FinTech Disruption, Payment Data, and Bank Information*

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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. This information is valuable to the bank when making loans. Surprisingly, under mild conditions, consumers in the loan market also benefit ex ante from the bank being informed. 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. Overall consumer welfare depends on the consumer's affinity for bank services. Those with a high affinity may be worse off, whereas those with a low affinity benefit from cheaper access to payment services. Policies that give consumers complete control of their payment data break the bank's vertical integration of payment and lending, but such policies can also harm 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 transaction data allow the bank to better understand consumers' 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 offers electronic payment services to consumers at different prices. Consumers differ in their affinity for the bank; i.e., their inherent preference for using the bank. 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 low bank affinity. 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. Thus, our analysis shows that FinTech competition has a heterogeneous impact on consumers, with some consumers being worse off.

Important to our results is the idea that there are innate differences across consumers in terms of their desire to use a bank. Industry surveys 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."[1] 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 smartphone.[2] Our bank affinity variable captures this heterogeneity.

Our results 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). A natural question is whether giving consumers control of their data ameliorates the situation. We therefore consider a scenario in which consumers fully own their payment data and

[1] See https://www.aba.com/Tools/Documents/Millennials-Banking-Infographic.pdf.

[2] See http://www.pewinternet.org/fact-sheet/mobile/.

can freely transfer them. 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. This arrangement closely maps to the spirit of PSD2. 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 a model of FinTech

competition and characterizes its impact on the pricing of payment services and consumer welfare. Section 3 studies the effect of a data transfer policy. Section 4 concludes. All proofs are in Section A.2 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. The bank offers both loans and payment services, while the FinTech firms are stand-alone payment processors.

Each consumer receives 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, the bank's physical presence gives consumer i an additional convenience utility of b_i that ranges from $-\infty$ to $+\infty$, and is drawn from a distribution F. The variation in a consumer's convenience for going to a brick-and-mortar bank and getting assistance from a real person could stem, for example, from demographic characteristics and education level. A consumer who does not use electronic payment services from either the bank or a FinTech company must conduct all transactions in cash, in which case she is 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 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

extra benefit b_i of using the bank for payment, 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.

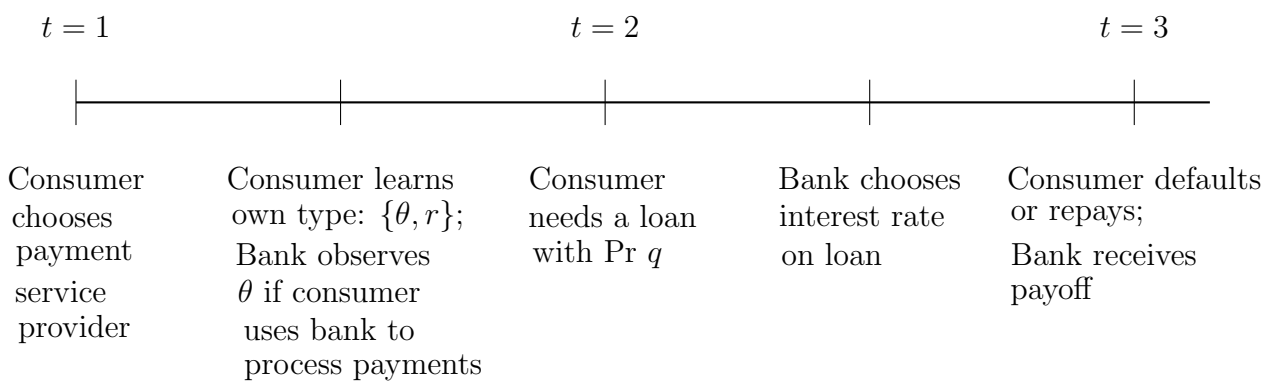


Figure 1: **Timing of Events**

Note that the unsecured 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 a mortgage loan, or an investment product targeted toward consumers with particular wealth levels.

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:

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

The usual first-order condition in r yields

$$(1 - H(r))\theta - h(r)(\theta(1 + r) - 1) = 0. \tag{2}$$

That is, at the optimal interest rate, if the bank increases the rate by a small amount, the additional profit from consumers who stay is exactly offset by the lost profit from consumers who drop out. If the second-order condition is satisfied, the optimal interest rate is then given by the implicit equation

$$r_I^*(\theta) = \frac{1}{\theta} - 1 + \frac{1 - H(r_I^*(\theta))}{h(r_I^*(\theta))}, \tag{3}$$

where 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.

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:

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

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

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

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

$$V(r) \equiv r - \frac{1 - H(r)}{h(r)}. \tag{6}$$

Then, the bank's optimal interest rates above can be concisely expressed as

$$V(r_I^*(\theta)) = \frac{1}{\theta} - 1, \tag{7}$$

$$V(r_U^*) = \frac{1}{E(\theta)} - 1. \tag{8}$$

As the derivation above shows, 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.[3]

The second-order condition for optimality is satisfied if the distribution $H(\cdot)$ is regular; that is, has an increasing virtual valuation. 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 valuation $V(\cdot)$ is strictly increasing.*

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*

$$V(r_I^*(\theta)) \quad = \quad \frac{1}{\theta} - 1. \tag{9}$$

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

$$V(r_U^*) \quad = \quad \frac{1}{E(\theta)} - 1. \tag{10}$$

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

Notice that part (i) implies that, as expected, a more creditworthy consumer (i.e., a consumer with a higher θ) is charged a lower interest rate on the bank loan.

