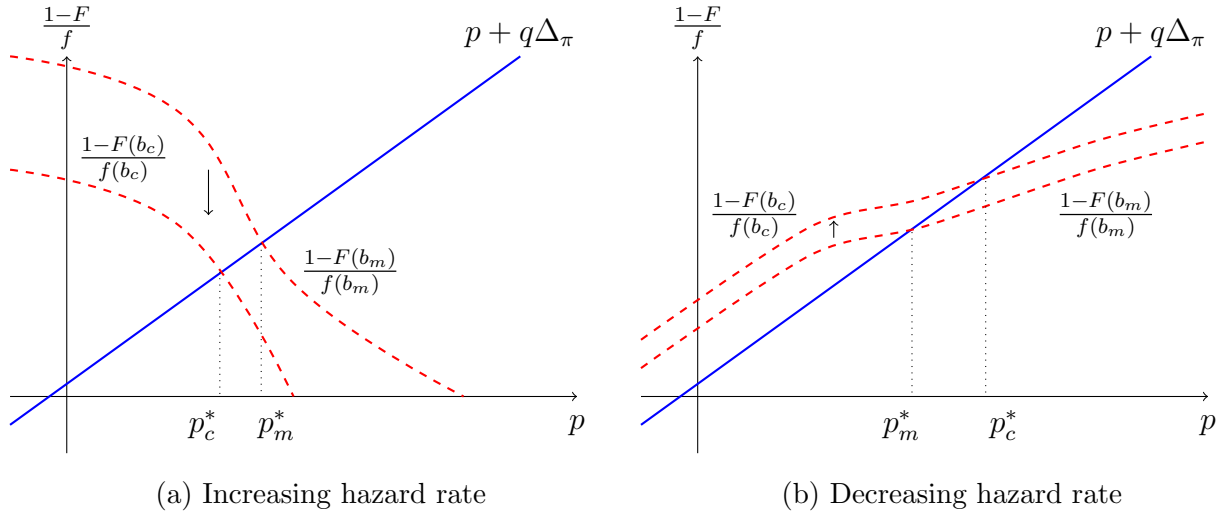


Figure 2: **Bank’s pricing of payment services**

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 $\frac{1-F}{f}$ 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 effect when the FinTech firms enter is to shift 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).

We provide an example of a flexible distribution that, depending on parameters, can have either an increasing or decreasing hazard rate.

Example 1 Suppose that bank relationship b has a Weibull distribution with scale parameter λ and shape parameter k (note that the support of this distribution is bounded below at 0, so here we need $b \geq 0$). Then,

$$F(b) = 1 - e^{-\left(\frac{b}{\lambda}\right)^k}, \text{ and } f(b) = \frac{k}{\lambda} e^{-\left(\frac{b}{\lambda}\right)^k} \left(\frac{b}{\lambda}\right)^{k-1}. \quad (18)$$

The hazard rate of this distribution is $\frac{f(b)}{1-F(b)} = \frac{k}{\lambda} \left(\frac{b}{\lambda}\right)^{k-1}$. The hazard rate is therefore increasing in b if $k > 1$, constant if $k = 1$, and decreasing if $k < 1$. ■

4 Consumer Welfare

We are interested in how FinTech competition affects the welfare of different consumers, based on their bank relationship value b .

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 relationship value 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 relationship value. Table 2 shows the ex ante expected consumer welfare conditional on bank relationship value b . As Proposition 2 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	$p_m^* - b - q\Delta_{S_\ell}$	$p_m^* - p_c^*$

Table 2: **Expected consumer welfare with a monopolist bank (W_m) and with bank-FinTech competition (W_c)**

Note that consumers with bank relationship value $b < b_m^*$ 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 relationship distribution, through its effect on the bank's price for payment services, has a critical effect on consumer welfare.

Proposition 3

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

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

Given our comments in Section 3.1 on factors underlying the bank relationship 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 3, 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.

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 3 *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 Square, which began as a payment processor and is now offering loans through Square Capital, and Ant Financial Services, which began as AliPay and then expanded into a broader financial services company.

