Liability, Information, and Anti-fraud Investment in a Layered Retail Payment Structure

-Incomplete and Preliminary -

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February 12, 2016

Abstract

Motivated by recently introduced retail payment schemes using information technology, often called "FinTech," we examine the effects of the fraud liability regime and the information accessibility on the incentive for the anti-fraud investment in a vertically separated payment scheme. It is shown that, under full liability regime in which one of the service providers is responsible for the recovery of fraud loss, the anti-fraud investment is made more by parties with the liability and with higher bargaining power, and the anti-fraud investment is socially sub-optimal. The sub-optimality still holds when the liability is imposed proportionally to the portion of the surplus for each service provider. When the FinTech payment service provider(FPP) raises its revenue other than from the fee, the integrated payment service provider (IPP) would cooperate with the FPP only under the FPP liability regime, in which case the FPP increases the anti-fraud investment.

Key Words: Payment System, Fraud, Liability, FinTech

1 Introduction

The retail payments landscape is characterized by a wide diversity of payment instruments and activities at different stages of the payment process. The rapid progress in information and communication technology (ICT) has led to new types

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of enhanced ICT-based retail payments services, often referred to as "FinTech," in recent days.

Retail payment schemes are characterized by a multi-layered structure. A retail payment service provider needs to complete all stages of the payment process (see Figure 1 in Appendix).[1] Thanks to the tiered structure, the provider does not need to own all the necessary facilities and licenses for processing all stages of the payment chain. Many of the recent FinTech payment schemes such as Apple Pay and Samsung Pay have the structure of "platform on the platform," and can provide a broad range of retail payment services, including offline transactions, based on their user base obtained from their products or services such as mobile devices, operating system, messaging services, and so on.

The introduction of FinTech payment services, however, complicates the structure of the retail payment system, and may possibly increase the vulnerability of the payment system security and incidents such as fraudulent transactions and data breaches. For example, a sudden increase of fraudsrelated with the Apple Pay was a big issue in March 2015.[2] The introduction of FinTech payment scheme adds a layer, or layers, to the payment system. This addition first increases the vulnerability of an information system as the number of inter-institution transfer of information increases. Moreover, the increased number of participants in the payment system also complicates the design of payment schemes, which coordinates the participants' incentive for ex-ante investment (and ex-post handling) to reduce the financial transaction accidents such as frauds and data breaches. As Anderson and Moor (2006) note, the former may be addressed with an engineering approach, but the latter requires an economic approach, which gives implications about the design of an incentive scheme that provides appropriate rights and responsibilities to each participant.

This study examines this problem by investigating the effect of the information accessibility and liability regime on the investment incentive to reduce the financial accidents and the resulting users' welfare in a vertically separated payment scheme. We propose a parsimonious model of vertically separated payment scheme, and compare regimes varying the liability of financial transaction accidents. Our theoretical analysis shows that, under mild assumptions, the anti-fraud investment is made more by parties with the liability and, with the same share of the surplus, the FPP invests

[1] CPMI (2014) of Bank for International Settlements categorizes the payment process into five stages: (i) pre-transaction, (ii) authorization, (iii) clearing, (iv) settlement, and (v) post-transaction.

[2] At one point, a mobile payments advisor said "6 percent of Apple Pay purchases are completed with stolen cards"(Tsukayama and Halzack, 2015) while others dismiss such claims.(Paglier, 2015)

more than the the integrated payment platform (IPP) such as credit card companies and issuer/acquirer banks. Our results also show that the IPP would provide the core function or allow the information accessibility to the FPP only under the FPP liability regime. In this case, the FPP makes more anti-fraud investment.

The result gives a policy implication that the information accessibility and fraud liability need to go together. Information in a payment scheme include user identities/characteristics, user credit history, and transaction records. Many FinTech service providers, while many of them are not allowed to have transaction records under current circumstances, are positioned to have better knowledge about the user characteristics than the traditional payment service provider. Noting that the FinTech service providers create revenue from synergy effects of convergence, the transaction records may help them to enter the market. Thus, by combining fraud liability for the party with information accessibility, the internalization of security investment externality can be achieved. The result is also consistent with observations from retail payments markets. Google Wallet, which was launched in 2011, has never gained any momentum partly because banks are reluctant to share the payment information with Google. To the contrary, Apple Pay, which was launched in 2014, does not keep such information and has shown the more successful result so far.[3]

Varian (2004) and, more recently, Creti and Verdier (2014) identify the public good nature of information security in the sense that there is a positive spillover effect, which leads to the free-riding problem within the payment system. As for the investment decisions by participants of a "system," Varian (2004) is the first one which analyzes the reliability of information systems using a public-good, game-theoretic framework, following the model of Hirshleifer (1983), known as "weakest-link or best shot." Varian adds a third case of sum-of-efforts and shows that sum-of-efforts is the best, while weakest-link is the worst of all. His analysis also tells us that as more agents are added, systems become more reliable in the total-effort case, but less reliable in the weakest-link case. We also adopt this approach and propose an internalizing scheme of the externality in information security where a FinTech payment service provider exists as a front-end, or downstream, service provider.

