Fintech Finance and Financial Fragility — Focusing on China

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Abstract

Financial Technology (Fintech) is evolving quickly within the financial system, giving rise to new forms of lending and opening up a version of shadow banking. This is particularly true in China. While Fintech finance and shadow banks can improve a banking system, they can also become new sources of fragility. This paper aims to provide a theoretical analysis of risks of Fintech finance to financial sectors, with particular examples for China. These risks are most likely to be important when Fintech moves beyond its technological focus and performs financial intermediation, particularly bank-like, functions. We provide implications for the evolution of Fintech finance as new sources of payments and funding. We propose "ring-fencing" as an approach to mitigate risks from contagion.

Keywords:

Fintech; Shadow banking; Contagion; Financial fragility; Interconnectedness

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1. Introduction

"Fintech", the short form for Financial Technology, is beginning to transform modes of operating businesses in the finance and banking sectors. Sironi (2016) (p. 5) defines Fintech as "… a global phenomenon, born at the intersection between financial firms and technology providers, attempting to leverage on digital technology and advanced analytics to unbundle financial services and harness economies of scale by targeting long-tail consumers." Fintech firms have emerged as providers of services and funding, including retail lending, payments, analytics, personal finance, and Robo-advisors. Investment strategies directed at pools fitting particular client demands (as opposed to, say, strategies designed to outperform the market as a whole), called "Goal-based" investing, have become the Fintech investor core philosophy (see Sironi (2016) for more detailed description of Fintech, Robo-advisors, and investing).

A major trigger for this evolution has been the loss of confidence in the traditional banking system after the Global Financial Crisis. The evolution has also begun outside of countries hit by the crisis, such as China where, for instance, small and medium enterprises (SMEs) that have growth potential do not have easy access to the regular banking system. Furthermore, in the current low yield environment investors are motivated to seek more direct lending and investment platforms that offer lower transaction costs than regular financial intermediation and can avoid regulated deposit rates. Technology, particularly in the ability to process large data sets, has made direct lending easier. The idea is to use technology to analyze value and risk of the pools that would suit clients' needs, more rapidly and with lower transaction costs. As we shall see, this can also entail externalities and agency costs.

An example of Fintech is for lenders to use automated underwriting models for mortgage financing, via more accurate and detailed checking of house buyers due to easy access to enormous databases and better pricing models. Borrowers and lenders can spend less effort in loan origination and are willing to spend more in order to obtain convenient service from Fintech lenders (Philippon (2015) and Buchak *et. al.* (2017)). In the case of peer-to-peer (P2P) finance, cryptocurrencies (e.g. Bitcoin and Ethereum), blockchain, crowdfunding,

and other digital wallets, funds are directly transferred from fund providers to fund users without the need of any financial intermediaries. This also implies that credit risks are borne directly by the creditors (fund-providers) and not the P2P platform (also hence called "credit disintermediation").

This has stimulated increases in shadow banking as a way of intermediation. By shadow banking we mean financial institutions that perform bank-like intermediation functions, but outside the regular banking system. Key differences are absence of bank regulations, such as lending and deposit rate ceilings as well as portfolio restrictions, and deposit insurance and other forms of liability guarantees. The last two features are especially crucial since the absence of insurance and guarantees makes shadow banks more susceptible to runs. Of particular importance are lower costs (e.g., information costs) for intermediation services relative to regular banks, an ability to offer higher rates than those allowed by formal institutions due to government restrictions, and a broader range of regulatory arbitrage, for instance avoiding regulated capital requirements.

Fintech finance facilitates underwriting and information benefits with big data in making loans and valuing other assets that are prime targets for substitutes for traditional financial intermediation, where investors are essentially depositors in bank-like businesses. In China it can create an elastic source of funding for SMEs and real estate. However, because the Fintech firms are outside the scope of banking regulations and deposit insurance, default can trigger depositors' flight to quality, causing a contagious collapse of the Fintech firms.

We develop models in the spirit of the network models of Eisenberg and Noe (2001) and Acemoglu *et al.* (2015) to analyze whether Fintech finance is complementary to the financial system, in the sense of expanding funding availability, and/or disruptive, which might affect the stability of the banking sector as a whole. We pay particular attention to contagion in different states of interconnectedness. Our modeling is largely taxonomic: we exploit existing models to clarify how shadow banking and Fintech are connected, and their implications, with a focus on China's recent experience. We also develop analogies with

structures used in the U.S. before the Great Recession, which can be used as qualitative reference points for understanding risk.