Suppose the FinTech firms have exactly the same screening abilities as banks.⁶ 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.

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.⁷ 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 firm by allowing their data to be used 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 relationship value b is earned only if the consumer uses the bank as a payment processor.⁸

⁶Our 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.

⁷Recall also that we have set the marginal cost of offering payment services to zero. If this marginal cost exceeds $q(1-w)\Delta_\pi$, then the net price offered by the FinTech firms remains positive.

⁸We think of the relationship value as emerging from a longstanding relationship between the consumer and the bank. To the extent that the FinTech firms represent new entrants, a consumer using them has not yet established a relationship with them.

Thus, a consumer will choose the bank to process payments if and only if $b \geq b_i^* \equiv p_i^* + qE[\pi_I(r_I^*(\theta), \theta)]$. 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.

In this case, the bank's total expected profit for charging p for payment services is

$$\psi_i(p) = (1 - F(b_i^*))(p + qE[\pi_I(r_I^*(\theta), \theta)]), \quad (19)$$

which is again of the form assumed in Lemma 2. Thus, the optimal price is given by the implicit equation

$$\frac{1 - F(p_i^* + qE[\pi_I(r_I^*(\theta), \theta)])}{f(p_i^* + qE[\pi_I(r_I^*(\theta), \theta)])} = p_i^* + qE[\pi_I(r_I^*(\theta), \theta)]. \quad (20)$$

Observe that the bank's price for payment services exceeds that charged by the FinTech firms. As FinTech firms also make loans, it would appear that they should dominate banks. However, some consumers have high bank relationship values, and so are willing to stick with the bank as their financial services provider. We can show that competition in lending further erodes the bank's market share in payments. However, the welfare effects again depend on whether the bank's price for payment services increases or decreases with FinTech competition in lending.

Lemma 4

- (i) Suppose $\Delta_{S_\ell} + \Delta_\pi > 0$. Then, $b_i^* > b_c^*$, that is, the ability of FinTech firms to make loans further reduces the market share of the bank in the payment services market.
- (ii) If the bank relationship distribution F has an increasing hazard rate, then $p_i^* < p_c^*$.
- (iii) If the bank relationship distribution F has a decreasing hazard rate, then p_i^* may be lower or greater than p_c^* .

With Lemma 4 at hand, we can now compare the welfare of consumers if FinTech firms enter lending business (W_l) or not (W_c , the welfare in the previous section).

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

Table 3: **Welfare effects of FinTech lending**

Consistent with our previous results on welfare in Section 4, FinTech entry into lending may have a differential welfare effect across consumers. If $\Delta_{S_\ell} > 0$, then, as before, consumers with low bank relationship value (including those who are brought into the financial system when FinTech firms start to offer payment services), are strictly better off. The effect on consumers with high bank relationship value ($b > b_i^*$ in Table 3) depends on whether the bank's price for payment services increases or decreases when FinTech lending begins. The arguments here are similar to those in Proposition 3. If $p_i^* < p_c^*$, these consumers benefit from the lower price for bank payment services. In this case, consumers with intermediate bank relationship values, $b \in [b_c^*, b_i^*]$, are also strictly better off.⁹ However, if $p_i^* > p_c^*$, consumers with sufficiently strong bank relationship values experience a reduction in welfare when FinTech lending occurs.

5.2 FinTech Sale of Data

Next, consider direct sales of data by FinTech firms. Suppose that these firms do not lend to consumers, but instead sell consumer payment data to the bank. If the consumer applies for a loan, the bank contacts the FinTech firm to purchase the consumer's transaction data. 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.

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 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 $(\Delta_\pi - d)^w d^{1-w}$.

⁹Observe that $-b + p_c^* + qE[\pi(r_I^*(\theta), \theta)] > -b + p_i^* + qE[\pi(r_I^*(\theta), \theta)] = -b + b_i^* > 0$.