Several theoretical analyses of data breach present equilibrium results where the welfare is not maximized without regulation. Schreft (2007) examines whether or not

[3]Like Apple, Google also has its tokenization technology, called Host Computer Emulation (HCE), which isolates the payment information from a device. Google had not, however, adopt it until the launch of Android Pay in 2015. Some argue that Google's advertisement-based business model hindered the adoption of tokenization technology (Hwang, Kim, and Lee, 2015).

the markets could limit the risk that identity theft poses to the payment system and finds that the markets fail to curtail this risk due to existing market imperfections. Kahn and Roberds (2008) study identity and its use in credit transactions to find the equilibrium incidence of identity theft, which represents a tradeoff between the necessity to control transaction fraud and the wish to avoid intrusive monitoring of individuals. The results indicate that advances in technology will not diminish this tradeoff in equilibrium. Roberds and Schreft (2009) explore the implications of networks' collection of personal information data, data security, and costs of identity theft using a monetary-theoretic model. They find that too much data collection and too little security arise in equilibrium with non-cooperative networks compared with the efficient allocation. They propose potential regulatory policies such as mandated security levels and data-breach costs reallocation. Anderson and Moor (2006) and Sullivan (2013) also consider similar issues.

The structure of the electronic payment system with vertical separation is investigated in Rochet and Tirole (2003), Rochet (2007), Rochet and Tirole (2011), and Armstrong (2006).[4] Jun and Yeo (2016) directly focus on the impacts of the introduction of FinTech service added to the vertical structure of payment scheme. While the focus of these studies are the changes in competitive environments in retail payments markets, we focus more on the investments on the security and welfare, and, for this purpose, abstract the 'two-sidedness' from models of the previous literature.

Our study is most similar to the analysis of Creti and Verdier (2014), who examine the effects of liability regimes on the anti-fraud investments. They show that the price structure is biased in favor of participants without liability, and the social welfare is maximized when consumers have no liability. The results are derived from the assumption that the anti-fraud investment can be made only by the merchant, while liability is imposed either on the platform or on the consumer. Though Creti and Verdier (2014) raise important and interesting issues, they do not consider the vertically separated payment scheme and thus allocation of liability as we do.

The rest of this paper is organized as follows. We propose a model of a multi-layered payment scheme in section 2. In section 3, the equilibrium investment decisions depending on the liability regimes are examined. In section 4, we extend the model to incorporate the real world business model of the FPP. One of the key issues in the section is the effect of information accessibility. The final section concludes and discusses the specifications of the model used in this paper for future research.

[4] For survey of the papers and policy implications, see Yoon (2014).

2 Model

There are four participants in the market for the retail payment: U, the integrated payment platform(IPP, hereafter), D, Fin-Tech payment service provider(FPP, hereafter), M, a seller or a merchant, and C, a buyer or a consumer. Let $j \in J = \{M, C, U, D\}$ be the index for each participant. In the traditional electronic payment system, participants are M, C, and U, while in the newly introduced payment system, which we call 'Fintech Payment System(FPS),' all four participants take parts in.

It is assumed that, before the introduction of FPP, the IPP was the the monopolistic payment service provider. It provides core functions for payment such as payment approvals, clearings, settlements, and so on. It also provides services for merchants and consumers in the traditional electronic payment scheme such as payment card. For simplicity, assume there is no issuer and acquire in the model, that is, the platform is vertically integrated in the traditional payment scheme providing 'end-to-end services'.

On the other hand, in the FPS, the payment system is vertically separated. We assume the Fin-Tech service provider enters the payment service market as a front-end service provider. It provides mainly services for the merchant and the consumer, while the IPP provides the core functions.

From a transaction, the consumer enjoys two types of benefits. First, she gets the consumer surplus from the good/service he purchases, which we assume constant. Secondly, she enjoys the benefit from payment using FPS over using the traditional payment instrument, denoted by b. The benefit is mainly due to the reduction of the transaction cost. Following Rochet and Tirole (2003) and Rochet and Tirole (2011), the benefit is assumed to be probabilistic with density function f. For simplicity, we further assume the distribution is uniform on $[0, \bar{b}]$.

Regarding the merchant, we apply 'price coherence' on the price for products the merchant sells. That is, the merchant cannot discriminate the prices conditional on the payment instrument the consumer decides to use.[5] In addition, we assume the merchant gets no benefit from the adoption/acceptance of the FPS. It follows that the IPP and/or the FPP cannot charge any fee on the adoption/acceptance

[5]In Rochet and Tirole (2011), the price coherence is the equilibrium outcome. In many countries in past years, it had been implemented by the network rule made by the payment platform, so called 'no surcharge rule, until competition authorities and courts prohibits it. In Korea, no surcharge rule is legal regulation. We assume, even without such regulation or network rule, the price coherence holds mainly due to the competition among merchants.

of the FPS.[6] Finally, we also assumes the merchant has no option to invest on the transaction security.[7]

The IPP charges fee per transaction for the traditional payment service only on the merchant, which is fixed at f_0. In case of the FPS, the FPP charges additional fee f on the usage of the FPP to the consumer, and pays to the IPP for its service of core functions. We assume that the additional profit from the fee charged on the transaction using FPP is shared with FPP, letting $0 < \mu < 1$ be the portion that the platform takes.

For a transaction through FPS, there is an probability that a transaction is breached because of a financial transaction accident. To focus on the effect of the introduction of FPS, we consider the *additional probability* the the FPS induces. The probability of such accident, denoted by x, is assumed to be given exogenously. When the accident occurs, the loss $L > 0$ is incurred, which should be recovered by the party liable. We consider two liability regimes; the integrated payment platform regime and the Fin-Tech service provider regime. We assume that the participant who has the liability is fully responsible for the recovery of the loss (No Partial Liability).[8] We assume there is no cost, both for the IPP and the FPP, to provide the FPS, which does not affect the qualitative results of the paper.