It is clear that much of this is not new. The current Fintech-shadow bank structures are similar to the special purpose vehicles (SPVs) used to fund mortgage-backed securities a decade ago. The use of data to evaluate credit risk of mortgages is reminiscent of the move in the U.S. in the 1990s toward automated underwriting (see Straka (2000)). Our network-based analysis of fragility and Fintech, and the ensuing susceptibility of a system to instability from large shocks is also related to earlier analysis by Leijonhufvud (1968 and revisited in 2009) of "corridor effects," in which systems adjust in a stable manner to small shocks within some range, but react in an unstable manner to shocks outside the range.

Our models show that shocks to Fintech financing have to pass some threshold (in terms of number of failed SMEs and the amount they owed), before failure is contagious. Hence, a highly interconnected banking network is a necessary but not a sufficient condition for system failure; the magnitude and closeness of the connections matters, and the size of the corridors depends on the nature of the networks. Given the potential instability, we suggest ring-fencing, a recently popular approach to financial regulation, as a solution to mitigate the power of contagion from failure of Fintech finance to the banking sector. To the best of our knowledge, this is the first study to formalize the link between Fintech finance and the financial system.

2. Background of Shadow Banking and Fintech Financing

Shadow banking has been accused of being at the center of the Global Financial Crisis, leading to the Great Recession in the U.S, and subsequently tanking a sizable share of the global economy. On the other side of the world, shadow banking in China has rapidly expanded, filling a void in supplying credit to SMEs that are not able to borrow from the big four banks, and other commercial banks, that are mostly designed to fund State-Owned-Enterprises (SOEs) and big corporations.

Credit for small businesses in China has surged since 2008, with government support to combat against the ripple from the Global Financial Crisis. According to the People's Bank of China, loans to small enterprises reached 29.4% of the total loans by the end of 2013 (Yao, 2016). Another group actively participating in shadow banking is local government financing platforms (LGFPs), which are trust funds borrowing on behalf of local governments. The Central government initiated fiscal stimulus in 2009 in order to combat the potential economic downturn after the Great Recession. Seventy percent of this stimulus package has to come from the local governments, which have to utilize the LGFPs for funding sources. Many non-bank financial firms, such as trust companies and microfinance companies, that lend to SMEs are funded from investors in the form of Wealth Management Products (or WMPs).

Apparently because of the caution taken after the Crisis, Fintech finance has grown slower in the US than in Europe, where there are more lax regulations governing Fintech finance. In China, different forms of Fintech finance have emerged and grown, with the notable examples of mobile payment and crowd-funding. While the Fintech finance market is currently small relative to the general banking sector, the rapid increase in its depositors and borrowers suggests a bigger market relatively soon. This is especially due to easy entry and exit, coupled with high yield on deposits and relatively easy access to funds on the borrower side. A recent study shows that Fintech investment grew by 75% globally in 2015, with a 44% increase in the US, but 445% in China, although the latter represents only around USD2 billion, while the former is US4.5 billion (Accenture (2016)). In 2016, Ant Financial alone poured in USD4.3 billion (Wintermeyer (2017)).

The Fintech firms with which we are most concerned began as e-commerce firms (such as e-tailing platforms) that have evolved into financial intermediaries through collecting customers' (depositors) funds and redistributing them in the form of loans, and therefore have emerged as a basis for shadow banking. One can think of the basic structure as similar to a Special Purpose Vehicle (SPV), used in securitization models (Ashcraft and Scheierman (2008), and Brunnermeier (2009)), although in the Fintech case the asset

structure set-up is provided with more detailed information than has been provided by historical SPVs. The liability side can be thought of as similar to *tranching* the structure in the SPV, rather like CMOs and CDOs. In our case the structure is divided into equity and a deposit-like pieces, like a simple commercial bank. These structures are also similar to those used in Repurchase (Repo) markets and structured investment vehicles to fund pools of mortgages or other assets. In China the structuring has been stimulated by growth of SMEs, which thirst for more direct funding from investors, hopefully cutting down intermediation costs and avoiding regulation.