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 $d^* = (1 - w)\Delta_\pi$.*

Consider 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 $-q(1 - w)\Delta_\pi$.

As before, let p denote the price charged by the bank for payment services. At this price, consumers with $b < p + q\{(1 - w)\Delta_\pi - \Delta S_\ell\}$ choose a FinTech firm to process payments, and consumers with $b > p + q\{(1 - w)\Delta_\pi - \Delta S_\ell\}$ choose the bank. 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.

Denote $b_s \equiv p + q\{(1 - w)\Delta_\pi - \Delta S_\ell\}$. Then, the bank's profit may be written as:

$$\begin{aligned}\psi_s(p_s) &= (1 - F(b_s)) (p_s + qE[\pi_I(r_I^*(\theta), \theta)]) + F(b_s)q(E[\pi_I(r_I^*(\theta), \theta)] - (1 - w)\Delta_\pi) \\ &= (1 - F(b_s)) (p + q(1 - w)\Delta_\pi) + qE[\pi_I(r_I^*(\theta), \theta)] - q(1 - w)\Delta_\pi.\end{aligned}\quad (21)$$

Hence, from Lemma 2, the bank's optimal price for payment services satisfies the implicit equation:

$$\frac{1 - F(p + q\{(1 - w)\Delta_\pi - \Delta S_\ell\})}{f(p + q\{(1 - w)\Delta_\pi - \Delta S_\ell\})} = p_s + q(1 - w)\Delta_\pi.\quad (22)$$

In this case, the direction of the price change is unambiguous if the bank relationship distribution F has a decreasing hazard rate.

Lemma 6

- (i) *If the bank relationship distribution F has a decreasing hazard rate, then $p_d^* > p_c^*$.*
- (ii) *If the bank relationship distribution F has an increasing hazard rate, then p_d^* may be lower or higher than p_c^* .*

The effects on consumer welfare again depend on whether the bank's price for payment services increases or decreases. If it decreases and if $\Delta S_\ell > 0$, all consumers are better off when their data is sold, compared to the case of no data sales. Conversely, if ΔS_ℓ remains positive but the bank's price for payment services increases, then again consumers with low b are better off whereas those with high b are worse off.

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 simple 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.¹⁰

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

¹⁰This 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).

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

$$\psi_d(p) = (1 - F(p))p + qE[\pi_i(r_I^*(\theta), \theta)], \quad (23)$$

where we have used the fact that all consumers who need loans now transfer their payment data to the bank. From Lemma 2, 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 relationship values in Table 4 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.

	$b \in [0, b_c^*)$	$b \in [b_c^*, b_d^*]$	$b > b_d^*$
No data transfer	$v + qE[S_\ell(r_U^*, \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_c^* + qE[S_\ell(r_I^*(\theta), \theta)]$
Free data transfer	$v + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + qE[S_\ell(r_I^*(\theta), \theta)]$	$v + b - p_d^* + qE[S_\ell(r_I^*(\theta), \theta)]$
Difference	$q\Delta_{S_\ell}$	$p_c^* - b$	$p_c^* - p_d^*$

Table 4: **Consumer welfare before and after the free portability of payment data**

We characterize the effect of data portability on equilibrium welfare in Proposition 4 below.

Proposition 4 *Suppose that $\Delta_{S_\ell} + \Delta_\pi > 0$. Then, under free data portability:*

- (i) *All consumers are worse off if $\Delta_{S_\ell} < 0 < v + q\Delta_{S_\ell}$.*
- (ii) *Consumers with high bank relationship values ($b > p_c^*$) are worse off and those with low bank relationship values ($b < p_c^*$) are better off if $\Delta_{S_\ell} > 0$ and the bank relationship distribution $F(b)$ has a decreasing hazard rate everywhere. In this case, $p_d^* > p_c^*$.*
- (iii) *All consumers are better off if $\Delta_{S_\ell} > 0$ and, for all b , $\frac{f'(b)}{f(b)} > \left(\frac{\Delta_\pi}{\Delta_{S_\ell}} - 1\right) \frac{f(b)}{1-F(b)}$. In this case, $p_d^* < p_c^*$.*