Example 1 Suppose consumers' reservation interest rates are distributed uniformly on $[0, R]$. Then the bank's optimal interest rate offer is

$$\begin{aligned} r_I^*(\theta) &= \frac{R + (\frac{1}{\theta} - 1)}{2} \\ r_U^* &= \frac{R + (\frac{1}{E(\theta)} - 1)}{2}. \end{aligned}$$

As the actual rate charged in the informed case depends on the realization of the customer's type θ, $r_I^*(\theta)$ is smaller than r_U^* for high values of θ, and greater than r_U for low values of θ. However, by Jensen's inequality, $E\left(\frac{1}{\theta}\right) \geq \frac{1}{E(\theta)}$, and so we expect that the average offered interest rate across consumer types is larger when the bank is informed. ■

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) it if 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.

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:

$$S_\ell(r, \theta) = \theta \int_r^\infty (x - r)h(x)dx = \theta\Big(\int_r^\infty xh(x)dx - r(1 - H(r))\Big), \tag{11}$$

where the subscript "ℓ" is a shorthand for loans. The total consumer surplus in the loan market aggregates this quantity across all consumers. We exhibit a condition under which, surprisingly, the ex ante consumer surplus from the bank loan is also greater when the bank is informed about the consumer's repayment probability.

Condition 1 $-\frac{V''(r)}{V'(r)} < \frac{h(r)}{1-H(r)}$ for all $r > 0$.

This condition requires that the virtual valuation is not "too concave." Observe that the right-hand size is the hazard rate of $H(\cdot)$; that is, is the inverse of the mark-up on the loan. The condition is satisfied by standard probability distributions such as the uniform and the exponential ones, both of which have linearly increasing virtual valuations (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,*

$$\int_0^1 \pi_I(r_I^*(\theta), \theta) dG(\theta) > \pi_U(r_U^*). \tag{12}$$

(ii) If Condition 1 is satisfied, 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,

$$\int_0^1 S_\ell(r_I^*(\theta), \theta) dG(\theta) > \int_0^1 S_\ell(r_U^*, \theta) dG(\theta). \tag{13}$$

(iii) If the inequality in Condition 1 is reversed for all $r > 0$, then 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, under Condition 1, consumer surplus is also convex in θ and hence the consumer prefers an informed bank. But if the inequality in Condition 1 is reversed, consumer surplus becomes concave in θ and she prefers not to give her information to the bank.

Example 2 As in Example 1, let the reservation interest rate be uniformly distributed over $[0, R]$ for each θ. Let $r(\theta)$ denote the interest rate offered to a consumer with type θ. When the bank is informed about the repayment probability, $r(\theta) = r_I^*(\theta)$. When the bank is uninformed, the rate is the same for all consumer repayment probabilities, and $r(\theta) = r_U^*$ for each θ.

In this case, the surplus enjoyed by a consumer of type θ, offered a loan at rate r is computed to be

$$S_\ell(\theta) \;=\; \theta\Big(\frac{R}{2} - \frac{r(\theta)^2}{2R} - r(\theta)\frac{R - r(\theta)}{R}\Big) \;=\; \theta\Big(\frac{R}{2} + \frac{r(\theta)^2}{2R} - r(\theta)\Big).$$

Direct calculation, which uses the expressions in Example 1, shows that $S_\ell(r_I^*(\theta), \theta)$ is convex in θ. Further, $r_U^* = r_I^*(E(\theta))$. Therefore, the consumer's ex ante surplus (taking expectations over the consumer's repayment probability) implies that $E[S_\ell(r_I^*(\theta), \theta)] > S_\ell(r_U(E(\theta)), E(\theta))$.

It may be noted from Example 1 that $r_I^* = \frac{1}{2}\Big(R + \frac{1}{\theta} - 1\Big)$ is convex in θ. Therefore, $E_\theta(r_I^*) > r_U^* = r_I^*(E(\theta))$. That is, the offered interest rate to a consumer is higher in expectation if the bank is informed.

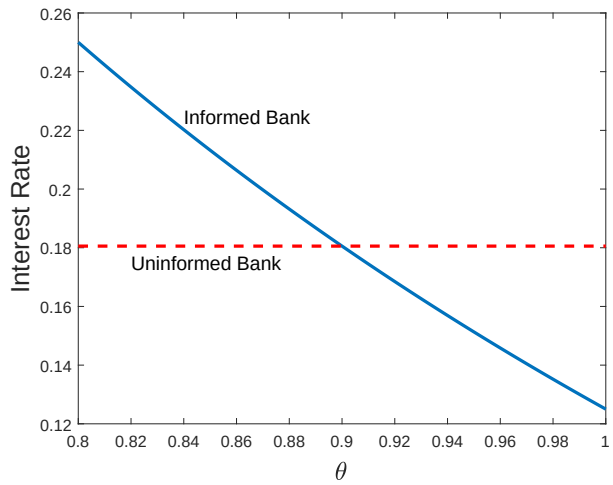
Both prices and quantities of loans change when the bank is informed about repayment probability. The probability that a consumer with type θ accepts a loan when the offered interest rate is $r(\theta)$ is given by $1 - H(r)$. This is interpretable as the volume of loans issued to consumers with type θ. Denote $Q(\theta) = 1 - H(r(\theta))$. When the bank is informed about consumer type, we have $H(r_I^*(\theta)) = \frac{1}{2R}\Big(R + \frac{1}{\theta} - 1\Big) = \frac{1}{2} + \frac{1}{2R}\Big(\frac{1}{\theta} - 1\Big)$. Thus, $Q(\theta) = \frac{1}{2} - \frac{1}{2R}\Big(\frac{1}{\theta} - 1\Big)$, which is concave in θ. As a result, the expected volume of loans decreases when the bank is informed; that is, $E_\theta(Q(\theta)) < Q(E(\theta))$.

Therefore, when the bank is informed, the expected interest rate offered to a consumer increases, and the expected volume of loans decreases. Nevertheless, the expected consumer surplus increases. Importantly, the volume increases for consumers who are offered low interest rates (i.e., those who have high θ) and decreases for consumers offered high interest rates (i.e., those with low θ), and the volume response at a given interest rate is sufficient to ensure that the expected consumer surplus increases.