The financial accident can be prevented with some probability when participants invests on the payment security. We let $p(e_U, e_D)$ be probability that the transaction accident is prevented, where e_j is the investment by participant j. Let $e = (e_U, e_D)$. Then, $q(e_U, e_D) \equiv 1 - p(e_U, e_D)$ is the probability that the transaction accident is not prevented, and $Lxq(e_U, e_D)$ is the expected loss. We assume the followings;

Assumption 1 *The probability that the transaction accident is not prevented, $q(e_U, e_D)$ satisfies;*

i) $\frac{\partial q(e)}{\partial e_j} < 0$ *for all* $j = U, D$,

ii) $\frac{\partial^2 q(e)}{\partial e_j^2} > 0$ *for all* $j = U, D$,

[6] The payment providers may charge fees to the merchant for some technical reasons. However, if we assume the perfect pass-through rate, the result is identical to the case of the model. Note that perfect pass-through rate is the result of the equilibrium in various market structures such as the perfect competition, monopoly, and Hotelling type's differentiated product market.

[7] Creti and Verdier (2014) assumes only the merchant has an option to invest. Again, assuming the perfect pass-through, the results would be the same as the case of investment by the consumer only in this paper.

[8] Creti and Verdier (2014) considers partial liability of the consumer. We ignore such case because we are mostly interested in the allocation of liability and information accessability *among service providers.*

iii) $\frac{\partial^2 q(e)}{\partial e_U \partial e_D} < 0$.

The second assumption implies diminishing returns to the investment, and the third assumption implies the efforts by each service provider are strategic complements in reducing fraudulent transactions and is required for the existence of the equilibrium.

Though the consumer is not responsible for the recovery of the loss, she suffers from the disutility when financial transaction occurs. Such disutility may reflects the cost to claim, the time for the delayed purchase or the refund, and any inconvenience due to the accident. It also reflects the reliability of the payment system. Thus, it is natural to assume the disutility depends on the probability of the accident $xq(e_U, e_D)$). For simplicity, we assume the disutility is linear, letting $c(xq(e_U, e_D)) \equiv cxq(e_U, e_D)$, where c is a positive constant.[9]

Timing of the game is as follows: The liability regime and information accessibility are given ex-ante. In the first stage, participants decides the amount of investment simultaneously. After observing the investments, the FPP decides the fee f. Finally, the transaction is made, and if transaction accident occurs, settlement is made according to the liability rule. We adopt Subgame Perfect Nash equilibrium as the solution concept.

3 Liability and Anti-fraud Investments

3.1 Integrated payment platform liability regime

We analyze the model of the FPP as an option for payment, varying liability regimes turn by turn. We first examine the IPP liability regime.

Applying backward induction, consider the second stage game first. Given observed e, the consumer compare the benefit from the usage of FPP and the cost which is composed of the fee and the cost due to the increased risk of fraud. The FPS confronts the trade-off between decrease in consumer using FPP and increase in the fee. We have the following lemma.

Lemma 1 *Given the first stage investment $e = (e_U, e_D)$, the second stage Nash equilibrium is the optimal fee f^* and threshold consumer $\hat{b}^*$ which satisfies*

[9] It would be more natural to assume $c(\cdot)$ is increasing convex($c' > 0$, $c'' > 0$), because as the probability of such accident increases, the reliability of the payment system may be increasingly disrupted. However, the linear assumption does not change the qualitative results while makes the analysis much simpler.

$$f^*(e) = \frac{\bar{b} - cxq(e)}{2}, \tag{1}$$

and

$$\hat{b}^*(e) = \frac{\bar{b} + cxq(e)}{2}. \tag{2}$$

Proof) The consumer with benefit b would use the FPP if and only if $b - f - c(xq(e)) \geq 0$. Let the threshold consumer be $\hat{b}$. Then, we have

$$\hat{b} = f + c(xq(e)) \tag{3}$$

. Noting that the cost of anti-fraud investment is a sunk cost at the second stage, the second stage surplus of FPP from consumer's usage of the FPS, denoted by S_F, is

$$\begin{aligned} S_F(f) &= (1-\mu)\int_{\hat{b}}^{\bar{b}} f dH \\ &= (1-\mu) f \cdot \frac{\bar{b} - \hat{b}}{\bar{b}} \\ &= (1-\mu) f \cdot \frac{\bar{b} - f - cxq(e)}{\bar{b}} \end{aligned}$$

under the assumption of the uniform distribution of b. The surplus maximizing fee is from the the first order condition, and the equilibrium threshold consumer is from equation (3), which completes the proof. ■

Now, consider the first stage game. From the equilibrium fee in the second stage game, the total equilibrium surplus S^{eq} is

$$S^{eq}(e) = \int_{\hat{b}^*(e)}^{\bar{b}} f dH = \frac{(\bar{b} - cxq(e))^2}{4\bar{b}} \tag{4}$$

. Then, the equilibrium surplus for $j = U, F$ is $S_j^{eq} = \mu_j S^{eq}(e)$. Anticipating the equilibrium fee and resulting surplus in the second stage, payment service providers U and D choose their level of anti-fraud investment. The profit function depends on who is liable for the loss. Under the IPP liability regime, the profits of IPP and FPP, denoted by π_U and π_F, respectively, are as follow:

$$\begin{aligned} \pi_U &= \mu S^{eq}(e) - \int_{\hat{b}^*}^{\bar{b}} Lxq(e) dH - e_U \\ &= \mu \frac{(\bar{b} - cxq(e))^2}{4\bar{b}} - \frac{\bar{b} - cxq(e)}{\bar{b}} Lxq(e) - e_U, \end{aligned} \tag{5}$$

$$\pi_D = (1-\mu)S^{eq}(e) - e_D = (1-\mu)\frac{(\bar{b} - c(xq(e))^2}{4\bar{b}} - e_D. \tag{6}$$

The best response function is derived from the first order condition of π_U and π_D, and the Nash equilibrium of the first stage game is, as long as it exists, derived from the simultaneous equation of the two first order conditions. The following proposition characterizes the equilibrium. The proof is presented in the Appendix A2.