2.1 Players and Products

More recent participants in Fintech are e-commerce companies and Internet companies. Alibaba is an example. It sets up a micro-lending business for SME loans that are funded by "deposits" by Alibaba customers, whose small accounts are used for purchases online. Relative to traditional shadow banking, Alipay, the payment platform for Alibaba, covers many investors, but mostly small amounts (could be as small as RMB1.00). With their Fintech advantage through their huge customer database in e-commerce retailing (or "e-tailing"), they are able to develop credit assessment models to evaluate the credit performance of their borrowers. The deposits at Alibaba are what generate the shadow bank, and they are largely unregulated and uninsured. Another popular source is the P2P lending platforms for investors looking for high returns and small firms that need quick funding, bypassing regulations on microcredit firms. These usually operate with high leverage, with loan sizes exceeding registered capital.

Wealth Management Products (WMPs) are unsecured financial products like bond funds, rather than short term deposits, usually sold to small investors seeking higher returns than those offered by bank deposits. They have been offered by many banks and financial institutions in China. Some are forms of shadow banking (when these products are subsequently transferred to trust funds, so as not to be recorded on the banks' balance sheets, and then funded with tranched liabilities). Online WMPs became popular when e-commerce companies started to accept deposits on the "e-wallets" of customers of the e-tailing business. An example is the Yu'E Bao (a Chinese term meaning "Treasure from

Remaining Balance") of Alibaba, which has a large share in the e-tailing market in China, and offers online WMPs.

WMPs have low entry barriers; there is no minimum for investment amounts for customers, who are the depositors. Because non-financial institutions are not subject to interest rate restrictions investors can be promised an annual interest rate of 5% to 7% (or even higher), a very high rate when compared to the one-year deposit rate of 3.3% in China. Borrowers from Alibaba, through AliLoan, are normally sellers in the e-tailing platform of Alibaba called TaoBao (Chinese term for "Digging Treasure"). This is an example of how an institution like Alibaba can utilize its technology and big data to analyze the creditworthiness of these borrowers, who can be small businesses with high risks (Alibaba later merged all its e-funding business into Ant Financial in 2014). Another competitor is the TenPay and WeBank of TenCent, one of the largest social network provider in China.

2.2 Market Structure

A simple representation of incentives behind market structure is that the major banks ration credit and are heavily regulated. They charge a (regulated) price that is too low to clear the market, pay a low regulated deposit rate and are subject to capital and other requirements. As a result there is an excess demand for credit, and a private market can emerge to fill the gap, even if it is at a competitive disadvantage in terms of cost of funds (banks raising money via guaranteed deposits). The shadow banking market is free to pay deposit rates that are above regulated bank deposit rates and charge higher rates to their borrowers.

The rise of Fintech firms that offer bank-like functions is a threat to traditional, regulated financial intermediaries, as they can use service and speed to take business away from the regular banking system, while lending at higher rates. Flexibility from the lack of regulatory bodies, the much wider customer and debtor bases, and the unlimited scope of expansion in terms of accessibility, forms and modes, have blurred the boundaries among lenders, borrowers, and intermediaries of traditional banking system. Even though bank and non-bank financial institutions have joined the trend of adopting more financial technology in order to maintain their competitive positions, they do not possess the same

technology and flexibility as the Fintech firms that possess both technological expertise and big data on extracting information on a wide range of SMEs and investors.

The advantages of Fintech finance are also sources of risk to the general financial system. For instance, e-payment platforms (such as Alipay) charge very small transaction costs relative to other bank card payments, but that means it is easy to move money around. A risk is that the sellers of commodities bought via the platform will have trouble obtaining their payments from consumers if the platform fails, or are at risk of failing, because of the credit business. Fintech firms as shadow banks often lack expertise in financial services, while simultaneously significantly broadening the number and type of borrowers. In the case of equity crowdfunding, the businesses involved are usually very risky, and the potential return is estimated with very low precision over usually at least a five to seven year start-up period. Blaseg and Koetter (2016), for example, conclude that equity crowdfunding is a main source of financing for smaller ventures and those with fewer tangible assets.

Acharya *et a*l. (2017) mentions that WMPs have caused financial institutions to be more closely connected than ever, and thus the rollover risks of WMPs increase the risk of contagion across financial institutions in a way that is similar to shadow banking via, for instance, securitized banking in the Repo market in the U.S. in 2007 and 2008 (Gorton and Metrick (2012)). This can create illiquidity problems, and a sudden lack of capital can result in difficulty in rolling over of loans, and default of the guaranteed principal for investors, which can lead to fragile banking if the capital of their business comes from traditional banks.