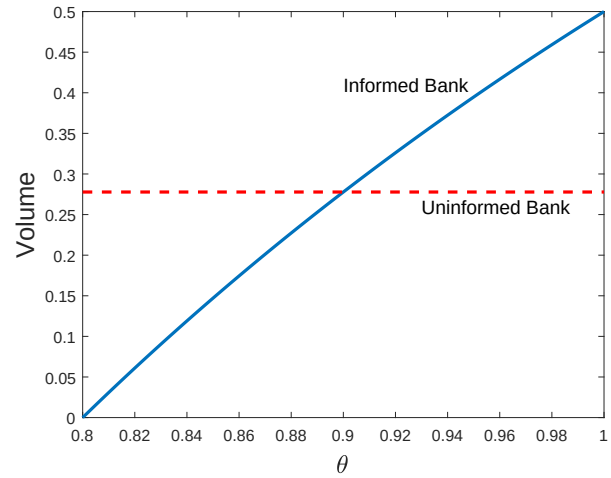
Consider a numeric example with $\theta \in [\frac{1}{1+R}, 1]$, and $R = 0.25$. In Figure 2, we plot the interest rate, volume, and consumer surplus as a function of θ for the two cases: (i) the bank is informed about θ (solid lines), and (ii) the bank is uninformed about θ (dashed lines).

■

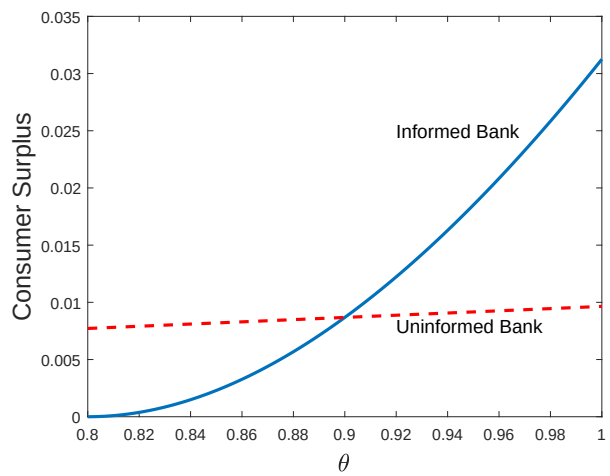
Condition 1 provides a sufficient condition for expected consumer surplus to increase when the bank is informed about consumer repayment probabilities. The condition is stronger than is required, in the sense that expected consumer surplus is higher with the informed bank whenever the condition holds for interest rates in the range covered by the set $\{r_I^*(\theta)\}_\theta$,



(a) Offered interest rate



(b) Volume



(c) Consumer surplus

Figure 2: Interest rate, volume, and consumer surplus when r is uniform over $[0, 0.25]$ and θ is uniform over $[0.8, 1]$

rather than for all $r > 0$. Further, there are distributions such that Condition 1 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 depends on the distribution of θ. We illustrate this point in Example 3.

Example 3 In Appendix A.1, we consider distributions which have a linear density over a

range $r \in [0, R]$. That is, $h(r) = a_0 + a_1 r$ for r in this range. As we show in that section,

(i) Condition 1 holds for all $r \in [0, R]$ whenever $a_1 \leq 0$. That is, if the reservation interest rate has a relatively large mass of consumers near the reservation rate 0, and relatively few consumers with high reservation rates near R, Condition 1 holds. Note that this set of distributions includes the uniform distribution over $[0, R]$.

(ii) Suppose that $a_1 > 0$, so that there are more consumers with high reservation interest rates (near R) than there are with low reservation rates (near 0). Then, Condition 1 continues to hold as long as the density at 0, a_0 is above some threshold $\hat{a}(R)$. However, if $a_0 < \hat{a}(R)$, then there exists a threshold rate $\hat{r} \in (0, R)$ such that Condition 1 is violated for $r \in [0, \hat{r})$ but is satisfied for $r \in (\hat{r}, R]$. That is, the condition is violated at low reservation rates and is satisfied at high reservation rates.

Now, suppose that we are in Case (ii) with $a_1 > 0$, and further that $a_0 < \hat{a}$. Suppose further that the distribution of θ is such that for each feasible θ, we have $r_I^*(\theta) \in [0, \hat{r})$. This will be the case when the feaisble values of θ are high; that is, when consumers are highly creditworthy. Then, because Condition 1 is violated for r in this range, the expected consumer surplus is lower when the bank is informed about θ than when the bank is uninformed.

Conversely, suppose consumers are not too creditworthy, and the feasible values of θ are sufficiently high that, for each θ, we have $r_I^*(\theta) \in (\hat{r}, R)$. Then, Condition 1 holds at each relevant value of r, and expected consumer surplus is higher when the bank is informed.

Finally, suppose the feasible values of θ are such that the range of values for $r_I^*(\theta)$ straddles $\hat{r}$. Then, whether consumer surplus is higher or lower when the bank is informed depends on $G(\cdot)$, the complete distribution of θ. If the mass of θ values is high for values close to 1 (for which the offered interest rate r_I^* will be low), consumer surplus is lower when the bank is informed. Conversely, if this mass is low, consumer surplus increases when the bank is informed. ■

2.3 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.

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.) In what follows, we impose the following condition on the distribution F and its associated density f.

Condition 2 $\frac{f'(b)}{f(b)} > -\frac{2f(b)}{1-F(b)}$ for all b.

That is, the density should not decline too steeply at any point.