Proposition 1 *Under the IPP liability regime, for sufficiently low $x > 0$, the Nash equilibrium $e^* = (e_U^*, e_D^*)$ of the first stage game exists and satisfies the following equations;*

1. $\frac{-\mu cx}{2\bar{b}}(\bar{b} - cxq(e^*))\frac{\partial q(e^*)}{\partial e_U} - \frac{Lx}{\bar{b}}(\bar{b} - 2cxq(e^*))\frac{\partial q(e^*)}{\partial e_U} = 1,$
2. $\frac{-(1-\mu)cx}{2\bar{b}}(\bar{b} - cxq(e^*))\frac{\partial q(e^*)}{\partial e_D} = 1.$

With large $x > 0$, the cost from the increasing risk of FPS overwhelms the benefit from its usage, and the optimization problems lead to corner solutions in which no consumer use FPP in equilibrium. Note that as x and L increases, both of the best response functions of U and D are upward moving, which implies that the investments level of both service providers increase. In addition, other things being equal, as μ increases, the best response function of U moves upward while the best response function of D moves downward, which leads to increase in the investment by U and decrease in that by D. This suggests that the party with high bargaining power in sharing the surplus invests more.

The effect of the anti-fraud investments can be decomposed of two effects. To see this, consider equation (16) of the partial derivative of π_U with respect to e_U;

$$\frac{\partial \pi_U}{\partial e_U} = \underbrace{\frac{-\mu cx}{2\bar{b}}(\bar{b} - cxq(e))\frac{\partial q(e)}{\partial e_U}}_{\text{indirect marginal effect}} \quad \underbrace{-Lx\frac{\partial q(e)}{\partial e_U}}_{\text{direct marginal effect}}$$
$$+ \underbrace{\frac{2cx^2Lq(e)}{\bar{b}}\frac{\partial q(e)}{\partial e_U}}_{\text{interacted effect}} - \underbrace{1}_{\text{marginal cost}}.$$

The first term is the indirect effect of the investment where higher anti-fraud investment induces more consumer to use the FPP and the FPS can charge higher fee at the same time. The second term is the direct effect of the investment reflecting the reduction of expected liable loss due to the investment. The third term is the interacted effect where the anti-fraud investment induces more consumers, which increases the expected loss from the fraudulent transactions. The second term is positive while the third term is negative, but with sufficiently small $x > 0$, the sum of the second and third terms is positive.

The optimal choice of the FPP in the first stage is similar to that of U, except for that the FPP is not responsible for the loss, as we can see on the following decomposition. Note that there is no direct effect for the FPP.

$$\frac{\partial \pi_D}{\partial e_D} = \underbrace{\frac{-(1-\mu)cx}{2\bar{b}}(\bar{b} - cxq(e))\frac{\partial q(e)}{\partial e_D}}_{\text{indirect marginal effect}} - \underbrace{1}_{\text{marginal cost}}.$$

The indirect effect of the investment by the U, $-Lx\partial q(e^*)/\partial e_U$ is positive, which implies that, given equal share of the surplus ($\mu = 1/2$), the best response function of the U is higher than that of D. Thus, the equilibrium investment by U is higher than that by D. We have the following corollary.

Corollary 1 *Under the IPP liability regime, the anti-fraud investment level by each payment service provider is increasing in the probability of the accident, the size of the loss, and the portion that it gets from the surplus. With the equal share of the surplus, the IPP invests more than the FPP.*

3.2 Fin-Tech service provider liability regime

The FPP regime is symmetric with the IPP liability regime. The second stage game is identical to what we have shown in the previous subsection, and in the first stage game, the only difference lies in who is liable for the loss. We state the equilibrium and the implication without further explanation.

Proposition 2 *Under the FPP liability regime, for sufficiently low $x > 0$, the Nash equilibrium $e^* = (e_U^*, e_D^*)$ of the first stage game exists and satisfies the following equations;*

1. $\frac{-\mu cx}{2\bar{b}}(\bar{b} - cxq(e^*))\frac{\partial q(e^*)}{\partial e_U} = 1.$
2. $\frac{-(1-\mu)cx}{2\bar{b}}(\bar{b} - cxq(e^*))\frac{\partial q(e^*)}{\partial e_D} - \frac{Lx}{\bar{b}}(\bar{b} - 2cxq(e^*))\frac{\partial q(e^*)}{\partial e_D} = 1,$

Corollary 2 *Under the FPP liability regime, the anti-fraud investment level by each payment service provider is increasing in the probability of the accident, the size of the loss, and the portion that it gets from the surplus. With the equal share of the surplus, the FPP invests more than the IPP.*

3.3 Social optimum and efficiency of the market equilibrium

To figure out whether the equilibrium investment under a certain regime is socially optimal, sub-optimal, or super-optimal, we need to compare equilibrium q with socially optimal q. Let the social welfare function be SW.

$$SW(e, \tilde{b}) = \int_{\tilde{b}}^{\bar{b}} b - (c+L)xq(e)dH - e_U - e_D \tag{7}$$