Some Fintech companies therefore seek strategic partners to mitigate the problem of lack of financial expertise and capital. For example, Alibaba's Ant Financial partners with several banks, such as China Minsheng Bank, so that the former can collect funding and pass it on to the latter to lend out, in return for a high enough rate on the online WMP. Even though accounts in Yu-E Bao are small, ranging from a few to a few thousand US Dollars, the Ant Financial money market fund generated a return of 3.93% in the first quarter of

2017. This attracts more of its customers to deposit their money to Yu-E Bao, creating a big fund that is directly connected to the formal banking sector. Another important issue is that investors, particularly small investors, tend to rely heavily on explicit and implicit guarantees (Buchak *et al.* (2017)) to manage their risk and moral hazard concerns. If there is a market downturn and guarantees are "called" this fund could make a big withdrawal from associated banks. Hence, (implicit) guarantees pose a threat to the Chinese banking sector. Companies like Alibaba can be either too big or too connected to fail. Zhou *et al.* (2015) provides a thorough narration of the change in regulations in coping with the change in Fintech in China, which is still far from optimal.

While there has been a rapidly developing literature about how Fintech works, and how different platforms have preempted the credit market, there is scant research about whether Fintech finance can help expand, or threaten, the banking industry. Philippon (2016) is one of the first to study how Fintech can change the banking system by providing cheap, transparent and easily accessible funding, in contrast to expensive traditional banking services, which still rely heavily on implicit and explicit government guarantees. Buchak *et al.* (2017) compare Fintech and non-Fintech shadow banks and focus on how Fintech firms have penetrated into the mortgage refinancing business. Tasca *et a*l. (2016) offers a comprehensive collection of Fintech finance from different perspectives.

2.3 Systemic Risks

Interconnectedness that increases systemic risk, leading to contagion, has been widely explored, especially after the Global Financial Crisis (see for example, Allen and Gale (2000), Gai and Kapadia (2010), Acemoglu *et al.* (2015), and Roukny *et al.* (2016)). Studies of how different forms of banking networks can lead to varying degrees of contagion and financial fragility are also plentiful. For example, Elsinger *et al.* (2006) finds that: (1) highly correlated portfolio exposure is a more crucial reason for contagion, (2) this could be small given low bankruptcy costs, (3) there are effective measures to combat crisis, and (4) costs of being a "lender of last resort" could be much smaller than previously thought.

Glasserman *et al*. (2015) concludes that either the shock to the network must be large, or the affected bank must have small net worth to trigger contagion, and that deteriorated credit quality can speed it up. Kaister (2016) argues that the potential for bailouts creates incentives that lead to a more fragile financial system, although prohibition of bailouts can also lead to welfare reduction and higher probability of crisis. Bernard *et al*. (2017) suggests conditions under which no-intervention threats by the regulatory body can be helpful and when bail-ins are actually better than bail-outs in stopping contagion across various banking networks.

3. Banking and Networks

In order to provide a theoretical analysis of the potential risk of Fintech finance to the financial/banking sector, we first need to know how banks are connected. Figure 1 depicts some examples of possible financial/banking network systems (see, for example, Roukny *et al*. (2016) for modeling with different network structures). For simplicity, we assume that the system consists of four banks, denoted as nodes 1 to 4. The first example is a "star network" in which all banks are linked only to Bank 1. A typical example is for Bank 1 to be the central bank or quasi-central bank of a city, state, or country. Another example would be for this Figure to be a snapshot of a "Too-Big-to-Fail" bank in a large system, where a very big bank is linked to other, possibly nearby, very small banks. The second one is the "ring network" where each bank is connected with pairwise liabilities only with its two adjacent banks. In reality, "star network" and "ring network" banking systems are very unlikely because banks work closely together, and banking systems work globally. The last one in our discussion is the "complete network" in which all banks are connected to each other with pairwise liabilities. Other possibilities are somewhere in between the "star" or "ring" network and the "complete network" in that banks are connected to more than one or two, but not all, banks in the systems.