2.3.1 A Monopolist Bank

First, suppose the bank is a monopolist in the payment processing market, i.e., before FinTech entry. Suppose the bank charges a price p for processing payments. Conditional on p, a consumer who has 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 is unbanked. Therefore, a consumer chooses the bank if and only if

$$b_i \geq b_m(p) \equiv p - v - q \underbrace{\Big(E[S_\ell(r_I^*(\theta), \theta)] - E[S_\ell(r_U^*, \theta)]\Big)}_{\Delta_{S_\ell}}. \tag{14}$$

From Proposition 1, the term Δ_{S_ℓ} is positive if and only if Condition 1 holds.

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

$$\psi_m(p) = (1 - F(b_m))\,(p + qE[\pi_I(r_I^*(\theta), \theta)]) + F(b_m)q\pi_U(r_U^*). \tag{15}$$

Note that the π_I and π_U terms refer to the bank's expected profits from lending, and do not depend on p.

Taking the first-order condition with respect to p, and using the fact that $\frac{db_m}{dp} = 1$, we obtain:

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

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 first-order condition can be re-expressed as

$$\frac{1 - F(b_m(p))}{f(b_m(p))} = p + q\Delta_\pi. \tag{16}$$

The left-hand side is the inverse hazard rate, and its value at $b_m(p)$ captures the volume of customers who are served by the bank over the mass of people who are just indifferent between

accepting bank's payment service and not. The right-hand side is the marginal benefit to the bank of an additional customer; namely, the revenue from banking and payment services plus the incremental benefit from the loan market when the bank is informed about consumer repayment type, compared to the case in which it is uninformed.

Lemma 2 *Suppose the bank is a monopolist provider of payment services. Then, it charges a price p_m^* for payment services, where p_m^* satisfies the implicit equation*

$$\frac{1 - F(b_m(p_m^*))}{f(b_m(p_m^*))} = p_m^* + q\Delta_\pi, \tag{17}$$

Consumers with affinity for bank services $b \geq b_m(p_m^*)$ choose the bank, while those with $b < b_m(p_m^*)$ remain unbanked.

Notice that even though the bank is a monopolist, it internalizes the informational benefit of processing the client's payments. This means that the threshold between the banked and the unbanked is lower than it would be without the additional profit from the loan market. To see this, consider Figure 3. The threshold b_m determines the consumer who is indifferent between being banked and unbanked, taking into account the future benefit of having a relationship with the bank and getting a loan. If, instead, we had $q = 0$ (so that a consumer does not need a future loan from the bank), there is an analagous $\hat{b} > b_m$ that determines participation by consumers. The difference between these two is the (implied) benefit from the bundling of banking services.

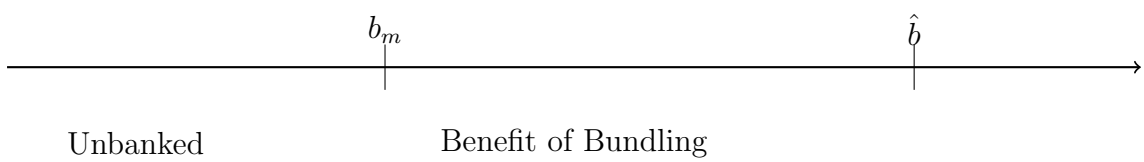


Figure 3: **Banked and unbanked consumers.**

2.3.2 A Bank in 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.

Consumers have rational expectations about the loan market in period 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, a consumer chooses the bank for payments if and only if

$$b_i \geq b_c(p) \equiv p - q\Delta_{S_\ell}. \tag{18}$$

The bank's total profit is therefore

$$\psi_c(p) \quad = \quad (1 - F(b_c))(p + qE[\pi(r_I^*(\theta), \theta))] + F(b_c)q\pi_U(r_U^*). \tag{19}$$

The bank's first-order condition is thus similar to the condition when it is a monopolist, with the important difference that the threshold consumer is determined by $b_c(p)$ rather than $b_m(p)$.

Lemma 3 *When the FinTech providers are present, the bank's optimal price p_c^* for payment services is implicitly given by*

$$\frac{1 - F(b_c(p_c^*))}{f(b_c(p_c^*))} = p_c^* + q\Delta_\pi. \tag{20}$$

Consumers with an affinity for bank service $b \geq b_c(p_c^*)$ choose the bank as a payment processor, and those with $b < b_c(p_c^*)$ choose a FinTech firm.

The bank's choice of payment services price does not affect any of q (the probability a consumer will need a loan), Δ_{S_ℓ} (the benefit to a consumer of the bank being informed about repayment type), or Δ_π (the benefit to the bank of being informed about repayment type). Thus, in choosing its optimal payment services price, the bank can treat all these quantities as given.

Consider the optimal price for payment services when the bank competes with FinTech providers, p_c^*. If the profit function of the monopolist bank is decreasing at p_c^*, then $p_c^* > p_m^*$; that is, the bank in competition charges a *higher* price for payment services than the monopolist bank. As we show in the proof of the following proposition, if the hazard rate of distribution F is decreasing between $b_m^* \equiv b_m(p_m^*)$ and $b_c^* \equiv b_c(p_c^*)$, the competitive price will exceed the monopolist price.

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^*:*

(i) Is strictly lower than its price when it is a monopolist, p_m^*, if the bank affinity distribution F has an increasing hazard rate everywhere;

(ii) Is strictly higher than its price when it is a monopolist, p_m^*, if the bank affinity distribution F has a decreasing hazard rate everywhere.

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 affinity distribution F has an increasing hazard rate, prices are indeed reduced for all consumers by competition. This intuitive outcome is probably the one intended by competition regulators. 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. Some of them (with bank affinity 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 affinity 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 affinity 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.