From the first order condition, the socially optimal threshold consumer $\tilde{b}^{SO}$ must satisfy $\tilde{b}^{SO} = (c+L)xq(e^{SO})$. Different from the market equilibrium, the threshold depends on the loss from the fraudulent transaction. Given the socially optimal threshold, the optimal investments by $j = U, D$ must satisfy;

$$\begin{aligned}
&- \frac{(c+L)x(\bar{b} - \tilde{b}^{SO})}{\bar{b}} \frac{\partial q(e^{SO})}{\partial e_j^{SO}} - 1 \\
&= -\frac{(c+L)x}{\bar{b}} (\bar{b} - (c+L)xq(e^{SO})) \frac{\partial q(e^{SO})}{\partial e_j} - 1 \\
&= 0
\end{aligned} \tag{8}$$

By summing up the marginal social welfare functions for $j = U, D$ side by side, we get the following equations;

$$-\frac{(c+L)x}{\bar{b}} (\bar{b} - (c+L)xq(e^{SO})) \left(\frac{\partial q(e^{SO})}{\partial e_U} + \frac{\partial q(e^{SO})}{\partial e_D} \right) = 2 \tag{9}$$

To compare the social optimum with the equilibrium outcome under the IPP liability regime, consider two equations in Proposition 1. To make the comparison easy, suppose that the IPP and FPP equally shares the second period surplus, i.e., $\mu = 1/2$. Then, by adding up the two equations side by side and rearranging it, we get

$$-\frac{(c+L)x}{\bar{b}} (\bar{b} - cxq(e^*)) \left(\frac{\partial q(e^*)}{\partial e_U} + \frac{\partial q(e^*)}{\partial e_U} \right) + \Psi = 2 \tag{10}$$

, where

$$\Psi = \frac{Lx}{\bar{b}} (\bar{b} - cxq(e^*)) \frac{\partial q(e^*)}{\partial e_D} + \frac{Lx}{\bar{b}} cxq(e^*) \frac{\partial q(e^*)}{\partial e_U} \tag{11}$$

$$= Lx \frac{\partial q(e^*)}{\partial e_D} + \frac{cLx^2}{\bar{b}} q(e^*) \left(\frac{\partial q(e^*)}{\partial e_U} - \frac{\partial q(e^*)}{\partial e_D} \right) \tag{12}$$

The formula Ψ represents the distortion of the equilibrium outcome from the social optimum. The first term of (11) is the direct distortion due to the lack of liability on the FPP, and the second term is the indirect distortion due to the interaction effect. Note that from Assumption 1 the first term of (12) is negative, and from Proposition 1, because $e_U^* > e_D^*$ under the IPP liability regime, the second term of it is also negative. It implies that the overall incentive for anti-fraud investment in market equilibrium is less than the socially optimal level. Due to the symmetry, the result would the same in the case of the FPP liability regime.

Proposition 3 *With the equal share of the surplus, the anti-fraud investment is socially sub-optimal under the IPP and FPP liability regime.*

3.4 Proportional liability regime

So far, we assume that one party, either the IPP or FPP, is fully liable for the loss from the fraudulent transaction. The assumption is plausible under the current regulation or the market convention, one may think of other liability regime to reduce the distortion. Proportional liability regime in which each party is to be liable for the portion of the loss and the portion is proportional to its share of the surplus. This *proportional liability regime*, however, does not fully recover social optimum.

To see this, consider the case in which the IPP is responsible for μ portion of the loss while the FPP is for $(1-\mu)$ portion of it. Then, it is straightforward that the equilibrium e^* satisfies the following two equations;

1. $\frac{-\mu cx}{2\bar{b}}(\bar{b} - cxq(e^*))\frac{\partial q(e^*)}{\partial e_U} - \frac{\mu Lx}{\bar{b}}(\bar{b} - 2cxq(e^*))\frac{\partial q(e^*)}{\partial e_U} = 1,$
2. $\frac{-(1-\mu)cx}{2\bar{b}}(\bar{b} - cxq(e^*))\frac{\partial q(e^*)}{\partial e_D} - \frac{(1-\mu)Lx}{\bar{b}}(\bar{b} - 2cxq(e^*))\frac{\partial q(e^*)}{\partial e_D} = 1.$

Adding up two equations and rearranging it yields the following equation

$$\begin{aligned} &-\frac{(c+L)x}{\bar{b}}(\bar{b} - cxq(e^*))\left(\frac{\partial q(e^*)}{\partial e_U} + \frac{\partial q(e^*)}{\partial e_U}\right) \\ &+\frac{cLx^2}{\bar{b}}q(e^*)\left(\frac{\partial q(e^*)}{\partial e_U} - \frac{\partial q(e^*)}{\partial e_D}\right) \\ &= 2 \end{aligned} \tag{13}$$

Compared to the social optimum in (9), there still remains the negative distortion, though the distortion is smaller than the outcome under the full liability regime. The result is due to the interaction effect. Reducing the probability of the fraudulent transactions directly decreases the expected loss, but it also increases the consumer base. The latter effect increases revenue not only the investing party but also the other party. Thus, even under the proportional liability regime, the positive externality from the investment is not fully internalized.