The unintended consequence of giving consumers complete ownership of their payment data is that the bank no longer needs to offer a better price in payment services to consumers in an effort to acquire such data. Analogous to our earlier result that FinTech entry may reduce or increase the bank's price for payment services, the free transfer of consumer payment data has an ambiguous effect on the bank's price for payment services. When consumers benefit ex ante from providing the bank with their payment information (i.e., when $\Delta_{S_\ell} > 0$), the effect on payment pricing of data portability depends on the distribution of bank relationship values, F , as well as the value of information about consumer repayment types for the bank and for consumers (Δ_π and Δ_{S_ℓ}).

In this case, if the price for payment services falls with data portability, then all consumers are better off when data can be freely transferred. Notice that the condition in part (iii) of the proposition is less likely to be satisfied when the ratio $\frac{\Delta_\pi}{\Delta_{S_\ell}}$ is higher; i.e., when the bank gains relatively more from the consumer's information than the consumer does. Conversely, if the price for payment services increases with data portability, consumers with a weak bank relationship are better off, whereas those with a strong bank relationship are worse off.

If consumers ex ante prefer that the bank is uninformed, the price for payment services increases under data portability, and all consumers are worse off. In this case, once a consumer knows their own repayment probability, the unraveling argument implies that consumers willingly provide their information to the bank. Thus, the bank benefits in two ways from the availability of free data transfer.

The standard economics approach to an externality is to add a market. However, in the case of bank lending, imperfections in the loan market (captured by the $H(\cdot)$ distribution) imply that giving consumers control over their data will not necessarily make all consumers better off. Indeed, as we have argued there may be a transfer of welfare from those who are less flexible in choosing services (the technologically unsophisticated) to those who are more able to take advantage of FinTech disruption.

6 Conclusion

We have presented a simple model that illustrates the complex effects that can occur when a FinTech entrant competes 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. More surprisingly, under some conditions that are not very strict, consumers also gain from providing their information to the bank.

We show that FinTech competition in payment processing disrupts this information externality in loan markets. The bank loses market share, consumer information, and profit from the loan. Consumers, in turn, may also suffer from the lost information if they happen to need a loan. The FinTech entry may either reduce or, somewhat surprisingly, increase the price of the bank's payment services. The latter case applies if the bank decides to focus its payment business on the part of population that is the most reliant on brick-and-mortar banks and hence has a higher price tolerance.

The potential for the bank's price for payment services to increase with FinTech entry generates a heterogeneous impact on overall consumer welfare. On the one hand, older and richer consumers who continue to use the bank experience a reduction in welfare, due to the bank charging them a higher price. On the other hand, technologically sophisticated consumers gain the most, due to the reduction in their cost for payment services.

In our base model, FinTech firms do not profit from consumer transaction data. In practice, we expect FinTech firms to profit from these data in one of two ways: either expanding into lending, or directly selling the data to a bank. We show that our results on welfare qualitatively continue to hold in these settings. Specifically, the welfare gain for consumers with weak bank relationships comes mainly from the lending markets because their payment data make interest rates more informed.

We show that giving consumers complete ownership and portability of their payment data effectively unbundles payment services from bank loans. Breaking the integrated business model gives some consumers more choice and lower prices. However, other consumers, especially those relying on banks and not technologically sophisticated, may suffer as the bank exercises its superior pricing power over this population. This result highlights the likely heterogeneous impact of PSD2 on consumer welfare.

Our model focuses on the effects of the information externality on consumers. We note, however, that this externality could have broader implications. Banks frequently provide information and guidance to policy makers about the macro economy. In as much as consumer payment flows are informative about the broader economy, the statements that they make will be less precise if they no longer have access to payments data.

PSD2 is not the only regulation that has led to interesting disruptions in the distribution

of financial information. For example, the GDPR provides privacy benefits to the consumer, but does not provide a framework or platform for consumers to transfer their data. There is, therefore, a missing market for information, generating a need for “information merchants” to step in and establish the market.