Prior to the introduction of a FinTech payment provider, the bank competes with the cash economy, which provides consumers a base service level (which we normalize to zero). When FinTech providers enter, consumers who patronize these firms receive the benefit of electronic payment which they value at $v > 0$. As these consumers leave the bank's pool of potential customers, the residual demand curve faced by the bank changes. Consumers who self-elect to stay with the bank have high bank affinity values and have high price tolerance. If there is a sufficiently large number of these consumers, the bank will choose to focus on making a high profit margin on price-tolerance customers rather than compete for the price-sensitive customers with FinTech providers. Indeed, the technical condition of decreasing hazard rate implies that the density function of bank affinity $F(b)$ must fall quite rapidly in b, that is, there is a large mass of consumers with very low bank affinity values that the bank optimally choose to give up. 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).

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.

Example 4 Set $v = 0.2, q = 0.8$, and $\Delta_{S_\ell} = \Delta_\pi = 0.15$. Suppose that bank affinity b has a Weibull distribution with scale parameter λ and shape parameter k. That is,

$$F(b) = 1 - e^{-\left(\frac{b}{\lambda}\right)^k}, \text{ and } f(b) = \frac{k}{\lambda} e^{-\left(\frac{b}{\lambda}\right)^k} \left(\frac{b}{\lambda}\right)^{k-1}. \tag{21}$$

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 $k < 1$.

Note that the support of the Weibull distribution is $[0, \infty)$. We verify numerically that the bank's optimal price for payment services leads to a strictly positive value for b_c and b_m in each case we consider below.

Fix $\lambda = 1$, and consider $k = 0.5, 1, 2$. Note that when $\lambda = 1$ and $k = 1$, the distribution collapses to the exponential distribution. In Table 2, we exhibit the bank's optimal payment services price under monopoly and competition for each of these cases.

				Threshold	Mkt Share	
Value of k	Hazard Rate		Price	Consumer	Bank	Unbanked/FinTech
0.5	Decreasing	Monopoly	3.226	2.866	0.184	0.816
		Competition	3.489	3.329	0.161	0.839
1	Constant	Monopoly	0.84	0.480	0.619	0.381
		Competition	0.84	0.680	0.507	0.493
2	Increasing	Monopoly	0.853	0.493	0.784	0.727
		Competition	0.725	0.565	0.216	0.273

Table 2: **Bank's price for payment services under monopoly and competition**

Observe that the bank charges a greater price under competition than under monopoly when $k = 0.5$; that is, the hazard rate is decreasing.

We verify the second-order condition for the bank in the example. Observe that

$$f'(b) \;=\; \frac{k}{\lambda}\, e^{-\left(\frac{b}{\lambda}\right)^k} \left(\frac{b}{\lambda}\right)^{k-2} \left(\frac{k-1}{\lambda} - \frac{k}{\lambda}\left(\frac{b}{\lambda}\right)^k\right) = f(b)\Big(\frac{k-1}{b} - \frac{kb^{k-1}}{\lambda^k}\Big).$$

Thus, $\psi''_m(p) = -f(b_m)\Big[2 + \Big(\frac{k-1}{b} - \frac{kb^{k-1}}{\lambda^k}\Big)(p + q\Delta_\pi)\Big]$. The second derivative $\psi''_c(p)$ is similar, with b_c substituted in for b_m. It can be immediately verified that the second-order condition is satisfied at the prices and threshold consumers shown in Table 2. ■

2.4 Consumer Welfare

We are interested in how FinTech competition affects the welfare of various groups of consumers, sorted on their bank affinity b. Due to its close connection to demographics, bank affinity is a slow-moving variable and therefore is empirically observable.

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 surplus from this use. The gross benefit from the payment service is v. A consumer who uses a FinTech firm pays zero for this use, and so derives a surplus from payment services equal to v. A consumer who uses a bank pays a price p but also obtains their bank affinity value b, for a surplus from payment services of $v + b - p$. In addition, at time 1, the consumer obtains an expected benefit equal to qES_ℓ 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 value. Table 3 shows the ex ante expected consumer welfare conditional on bank affinity 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, $W_c - W_m$.

First, consider consumers who have the lowest bank affinity, $b < b^*_m$. These are likely to be young millenials. These consumers never use a bank for electronic payments, but

	$b < b_m$	$b \in [b_m^*, b_c^*]$	$b > b_c^*$
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 3: **Expected consumer welfare with a monopolist bank versus bank-FinTech competition**

use a FinTech firm to process payments when the choice is available. The bank never has their payment data and always prices their loans at the uninformed rate r_U^*. For this group, competition provides an unambiguous benefit of electronic payment services, which has value $v > 0$ in our model.

Second, consider the group of consumers who have the highest bank affinity, or $b > b_c^*$. These are likely to be older consumers. These consumers always use the bank, regardless of FinTech competition. Their loans are priced at the informed rate in both cases, so the difference in surplus due to FinTech competition is the drop in the price of payment services, $p_m^* - p_c^*$. As we have shown in Proposition 2 and Example 4, this utility gain is positive if the distribution of bank affinity, $F(b)$, has an increasing hazard rate and is negative if $F(b)$ has a decreasing hazard rate.

Finally, consider the middle group of consumers with bank affinity in the range $[b_m^*, b_c^*]$. These are likely to be middle-aged people who are highly educated and wealthy. These consumers were using the bank as the payment processor when it was a monopolist, but later switch to a FinTech firm. These consumers benefit from the saved cost p_m^*, but they also lose their bank affinity value b and the additional consumer surplus from the loan market, $q\Delta_{S_\ell}$. As these consumers choose to switch to a FinTech firm, after FinTech entry they must be better off not using the bank. However, it is not clear that their overall consumer surplus is higher after FinTech entry, because the bank changes its price of payment services from p_m^* to p_c^*. If $p_m^* > p_c^*$, then

$$p_m^* - b - q\Delta_{S_\ell} \geq p_m^* - b_c^* - q\Delta_{S_\ell} = p_m^* - q\Delta_{S_\ell} - (p_c^* - q\Delta_{S_\ell}) = p_m^* - p_c^* > 0, \tag{22}$$

where the equality follows from the definition of b_c^*. If, however, $p_m^* < p_c^*$, then by continuity, a consumer benefits from FinTech competition if and only if $b \leq p_m^* - q\Delta_{S_\ell}$. In other words, some consumers who have relatively high bank affinity have switched to FinTech

firms because the bank has increased its price; they would have stayed with the bank had the bank not done so.