Proposition 4 *The anti-fraud investment is socially sub-optimal under the proportional liability regime, but the distortion is smaller than those under the full liability regimes.*

4 Fin-Tech and Anti-fraud Investments

4.1 Fin-tech business models

In the previous section, we examines the effect of the liability regime on the anti-fraud investments. In doing so, we presumes that the IPP and the FPP are quite symmetric in their revenue raising; both of them earn their revenue from the fee on the consumer. In this line, the FPP is not distinguished from other payment service providers in a layered payment structure. As noted in the introduction, however, the FPS is characterized as a *platform on the platform*, and the FPP's business model in real world might be different from what is described.

In most cases, the FPPs are non-financial institutions and make their profits from their own platform. Among others, there are two prominent types of business model for the FPPs. First, in case of Apple Pay or Samsung Pay, the FPP is device manufacturer and its main source of the revenue is the device sales. In this case, the FPP is mainly interested in increasing the consumer base, not fee raising. Secondly, in case of Google Wallet and Naver Pay, the FPP is the platform software provider. In this case, the source of the revenue is complicated. The FPP may raise revenue from the fee, but they are also interested in the information from the FPS usages and raises revenue from the platform business using the information.

Taking this business model of the FPPs into account, in this section, we analyzes the impact of the liability regimes on the anti-fraud investment, when the source of the revenue of the FPP is not the fee from users.

4.2 Lump-sum revenue from FPS adoption

When the FPP raises its revenue from the users who adopts the FPS, its objective is to increase the consumer base. In this case, in the second stage of the game, the equilibrium fee would be $f^* = 0$, and marginal consumer is $\hat{b}^* = cxq(e)$.[10] Now, consider the first stage game. An interesting feature of the model in this case is that the IPP would not cooperate with the FPP without lump-sum transfer under the IPP liability regime. This is because, the fee is the same as what it charges to

[10]Note that zero fee means the fee is the same as what the traditional electronic payment scheme charges.

the traditional scheme users, raising no revenue, while it incurs costs from increased financial accidents. Thus, let's focus on the FPP liability regime.

Under the FPP liability regime, note that the IPP has no incentive to invest on the prevention of the frauds. Let the revenue of the FPP be proportional to the user base, i.e., $\pi_D = \gamma I[b \geq \hat{b}^*]$, where $I[\cdot]$ is the indication function and $\gamma > 0$. Then,

$$\begin{aligned}\pi_D &= \int_{\hat{b}}^{\bar{b}} \gamma - Lxq(e)dH - e_D \\ &= \frac{\bar{b} - cxq(e)}{\bar{b}} (\gamma - Lxq(e)) - e_D \end{aligned} \tag{14}$$

and the first order condition gives

$$\begin{aligned}\frac{\partial \pi_D}{\partial e_D} = & \underbrace{-\frac{\gamma cx}{\bar{b}} \frac{\partial q(e)}{\partial e_D}}_{\text{indirect marginal effect}} \underbrace{-Lx\frac{\partial q(e)}{\partial e_D}}_{\text{direct marginal effect}} \\ &+ \underbrace{\frac{2cx^2 Lq(e)}{\bar{b}} \frac{\partial q(e)}{\partial e_U}}_{\text{interacted effect}} \underbrace{-1}_{\text{marginal cost}} \\ &= 0\end{aligned}$$

Comparing the result with the result in the previous section, the FPP invests more because the effect of the investment on increasing the user base is higher and the revenue is not shared with the IPP. Note, however, that the effect of the information accessibility on the total anti-fraud investment in equilibrium is ambiguous, because it depends on the shape of q.

Proposition 5 *When the revenue of the FPP is proportional to the user base, only the FPP liability regime is viable. In that case, as long as the profit ratio(γ) is not small, the anti-fraud investment by the FPP is higher than when the FPP raises the revenue from the fee.*

4.3 Personalized surplus extraction from FPS usage

When the FPP raises its revenue from platform business using the personal information of the user benefit, the key issue is the accessability of the information. If the FPP has the right to access the information regarding the transaction records, it has higher chance to incorporate the information to what it already knows; the information regarding the user characteristics. In this case, the FPP can raise its revenue not resorting to the fee by expropriating the transaction benefit from the

FPS usage. For example, the operating system providers or internet/mobile portals may increase their profits by personalized advertisements when they can access the transaction data and match them to the personalized data. Such surplus extraction without fee charges, of course, can be made without transaction data, as long as the FPP knows the transaction benefit distribution. However, it is clear that the transaction data help the FPP to extract the surplus based on the personalized benefit. In this case, in a sense, the fee structure would be similar to the two-part tariff by the monopolist. The FPP then has an incentive to lower the fee and raise the revenue from other sources. In addition, the accessibility may increase the productivity of the anti-fraud investment by the FPP.

To capture the idea, we consider an extreme case; in the second stage game, the FPP can extract full user surplus, letting the fee as lower as possible. Then, the equilibrium fee would be $f^* = 0$, and marginal consumer is $\hat{b}^* = cxq(e)$, the same as the case of the previous subsection.