A Proofs

A.1 Proof of Lemma 1

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

$$-h(r)(\theta(1+r) - 1) + (1 - H(r))\theta = 0, \quad (24)$$

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

The second-order condition is

$$-h'(r)(\theta(1+r) - 1) - 2h(r)\theta < 0 \quad (25)$$

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. To see why it is a global maximum, note that the global maximum must be obtained either at a local maximum or at the boundary of the domain $r \in [1/\theta, \infty)$, but $\pi_I(r = 1/\theta, \theta) = 0$ and $\pi_I(r, \theta) \rightarrow 0$ as $r \rightarrow \infty$. Therefore, the first-order condition gives the optimal solution.

(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 Proposition 1

(i) 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 $\frac{d\pi_I(r_I^*)}{d\theta} = \frac{\partial\pi_I}{\partial\theta} = (1 - H(r_I^*(\theta)))(1 + r_I^*(\theta))$. Thus,

$$\frac{d^2\pi_I}{d\theta^2} = \frac{d}{dr_I^*} \left(\frac{d\pi_I}{d\theta} \right) \frac{dr_I^*}{d\theta} = \left(-(1 + r_I^*)h + 1 - H \right) \frac{dr_I^*}{d\theta}. \quad (26)$$

Now, the first-order condition for optimal interest rate in equation (24) 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 $E_\theta(\pi_I(r_I^*(\theta))) > \pi_U(r_U^*(E(\theta)))$.

(ii) Given the equation for consumer surplus from the bank loan, (8), we have

$$\frac{dS_\ell}{d\theta} = \int_r^\infty (x-r)h(x)dx - \theta(1-H(r))\frac{dr}{d\theta} > 0, \quad (27)$$

$$\frac{d^2S_\ell}{d\theta^2} = \underbrace{-2(1-H(r))\frac{dr}{d\theta}}_{>0} + \underbrace{\theta h(r)\left(\frac{dr}{d\theta}\right)^2}_{>0} - \theta(1-H(r))\frac{d^2r}{d\theta^2}. \quad (28)$$

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

$$\frac{dr}{d\theta} = -\frac{1}{\theta^2 V'(r)}, \quad (29)$$

$$\frac{d^2r}{d\theta^2} = \frac{1}{V'(r)} \left[\frac{2}{\theta^3} - V''(r) \left(\frac{dr}{d\theta} \right)^2 \right] = \frac{1}{V'(r)} \left[\frac{2}{\theta^3} - V''(r) \frac{1}{\theta^4 V'(r)^2} \right]. \quad (30)$$

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

$$\frac{d^2S_\ell}{d\theta^2} = \frac{1}{\theta^3} \left[\frac{h(r)}{V'(r)^2} + \frac{(1-H(r))V''(r)}{V'(r)^3} \right]. \quad (31)$$

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

$$V''(r) > -\frac{h(r)}{1-H(r)}V'(r), \quad (32)$$

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

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.3 Proof of Lemma 2

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

$$1 - F(\hat{b}) - f(\hat{b}) \frac{d\hat{b}}{dp} (p + \alpha) = 0. \quad (33)$$

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

$$1 - F(\hat{b}(p)) - f(\hat{b}(p)) (p + \alpha) = 0 \quad (34)$$

$$\frac{1 - F(\hat{b}(p))}{f(\hat{b}(p))} = p + \alpha. \quad (35)$$

From equation (34), the second-order condition for profit-maximizing is

$$-f(\hat{b}(p)) - f(\hat{b}) \frac{d\hat{b}(p)}{dp} - f'(\hat{b}(p))(p + \alpha) < 0. \quad (36)$$

From equation (34), we have $p + \alpha = \frac{1-F(\hat{b}(p))}{f(\hat{b}(p))}$. Substituting this into equation (36) and setting $\frac{d\hat{b}(p)}{dp} = 1$, the condition reduces to the inequality assumed in Assumption 2. ■