The following corollary summarizes this analysis.

Corollary 2.1 *(i) If the distribution of bank affinity $F(b)$ has an increasing hazard rate everywhere, then FinTech competition increases the welfare of each consumer.*

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

The welfare effects are also likely to be heterogeneous across countries. Bank affinity varies with demographic characteristics, and the distribution of such characteristics varies across countries. Thus, different countries may fall into different cases in Corollary 2.1, so a common policy such as PSD2 may have different welfare effects in these countries. Because these welfare implications operate through the price channel, the effects can be determined from observed prices for payment services.

3 Data Transfer

Our results depend on the externality generated by payment services on the loan market. So far, we have implicitly assumed that consumers' payment data cannot be transferred from a FinTech firm to the bank when the consumer needs a loan. In such a situation, some consumers who ex ante choose the FinTech firms for payments may regret this decision ex post if they do require a loan.

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.[4]

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. Thus, the consumer uses the bank if and only if $b_i \geq b_d(p) \equiv p$; that is, a fraction of $F(p)$ consumers use the FinTech firm and the remaining fraction $1 - F(p)$ use the bank.

The bank's total expected profit is therefore

$$\psi_d(p) = (1 - F(p))p + q \int_0^1 \pi_I(r_I^*(\theta), \theta) dG(\theta), \tag{23}$$

where we have used the fact that all consumers who turn out to need loans now transfer their payment data to the bank. Note that the second term, the bank's expected profit from the loan, is not a function of p. Hence, the bank's optimal choice of payment price p is given by

$$p^* \in \arg\max_p (1 - F(p))p. \tag{24}$$

That is, consumer's ability to freely transfer data breaks the bank's vertical integration of the two business lines. The bank no longer takes into account the associated profits in the loan markets in pricing its payment services.

The optimal price when data transfer is free is characterized in the following lemma.

Lemma 4 *If consumers have full ownership of their payment data and can freely transfer these data, then it separates the bank's pricing of the payment services and loan products.*

[4] 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 Condition 1 holds).

The bank's optimal price for payments is characterized by the implicit equation

$$p_d^* = \frac{1 - F(p_d^*)}{f(p_d^*)}. \tag{25}$$

Next, consider consumer welfare with and without data portability. We exhibit consumer welfare for different levels of bank affinity 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 3 below. The various cases in the proposition depend on the signs of Δ_{S_ℓ} and the quantity $\Delta_\pi + \Delta_{S_\ell}$. These are, of course, endogenous terms, since they depend on the bank's offered interest rates in the loan market. In Proposition 1, we have shown that under Condition 1, we have $\Delta_{S_\ell} > 0$. The following lemma provides a sufficient condition for the $\Delta_\pi + \Delta_{S_\ell}$ to be strictly positive.

Lemma 5 *Suppose that* $-\frac{V''(r)}{V'(r)} < 2\frac{h(r)}{1-H(r)}$ *for all* $r > 0$. *Then,* $\Delta_\pi + \Delta_{S_\ell} > 0$.

Observe that the condition in the statement of the lemma is implied by Condition 1, which is intuitive as Δ_π must be non-negative. Thus, whenever $\Delta_{S_\ell} > 0$, it follows that the sum $\Delta_\pi + \Delta_{S_\ell}$ is also strictly positive. Lemma 5 is therefore useful only when $\Delta_{S_\ell} < 0$.

We now characterize how data portability affects consumer welfare.

Proposition 3 *Suppose that* $\Delta_\pi + \Delta_{S_\ell} > 0$ *that is, total surplus is higher when the bank is informed about consumer repayment probabilities. Then, the bank's market share decreases under complete and free portability of consumer payments data; that is,* $b_d^* > b_c^*$. *Further,*

(i) If $\Delta_{S_\ell} > 0$, *then:*

(a) *If the distribution F of bank affinity has a decreasing hazard rate everywhere, then $p_d^* > p_c^*$. Hence, the free portability of data harms consumers with sufficiently high bank affinity values ($b > p_c^*$) and benefits consumers with low bank affinity values ($b < p_c^*$).*

(b) *If, for all b,*

$$\frac{f'(b)}{f(b)} > \left(\frac{\Delta_\pi}{\Delta_{S_\ell}} - 1\right) \frac{f(b)}{1 - F(b)}, \tag{26}$$

then $p_d^* < p_c^*$. Hence, the free portability of data benefits all consumers.

(ii) *If, instead, $\Delta_{S_\ell} < 0$, then all consumers are worse off with free data portability.*

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 affinity 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 equation (26) 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 low affinity for bank services are better off, whereas those with a high affinity 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.

4 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. On the other hand, technologically sophisticated population gain the most, due to the reduction in their cost for payment services.