Now, consider the first stage game. Again, the IPP would not cooperate with the FPP without lump-sum transfer under the IPP liability regime. Focusing on the FPP liability regime, the profit of the FPP is

$$\begin{aligned}\pi_D &= \int_{\hat{b}}^{\bar{b}} b - Lxq(e)dH - e_D \\ &= \frac{\bar{b}^2 - c(xq(e_D))^2}{2\bar{b}} - \frac{\bar{b} - cxq(e_D)}{\bar{b}} Lxq(e_D) - e_D \end{aligned} \tag{15}$$

and the first order condition gives

$$\begin{aligned}\frac{\partial \pi_D}{\partial e_D} = & \underbrace{\frac{-cxq(e)}{\bar{b}}\frac{\partial q(e)}{\partial e_D}}_{\text{indirect marginal effect}} \underbrace{-Lx\frac{\partial q(e)}{\partial e_D}}_{\text{direct marginal effect}} \\ & + \underbrace{\frac{2cx^2Lq(e)}{\bar{b}}\frac{\partial q(e)}{\partial e_U}}_{\text{interacted effect}} \underbrace{-1}_{\text{marginal cost}} \\ & = 0\end{aligned}$$

Comparing the result with the result without information accessibility, the FPP invests more when it has accessibility because it the effect of the investment on increasing the user base is high and the revenue is not shared with the IPP. If we assume the productivity of anti-fraud investment is higher with information accessibility than without it, we can easily see that there is bigger investment incentive for the FPP in the former case. Note, however, that the effect of the information accessibility on the total anti-fraud investment in equilibrium is ambiguous, which depends on the shape of q.

Proposition 6 *When the FPP needs to use the personal information of the user benefit to raise the revenue, without lump-sum transfer, the IPP would not allow the information accessability under the IPP liability regime. The FPP increases the anti-fraud investment when information accessibility is allowed.*

5 Discussions and Conclusion

In this paper, based on a parsimonious payment platform model with vertical separation, we characterise the usage fee and and anti-fraud investment decisions in equilibrium. We show that, under full liability regime, the anti-fraud investment is made more by parties with the liability and with higher bargaining power, and the anti-fraud investment is socially sub-optimal. The sub-optimality still holds under the proportional liability regime, even though the distortion is smaller than that under full liability regime. We also show that when the FPP raises its revenue other than from the usage fee, the IPP would cooperate with the FPP only under the FPP liability regime, in which case the FPP increases the anti-fraud investment. In particular, when the FPP raises the revenue from its own platform using the user transaction information, the IPP would allow the information accessability only under the IPP liability.

The result of our study suggests that policy intervention might be needed, since under the conventional liability regime the anti-fraud investment is socially sub-optimal. It also suggest that the information accessibility for the FPP may be given to the FPP only with its liability.

There are a few issues for future research. First of all, the model in this paper is based on the assumption that the anti-fraud investments by two service providers are strategic complements. This may not always hold, especially when the duplicated investments are wasteful. For example, Varian (2004) considers three cases regarding the way that efforts exerted by participants of the system affects the system reliability: 'sum of efforts,' 'weakest-link' where it depends on the minimum effort, and 'best-shot' where the reliability depends on the maximum effort. The first two cases are extreme cases of our model, while the third case is not analyzed through our model. To examine the equilibrium of the case, we need to consider model in which the anti-fraud investments are strategic substitutable, not complementary, modifying the Assumption 1, iii). However, in this case, the monotonicity of the best response functions are not guaranteed, nor are the existence and uniqueness of the equilibrium.

In addition, for tractability of the analyses, we present very simplify the vertical structure, abstracting several issues. We assume that the surplus from fee on the usage of the FPP is divided between the IPP and FPP according to the exogenous ratio. The assumption presumes the bargaining situation, where the ratio reflects the bargaining power. There are, however, other situations that the presumption does not hold. For example, the IF may first charge the fee on the provision of the core functions such as authentification, clearing, and settlement, and then the FPP decides the fee on the usage of the FPS. In this case, there would be the double marginalization problem in the second stage, which results in higher fee and narrower consumer usage. We also abstract the two-sidedness of the payment platform by assuming the fee for the usage of the FPS is imposed only on the consumer. Our model is a simplified version of 'macro' model in terms of Economides (1996), and the margin and bargaining power are exogenously given, not solved in the model. This leads to the lack of analysis on the (relative) price charged on the consumer and merchant, which is one of the important issues in payment system. We assumes the perfect pass-through, implicitly implying that the merchant can discriminate the price between consumers using traditional payment instrument and those using Fin-Tech based payment instrument. This assumption is plausible in some cases, but not general. Indeed, 'price coherence' is one of the factors from which distorted price structure is resulted. However, because we are not focusing on the inefficiency due to the price distortion, the price coherence problem does not matter for the validity of the results in this paper. Finally ignore the competition between platforms. The analysis on this topic might be crucial to derive policy implications. We leave these issues for future research.

For policy implications, it would be worthwhile to mention a rather traditional issue regarding the liability regimes, not covered in this paper: consumer liability versus payment service provider liability. A well-known example about this subject is the ATM fraud liability comparison between the United States and the United Kingdoms. While banks are generally liable for the costs of card fraud in the US, the banks could get away in the UK. UK banks, however, spend more on security and suffer more frauds (Anderson and Moor, 2006). In Korea, consumers are left with liability if they make 'significant' mistakes by law. The 'significance' is often judged by court, and Korea Supreme Court's decisions have often favored the companies' arguments.[11] The problem here is that 'significant' mistakes can occur more often

[11]From Jan. 2012 to July 2013, there were 185 lawsuits filed by online financial fraud victims

than consumers' expectation, and is exacerbated by the use of "National Public Key Infrastructure" security plug-ins on the client side.[12] Thus, it is no wonder that Korean banks and credit card companies favor running the security modules on the client side, which can increase the chance of consumer mistakes, but lead to less liability for them, and thus, the introduction of FinTech payments services has been delayed. For example, in 2013, when a major online bookstore in Korea tried to provide an online payment service with the enhanced user experience without the security plug-ins, card companies boycotted the bookstore, and just in two months after the launching, it eventually discontinued the payment service.

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against banks and card companies. Of the 51 final verdicts, plaintiffs lost 49 cases (Park, 2015).