A.4 Proof of Proposition 2

First, we show that $b_m^* < b_c^*$. 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

$$v + b_i - p_m + qE[S_\ell(r_I^*(\theta), \theta)] < qE[S_\ell(r_U^*, \theta)], \quad (37)$$

or

$$b_i < p_m - v - q\Delta S_\ell. \quad (38)$$

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

$$v + b_i - p_c + qE[S_\ell(r_I^*(\theta), \theta)] \geq v + qE[S_\ell(r_U^*, \theta)], \quad (39)$$

or

$$b_i \geq p_c - q\Delta S_\ell. \quad (40)$$

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

$$0 = \psi'_c(p_c) = 1 - F(p_c - q\Delta S_\ell) - f(p_c - q\Delta S_\ell)(p_c + q\Delta\pi), \quad (41)$$

$$0 = \psi'_m(p_m) = 1 - F(p_m - q\Delta S_\ell - v) - f(p_m - q\Delta S_\ell - v)(p_m + q\Delta\pi). \quad (42)$$

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,

$$0 = \psi'_m(p_m) \leq \psi'_m(v + p_c) = 1 - F(p_c - q\Delta S_\ell) - f(p_c - q\Delta S_\ell)(p_c + v + q\Delta\pi) \quad (43)$$

$$= -f(p_c - q\Delta S_\ell)v < 0, \quad (44)$$

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.

Next, we turn to the prices. Let p_c^* be the bank's optimal price under competition. Then, from the first-order condition in equation (41), it follows that

$$\frac{1 - F(b_c(p_c^*))}{f(b_c(p_c^*))} = p_c + q\Delta_\pi. \quad (45)$$

In what follows, note that $b_m(p_c^*) = b_c(p_c^*) - v < b_c(p_c^*)$.

(i) 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

$$\frac{1 - F(b_m(p_c^*))}{f(b_m(p_c^*))} > p_c + q\Delta_\pi. \quad (46)$$

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

(ii) 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

$$\frac{1 - F(b_m(p_c^*))}{f(b_m(p_c^*))} < p_c + q\Delta_\pi. \quad (47)$$

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

A.5 Proof of Proposition 3

(i) Suppose that $F(b)$ has an increasing hazard rate. From Proposition 2, 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 their 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 2, 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.6 Proof of Lemma 3

Substitute the value of $\frac{dr}{d\theta}$ from equation (29) into equation (26), to get

$$\frac{d^2\pi_I}{d\theta^2} = -(1 - H(r) - (1 + r)h(r))\frac{1}{\theta^2 V'(r)}. \quad (48)$$

Equation (31) is

$$\frac{d^2 S_\ell}{d\theta^2} = \frac{1}{\theta^3} \left[\frac{h(r)}{V'(r)^2} + \frac{(1 - H(r))V''(r)}{V'(r)^3} \right]. \quad (49)$$

Therefore,

$$\frac{d^2\pi_I}{d\theta^2} + \frac{d^2 S_\ell}{d\theta^2} = \frac{h(r)}{\theta^2 V'(r)^2} \left[V'(r) \left(\underbrace{-\frac{1 - H(r)}{h(r)} + (1 + r)}_{=\frac{1}{\theta}, \text{ by equation (2)}} \right) + \frac{1}{\theta} + \frac{1 - H(r)}{h(r)} \frac{V''(r)}{\theta V'(r)} \right]. \quad (50)$$

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

$$\frac{V''(r)}{V'(r)} > -\frac{h(r)}{1 - H(r)}(1 + V'(r)) \text{ for all } r, \quad (51)$$

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

A.7 Proof of Lemma 4

(i) The first-order condition for the FinTech competition is that

$$\frac{1 - F(p_c^* - q\Delta_{S_\ell})}{f(p_c^* - q\Delta_{S_\ell})} = p_c^* + q\Delta_\pi. \quad (52)$$