3.1 The Banking Network Model

We model the links among banks in a banking system in the spirit of Eisenberg and Noe (2001), Acemoglu *et al*. (2015), and Bernard *et al*. (2017). Suppose there are n banks, such

that bank $i = 1, \ldots, n$ has interbank obligations of L_{ij}, which is what bank i owes to any other bank j. Obviously, $L_{ij} = 0$ for $i = j$. Note however that bank i does not necessarily have interbank obligations with all $n - 1$ banks in the system, in which case $L_{ij} = 0$ for some ij's. For instance, in the simplest case of a "star network" as depicted on the left of Panel 1A of Figure 1, bank i can be any of node 2, 3, or 4, which has interbank obligations only with node 1. At the other extreme, all banks in the network have obligations with the other $n - 1$ banks, in which case the "complete network" on the right of the panel in the Figure applies. Let $L_i = \sum_{j=1}^{n} L_{ij}$. The relative liability share is

$$\pi_{ij} = \begin{cases} \dfrac{L_{ij}}{L_i} & \text{if } L_i > 0 \\ 0 & \text{otherwise} \end{cases} . \tag{1}$$

Denote other financial commitments such as wages and operating expenses as part of, but more senior, liabilities of the bank by w_i. Bank i also has cash on hand, c_i, and market value from outside investments (i.e. not interbank loans), A_i, which generates a random return of x_i.

Suppose all payments have to be made on the same date. If P_{ji} is the repayment of the liability from bank j to bank i, the total cash flow of bank i is

$$c_i + x_i + \sum_{j=1}^{n} P_{ji} . \tag{2}$$

where $P_{ii} = 0$ and $P_{ji} \leq L_{ji}$. If it cannot meet all its committed payments, that is,

$$c_i + x_i + \sum_{j=1}^{n} P_{ji} < L_i + w_i$$

it will have to liquidate some of its outside investments. Suppose only a fraction, α_i, of the fundamental value of outside investments can be recovered (because of fire sale, or sale within a short time). Bank i does not have to default as long as the relatively junior interbank liabilities can be covered by liquidating just enough of outside investments, provided that the senior obligations are covered. Otherwise, it would have to sell all its investments to repay all debts. That is, its liquidation would be determined based on

$$l_i = Min\left(\frac{1}{\alpha_i}\left(w_i + L_i - c_i - x_i - \sum_{j=1}^{n} P_{ji} \right)^{+}, A_i \right), \tag{3}$$

where the first term (in the parentheses) in the minimum function is the required amount, but is less than if liquidating all investments, while the second part times α_i is the amount that could be obtained from liquidating all assets. If the latter is still not enough to cover all interbank liabilities, the bank is assumed to have to default.

When bank *i* defaults, whatever is left over after the senior obligations are met will be distributed among banks for fulfilling the interbank liabilities. Hence, for any bank *j* $\forall\ j \neq i$ in the interbank system, payment from bank *i* to bank *j* is

$$P_{ij} = \pi_{ij}\left[Min\left(\left(c_i + x_i + \sum_{k=1}^{n} P_{kj} + \alpha_i l_i - w_i \right)^{+}, L_i \right) \right] \tag{4}$$

Otherwise, $P_{ij} = 0\ \forall\ j \neq i$ banks in the network if nothing is left from bank *i*. For simplicity let $\beta_{ij} = \frac{P_{ij}}{L_{ij}}$, which is similar to the partial recovery of interbank claims in Bernard *et al.* (2017). Expression (4) also means that whether any bank *i* defaults or not depends not only on the return from external investment, x_i, or α_i, the fraction of assets that could be liquidated, but also, and crucially, on whether other banks in the system are solvent and pay back bank *i*, and hence, if $\beta_{ij}\ \forall\ j \neq i$ is close to 1.

3.2 Network Fragility

Network fragility is a property of banks in a banking network that are risky in the sense of being subject to large losses quickly, due for example to taking too many risky investments and/or having too much leverage, or being subject to "tail risk" from the "fat tail" return distributions. Fragility is important in explaining the collapse of a banking system when defaults of some banks in the system cause other banks to default.

Recall that any bank *i* has outside investment that provides a random return of x_i. Following Acemoglu *et al.* (2015), we assume this investment return to be

$$x_i = a_i - \varepsilon_i$$

where $\varepsilon_i \in (a_i - w_i + \alpha_i A_i, a_i)$ representing some shocks is *i.i.d.*. The upper bound of ε_i is such that the outside investment returns nothing, while the lower bound implies that the return, together with liquidating the asset, should at least cover the senior obligation. This is different from Acemoglu *et al.* (2015), which assumes that all banks have the same shock, and therefore the same outside investment values, liquidation fractions, and senior obligations. We allow all these parameters to be bank specific.