Applying this model, we also 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 dislocations 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 Appendix

A.1 Analysis of Condition 1

Recall from equation (6) that $V(r) = r - \frac{1-H(r)}{h(r)}$. Therefore,

$$V'(r) = 1 - \frac{h(-h) - (1-H)h'}{h^2} = 2 + \frac{(1-H)h'}{h^2} \tag{27}$$

$$\begin{aligned} V''(r) &= \frac{h^2\{-hh' + (1-H)h''\} - 2hh'(1-H)h'}{h^4} \\ &= \frac{-h^2h' + h(1-H)h'' - 2(1-H)(h')^2}{h^3}. \end{aligned} \tag{28}$$

Now, Condition 1 can be expressed as:

$$\frac{-h^2h' + h(1-H)h'' - 2(1-H)(h')^2}{h^3} > -\frac{h}{1-H}\Big(2 + \frac{(1-H)h'}{h^2}\Big) \tag{29}$$

$$-h^2h' + h(1-H)h'' - 2(1-H)(h')^2 > -\frac{2h^4}{1-H} - h^2h' \tag{30}$$

$$(1-H)^2\{hh'' - 2(h')^2\} > -2h^4 \tag{31}$$

Observe that when $h'' = 0$ equation (31) reduces to

$$(1-H(r))h'(r) < h^2(r)\sqrt{2}. \tag{32}$$

Suppose now that the density of the reservation rate is linear over some range $[0, R]$. That is, for $r \in [0, R]$, we have $h(r) = a_0 + a_1 r$ for some suitable parameter values $a_0 \in [0, \frac{2}{R}]$ and a_1. Then, $h' = a_1$ and $h'' = 0$. Further, $h_0 = a_0$ implies that $a_1 = \frac{2}{R}\Big(\frac{1}{R} - a_0\Big)$.

Now, when $a_1 \leq 0$, it is immediate that equation (32) holds as a strict inequality at any r such that $h(r) > 0$. Thus, when $a_1 \leq 0$, Condition 1 holds as a strict inequality for all $r \in [0, R)$.

Now, suppose $a_1 > 0$; i.e., suppose that $a_0 < \frac{1}{R}$. Consider $r = 0$. At $r = 0$, equation (32) reduces to

$$\frac{2}{R}\Big(\frac{1}{R} - a_0\Big) < a_0^2\sqrt{2}. \tag{33}$$

There exists an $\hat{a} \in (0, \frac{1}{R})$ such that this inequality is satisfied (and hence Condition 1 holds) for $a_0 > \hat{a}$ and the inequality is violated (and hence Condition 1 fails to hold) for $a_0 < \hat{a}$.

Finally, suppose $a_0 < \hat{a}$. Observe that at $r = R$, inequality (32) is trivially satisfied. Therefore, there exists a threshold interest rate $\hat{r} \in (0, R)$ such that Condition 1 is violated for $r < \hat{r}$ and is satisfied for $r > \hat{r}$. ■

A.2 Proofs

Proof of Lemma 1

(i) Suppose the bank is informed about θ. As shown in equation (2), the first-order condition in r is

$$-h(r)(\theta(1+r)-1)+(1-H(r))\theta=0, \tag{34}$$

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

The second-order condition is

$$-h'(r)(\theta(1+r)-1)-2h(r)\theta \quad < \quad 0 \tag{35}$$

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 $\pi_I(r,\theta)\to 0$ as $r\to\infty$. 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. ■

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,

$$\frac{d^2\pi_I}{d\theta^2} \quad = \quad \frac{d}{dr_I^*}\Big(\frac{d\pi_I}{d\theta}\Big)\,\frac{dr_I^*}{d\theta}=\Big(-(1+r_I^*)h+1-H\Big)\frac{dr_I^*}{d\theta}. \tag{36}$$

Now, the first-order condition for optimal interest rate in equation (34) 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, (11), we have

$$\frac{dS_\ell}{d\theta} = \int_r^\infty (x-r)h(x)dx - \theta(1-H(r))\frac{dr}{d\theta} > 0, \tag{37}$$

$$\frac{d^2S_\ell}{d\theta^2} = \underbrace{-2(1-H(r))\frac{dr}{d\theta}}_{>0} + \underbrace{\theta h(r)\left(\frac{dr}{d\theta}\right)^2}_{>0} - \theta(1-H(r))\frac{d^2r}{d\theta^2}. \tag{38}$$

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

$$\frac{dr}{d\theta} = -\frac{1}{\theta^2 V'(r)}, \tag{39}$$

$$\frac{d^2r}{d\theta^2} = \frac{1}{V'(r)}\left[\frac{2}{\theta^3} - V''(r)\left(\frac{dr}{d\theta}\right)^2\right] = \frac{1}{V'(r)}\left[\frac{2}{\theta^3} - V''(r)\frac{1}{\theta^4 V'(r)^2}\right]. \tag{40}$$

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

$$\frac{d^2S_\ell}{d\theta^2} = \frac{1}{\theta^3}\left[\frac{h(r)}{V'(r)^2} + \frac{(1-H(r))V''(r)}{V'(r)^3}\right]. \tag{41}$$

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

$$V''(r) > -\frac{h(r)}{1-H(r)}V'(r), \tag{42}$$

which is Condition 1.

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

Proof of Lemma 2

The first-order condition for profit maximization is derived in the text, and is shown in equation (16). The second-order condition is

$$-2f(b_m(p)) - f'(b_m(p))(p + q\Delta_\pi) < 0. \tag{43}$$

From the first-order condition, at the ofptimal price, $p + q\Delta_\pi = \frac{1-F(b_m(p))}{f(b_m(p))}$. Thus, the second-order condition is satisfied if

$$f'(b) > -\frac{2f(b)^2}{1-F(b)} \tag{44}$$

for all b, which has been assumed in Condition 2. ■

Proof of Lemma 3

The first-order condition for profit maximization, $\psi'(c) = 0$, follows given the expression for $\psi_c(\cdot)$ in equation (19), and reduces to the equation in the statement of the Lemma. The second-order condition too is similar to the condition in Lemma 2. ■