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

$$\psi'_c(b_c) = 1 - F(b_c) - f(b_c)(b_c + q\Delta_{S_\ell} + q\Delta_\pi) = 0, \quad (53)$$

$$\psi'_l(b_l) = 1 - F(b_l) - f(b_l)b_l = 0. \quad (54)$$

Suppose, for contradiction, that $b_l \leq b_c$. Then using the fact that $\psi'_l(\cdot)$ is decreasing, we have

$$0 = \psi'_l(b_l) \geq \psi'_l(b_c) = 1 - F(b_c) - f(b_c)b_c = f(b_c)(q\Delta_{S_\ell} + q\Delta_\pi) > 0. \quad (55)$$

Hence, $b_l^* > b_c^*$ if $\Delta_{S_\ell} + \Delta_\pi > 0$.

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

$$\frac{1 - F(b_c(p_c^*))}{f(b_c(p_c^*))} = p_c^* + q\Delta_\pi, \quad (56)$$

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

The corresponding condition when FinTech firms also lend is

$$\frac{1 - F(b_l(p_l^*))}{f(b_l(p_l^*))} = p_l^* + qE\pi_I(r_I^*(\theta), \theta), \quad (57)$$

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

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

$$\frac{1 - F(b_l(p_c^*))}{f(b_l(p_c^*))} < p_c^* + q\Delta_\pi < p_c^* + E\pi_I(r_I^*(\theta), \theta). \quad (58)$$

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

(iii) A similar line of argument to (ii) shows that if F has a decreasing hazard rate, p_l^* may be higher or lower than p_c^* . \blacksquare

A.8 Proof of Lemma 5

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

The first-order condition for the optimal price is

$$-w \left(\frac{d}{\Delta_\pi - d} \right)^{1-w} + (1-w) \left(\frac{d}{\Delta_\pi - d} \right)^w = 0, \quad (59)$$

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

A.9 Proof of Lemma 6

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

$$\frac{1 - F(b_c(p_c^*))}{f(b_c(p_c^*))} = p_c^* + q\Delta_\pi, \quad (60)$$

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

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

$$\frac{1 - F(b_d(p_d^*))}{f(b_d(p_d^*))} = p_d^* + q(1-w)\Delta_\pi, \quad (61)$$

where $b_d(p) = p - q\Delta_{S_\ell} + q(1-w)\Delta_\pi > b_c(p)$.

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

$$\frac{1 - F(b_d(p_c^*))}{f(b_d(p_c^*))} > p_c^* + q\Delta_\pi > p_c^* + q(1-w)\Delta_\pi. \quad (62)$$

Therefore, it must be that $p_d^* > p_c^*$.

(ii) A similar line of argument to (i) shows that if F has an increasing hazard rate, p_d^* may be higher or lower than p_c^* . ■

A.10 Proof of Proposition 4

We first show that $b_d^* > b_c^*$, where $b_d^* = b_d(p_d^*)$. That is, the market share of the bank drops if 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

$$0 = \psi'_c(p_c^*) = 1 - F(p_c^* - q\Delta_{S_\ell}) - f(p_c^* - q\Delta_{S_\ell})(p_c^* + q\Delta_\pi), \quad (63)$$

$$0 = \psi'_d(p_d^*) = 1 - F(p_d^*) - f(p_d^*)p_d^*. \quad (64)$$

Suppose, for contradiction, 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

$$\begin{aligned} 0 &= 1 - F(p_d^*) - f(p_d^*)p_d^* \geq 1 - F(p_c^* - q\Delta_{S_\ell}) - f(p_c^* - q\Delta_{S_\ell})(p_c^* - q\Delta_{S_\ell}) \\ &= f(p_c^* - q\Delta_{S_\ell})q(\Delta_\pi + \Delta_{S_\ell}) > 0, \end{aligned} \quad (65)$$

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, consider the welfare effects of free data transfer.

- (i) Suppose that $\Delta_{S_\ell} < 0 < v + q\Delta_{S_\ell}$. The second inequality ensures that all consumers prefer a FinTech payment provider to using cash. As $p_c^* = b_c^* + q\Delta_{S_\ell}$, it follows that $p_c^* < b_c^*$. Further, we have shown that $b_d^* > b_c^*$, where $b_d^* = p_d^*$. Hence, $p_d^* > b_c^* > p_c^*$.