[12] NPKI plug-ins had been a standard and requirement for online transactions in Korea for a long time, and still has been dominant until now.

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Appendix

A1. Process of Retail Payments: a Diagram

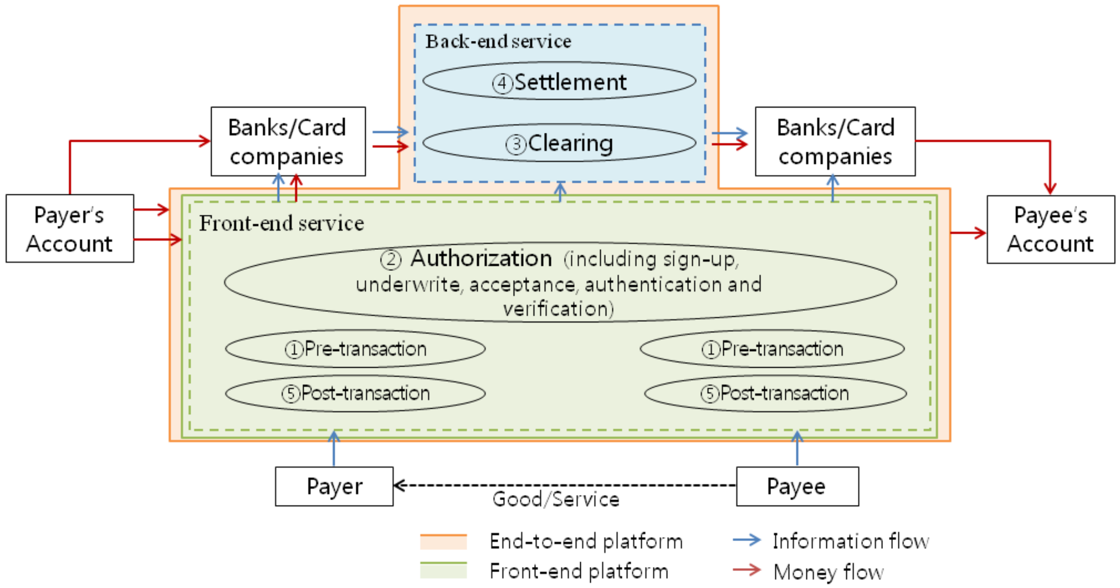

Figure 1: Process of Payments (Source: Jun and Yeo (2016))

A2. Proof of Proposition 1

Proof) By differentiating the equations (5) and (6) with respect to e_U and e_F, respectively, we have two first order conditions.

$$\begin{aligned}\frac{\partial \pi_U}{\partial e_U} &= \frac{-\mu cx}{2\bar{b}}(\bar{b} - cxq(e))\frac{\partial q(e)}{\partial e_U} - Lx\frac{\partial q(e)}{\partial e_U} + \frac{2cx^2 Lq(e)}{\bar{b}}\frac{\partial q(e)}{\partial e_U} - 1 \qquad (16)\\ &= \frac{-\mu cx}{2\bar{b}}(\bar{b} - cxq(e))\frac{\partial q(e)}{\partial e_U} - \frac{Lx}{\bar{b}}(\bar{b} - 2cxq(e))\frac{\partial q(e)}{\partial e_U} - 1 \qquad (17)\\ &= 0\end{aligned}$$

$$\frac{\partial \pi_D}{\partial e_D} = \frac{-(1-\mu)cx}{2\bar{b}}(\bar{b} - cxq(e))\frac{\partial q(e)}{\partial e_D} - 1 = 0 \qquad (18)$$

Under assumptions *i), ii)* of Assumption 1, the first two terms in (17) and the first term in (18) are positive and decreasing in e_U as long as $\bar{b} - 2cxq(e) > 0$ and thus $\bar{b} - cxq(e) > 0$. This implies that for small $x > 0$, the optimal e_U and e_D are uniquely defined given e_D and e_U, respectively.

For the existence and uniqueness of Nash equilibrium, consider the signs of cross derivative of π_U and π_D.

$$\begin{aligned}\frac{\partial^2 \pi_U}{\partial e_U \partial e_D} &= \frac{\mu c^2 x^2}{2\bar{b}}\frac{\partial q(e)}{\partial e_U}\frac{\partial q(e)}{\partial e_D} - \frac{\mu cx}{2b}(\bar{b} - cxq(e))\frac{\partial^2 q(e)}{\partial e_U \partial e_D}\\ &\quad + \frac{2cx^2 L}{\bar{b}}\frac{\partial q(e)}{\partial e_U}\frac{\partial q(e)}{\partial e_D} - \frac{Lx}{\bar{b}}(\bar{b} - 2cxq(e))\frac{\partial^2 q(e)}{\partial e_U \partial e_D} \qquad (19)\\ &> 0\end{aligned}$$

$$\frac{\partial^2 \pi_D}{\partial e_U \partial e_D} = \frac{(1-\mu)c^2 x^2}{2\bar{b}}\frac{\partial q(e)}{\partial e_U}\frac{\partial q(e)}{\partial e_D} - \frac{\mu cx}{2b}(\bar{b} - cxq(e))\frac{\partial^2 q(e)}{\partial e_U \partial e_D} > 0 \qquad (20)$$

The inequalities hold due to Assumption 1, *iii)*. This implies that the best response functions of U and D are monotone upward sloping and exhibit increasing differences, which guarantees the existence and uniqueness of the Nash equilibrium. (See Vives (2000) and Topkis (1998).) ■