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

$$v + b_i - p_m + qE[S_\ell(r_I^*(\theta), \theta)] < qE[S_\ell(r_U^*, \theta)], \tag{45}$$

or

$$b_i < p_m - v - q\Delta S_\ell. \tag{46}$$

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

$$v + b_i - p_c + qE[S_\ell(r_I^*(\theta), \theta)] \geq v + qE[S_\ell(r_U^*, \theta)], \tag{47}$$

or

$$b_i \geq p_c - q\Delta S_\ell. \tag{48}$$

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

$$0 = \psi_c'(p_c) = 1 - F(p_c - q\Delta S_\ell) - f(p_c - q\Delta S_\ell)(p_c + q\Delta\pi), \tag{49}$$

$$0 = \psi_m'(p_m) = 1 - F(p_m - q\Delta S_\ell - v) - f(p_m - q\Delta S_\ell - v)(p_m + q\Delta\pi). \tag{50}$$

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,

$$0 = \psi_m'(p_m) \leq \psi_m'(v + p_c) = 1 - F(p_c - q\Delta S_\ell) - f(p_c - q\Delta S_\ell)(p_c + v + q\Delta\pi) \tag{51}$$

$$= -f(p_c - q\Delta S_\ell)v < 0, \tag{52}$$

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 (20), it follows that

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

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

$$\frac{1 - F(b_m(p_c^*))}{f(b_m(p_c^*))} > p_c + q\Delta_\pi. \tag{54}$$

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

$$\frac{1 - F(b_m(p_c^*))}{f(b_m(p_c^*))} < p_c + q\Delta_\pi. \tag{55}$$

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

Proof of Lemma 4

The bank's profit when data transfer is free is given in equation (23). The first-order condition $\psi_d'(p) = 0$ directly yields the equation in the statement of the lemma. The second-order condition is satisfied under Condition 2. ■

Proof of Lemma 5

Substitute the value of $\frac{dr}{d\theta}$ from equation (39) into equation (36), to get

$$\frac{d^2\pi_I}{d\theta^2} = -(1 - H(r) - (1 + r)h(r))\frac{1}{\theta^2 V'(r)}. \tag{56}$$

Equation (41) is

$$\frac{d^2 S_\ell}{d\theta^2} = \frac{1}{\theta^3}\left[\frac{h(r)}{V'(r)^2} + \frac{(1 - H(r))V''(r)}{V'(r)^3}\right]. \tag{57}$$

Therefore,

$$\frac{d^2\pi_I}{d\theta^2} + \frac{d^2 S_\ell}{d\theta^2} = \frac{h(r)}{\theta^2 V'(r)^2}\left[\underbrace{-\frac{1-H(r)}{h(r)} + (1+r)}_{=\frac{1}{\theta}\text{, by equation (3)}} + \frac{1}{\theta} + \frac{1-H(r)}{h(r)}\frac{V''(r)}{\theta V'(r)}\right]. \tag{58}$$

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

$$V''(r) > -2\frac{h(r)}{1-H(r)}V'(r)\text{for all } r, \tag{59}$$

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

Proof of Proposition 3

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

$$0 = \psi_c'(p_c^*) = 1 - F(p_c^* - q\Delta_{S_\ell}) - f(p_c^* - q\Delta_{S_\ell})(p_c^* + q\Delta_\pi), \tag{60}$$

$$0 = \psi_d'(p_d^*) = 1 - F(p_d^*) - f(p_d^*)p_d^*. \tag{61}$$

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

$$\begin{aligned} 0 = 1 - F(p_d^*) - f(p_d^*)p_d^* &\geq 1 - F(p_c^* - q\Delta_{S_\ell}) - f(p_c^* - q\Delta_{S_\ell})(p_c^* - q\Delta_{S_\ell}) \\ &= f(p_c^* - q\Delta_{S_\ell})q(\Delta_\pi + \Delta_{S_\ell}) > 0, \end{aligned} \tag{62}$$

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 $b_d^* > b_c^*$.

Next, consider the effects on consumer welfare. As shown in Table 4, the change in welfare of consumers with affinity $b < b_c^*$ is just $q\Delta_{S_\ell}$. This term is clearly positive if $\Delta_{S_\ell} > 0$, which holds under Condition 1, and negative if $\Delta_{S_\ell} < 0$.

The change in welfare for consumers with bank affinity $b \geq b_c^*$ depends on

To show how the free portability of data affects the price for payment services, we observe that the expression for $\psi_d'(p)$ is obtained if we start from the expression of $\psi_c'(p)$ and then let

$q \downarrow 0$. Denote by p_c^* the solution for $\psi_c'(p_c^*) = 0$. Taking the total derivative of the first-order condition with respect to q, we get

$$0 = \Big(-2f(p_c^* - q\Delta S_\ell) - f'(p_c^* - q\Delta_{S_\ell})(p_c^* + q\Delta_\pi)\Big) dp_c^* \\ + \Big(f(p_c^* - q\Delta S_\ell)\Delta_{S_\ell} + f'(p_c^* - q\Delta S_\ell)(p_c^* + q\Delta_\pi)\Delta_{S_\ell} - f(p_c^* - q\Delta_{S_\ell})\Delta_\pi \Big) dq, \tag{63}$$

or

$$\frac{dp_c^*}{dq} = \frac{f(b_c^*)[\Delta_{S_\ell} - \Delta_\pi] + f'(b_c^*)[p_c^* + q\Delta_\pi]\Delta_{S_\ell}}{2f(b_c^*) + f'(b_c^*)[p_c^* + q\Delta_\pi]} \tag{64}$$

The denominator is nonnegative because of the second-order condition at the optimal p_c^*, but the numerator could be positive or negative.

Now, consider the welfare effects of free data transfer.

(i) 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.

(a) Suppose 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 $\frac{dp_c^*}{dq}$ in equation (64) may be written as

$$= f(b_c^*)(\Delta_{S_\ell} - \Delta_\pi) + f'(b_c^*)\frac{1 - F(b_c^*)}{f(b_c^*)}\Delta_{S_\ell}, \tag{65}$$

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

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

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.

(b) Suppose that, for all b,

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

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.

(ii) Suppose that $\Delta_{S_\ell} < 0$. 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.

■

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