From Table 4, consumers with $b < b_c^*$ experience a change in welfare equal to $q\Delta_{S_\ell}$, which is strictly negative. Consumers with $b \in [b_c^*, b_d^*]$ see a change $p_c^* - b$, which is also strictly negative as $b_c^* > p_c^*$. Finally, those in the range $b > b_d^*$ see a welfare change of $p_c^* - p_d^* < 0$. Thus, all consumers are worse off with free data transfer.

- (ii) Suppose that $\Delta_{S_\ell} > 0$. Consumers with $b < b_c^*$ see a change in welfare equal to $q\Delta_{S_\ell}$ (see Table 4), which is clearly positive.

Suppose further that F has a decreasing hazard rate for all b . Then, $f'(b)(1 - F(b)) + f(b)^2 < 0$. Observe that the numerator of $\frac{dp_c^*}{dq}$ may be written as $f(b_c^*)(\Delta_{S_\ell} - \Delta_\pi) + f'(b_c^*)\frac{1-F(b_c^*)}{f(b_c^*)}\Delta_{S_\ell}$, where we have substituted in the first-order condition $p_c^* + q\Delta_\pi = \frac{1-F(b_c^*)}{f(b_c^*)}$. Noting that $\Delta_{S_\ell} > 0$, we have

$$f(b_c^*)(\Delta_{S_\ell} - \Delta_\pi) + f'(b_c^*)\frac{1-F(b_c^*)}{f(b_c^*)}\Delta_{S_\ell} < f(b_c^*)(\Delta_{S_\ell} - \Delta_\pi) - f(b_c^*)\Delta_{S_\ell} < 0, \quad (66)$$

where the last inequality comes from $\Delta_\pi > 0$. In this case, p_c^* is higher if q is smaller, that is, if payment services and loans are decoupled, then the bank increases its price for payment services. Therefore, $p_d^* > p_c^*$.

It now follows from Table 4 that consumers with $b < p_c^*$ are better off and consumers with $b > p_c^*$ are worse off with free data transfer.

- (iii) Suppose that $\Delta_{S_\ell} > 0$ and, for all b ,

$$\frac{f'(b)}{f(b)} \gg \left(\frac{\Delta_\pi}{\Delta_{S_\ell}} - 1 \right) \frac{f(b)}{1 - F(b)}. \quad (67)$$

Then by the same logic as above, the free portability of data reduces p_c^* , so that $p_d^* < p_c^*$. From Table 4, it follows that all consumers are better off with free data transfer.

■

References

- Admati, A., Pfleiderer, P., 1990. Direct and indirect sale of information. *Econometrica* 58, 901–928.
- Agarwal, S., Chomsisengphet, S., Liu, C., Song, C., Souleles, N. S., 2018. Benefits of relationship banking: Evidence from consumer credit markets. *Journal of Monetary Economics* 96, 16–32.
- Black, F., 1975. Bank funds management in an efficient market. *Journal of Financial Economics* 2, 323–339.
- Chen, Y., Riordan, M., 2008. Price-increasing competition. *The RAND Journal of Economics* 39, 1042–1058.
- Klemperer, P., 1999. Auction theory: A guide to the literature. *Journal of Economic Surveys* 13, 227–286.
- Mester, L. J., Nakamura, L. I., Renault, M., 2007. Transactions accounts and loan monitoring. *The Review of Financial Studies* 20.
- Milone, M., 2019. Smart lending. Working paper .
- Puri, M., Rocholl, J., Steffen, S., 2017. What do a million observations have to say about loan defaults? Opening the black box of relationships. *Journal of Financial Intermediation* 31, 1–15.
- Schenone, C., 2010. Lending relationships and information rents: Do banks exploit their information advantage? *Review of Financial Studies* 23, 1149–1199.