Following some number of shocks, s_i, for bank i (here, for simplicity, we assume each shock of bank i is of the same magnitude for s_i times), the total value of the banking system is

$$U = \sum_{i=1}^{n} (c_i + a_i + A_i - s_i \varepsilon_i - (1-\alpha_i) l_i) \tag{5}$$

which is the sum of all cash inflows and asset values in the whole banking system minus those for banks that experience shocks from their outside investments and therefore are subject to liquidating some assets. In the extreme, when liquidation is not possible, $\alpha_i = 0$, the value of the system becomes

$$U = \sum_{i=1}^{n} (c_i + a_i + A_i - s_i \varepsilon_i) - \sum_{i \in D} A_i$$

where D is the group of banks that default.

3.3 Contagion and Fragility

Contagion happens when defaults by some banks in the system spread to other banks. Instability arises when contagion effects are amplified rather than dampened, i.e., when shocks come from outside the corridors. $\sum_{j=1}^{n} P_{ij}$ in (4), suggests that the more interconnected banks are, in terms of more pairwise liabilities among more banks in the system, the more likely the network will be contagious. This is not necessarily true, however, as more banks in the system can share the losses from the failed banks, provided that most of the banks are resilient enough. Nevertheless, the smaller is the total value of the banking system in (5), all else equal, the more fragile is the system (because small value

means small cushion for fragility). It is not the purpose of this paper to prove what kind of networks will be more contagious and fragile than others, and under what circumstances. Rather, we take for granted the findings from Acemoglu *et al.* (2015), which are also confirmed in Bernard *et al.* (2017), to analyze the situations in our Fintech-bank partnership network.

Acemoglu *et al.* (2015) define two different systems, System 1 and System 2, with the same number of banks, n, different in U in (5), such as U_1 and U_2 respectively. Then System 1 is more stable than System 2 if both experience similar times of shocks, s_i, but $E(U_1) \geq E(U_2)$ conditional on the realizations of ε_i. Furthermore, System 1 is more resilient than System 2 if $Min(U_1) \geq Min(U_2)$ conditional on taking the magnitudes of ε_i for all of the s_i. Hence, *fragility* of a bank network depends on the original "health" of the banks in terms of quality of their assets (*stability*), magnitudes of the shocks (*resilience*), and the structure of the network (*interconnectedness*).

Given this, Acemoglu *et al.* (2015) show that for small enough shocks, a complete network (as in Panel 1A) is the most resilient and stable type of financial network because the small shocks will be shared by many banks in the system, thereby exerting minimal effect to individual banks. On the other hand, a ring network (Panel 1A) in which any bank is linked only to two other banks in the system is least resilient and least stable. They also claim that higher similarity in the pairwise liabilities among banks generates less fragility. This provides an explanation of why "Too Big to Fail" banks might not be good for financial systems, because other smaller banks in the system will not be able to resist the shocks spread from these big banks.[1]

On the other hand, high magnitudes of shocks, $\varepsilon_{i,}$, and interbank liabilities (L_{ij}) lead to both complete and ring networks being least stable, while a network structure somewhere in between is relatively more stable and resilient. This is because the weaker interconnectedness ensures that the losses from the defaulting banks are taken by distressed

[1] This does not take into account some endogeneity issues in risk-taking. For instance big banks might take on less risk because of "franchise value."

banks that have to liquidate some assets, but not by all banks because not all are connected with the distressed banks. A complete network allows shocks to some banks to be completely transmitted to the entire system, hence increasing systemic risk. In addition, more evenly distributed pairwise liability adds to faster contagion.

Finally, Acemoglu *et al.* (2015) introduces "harmonic distance" as the closeness of a bank with another bank in terms of both distance and intensity of the liabilities. A bank that is close to all other banks with a smaller "harmonic distance" is the most "systemically important"; any possible default of this bank will be most contagious, an explanation of "Too Systemic to Fail" banks.

4. Fintech Networks and Shadow Banking

In this section, we expand on the previous section to illustrate various forms of intra- and inter-network connections within the Fintech financing and across to banks, respectively. We model how the banking network model is linked to Fintech finance when the latter becomes a form of shadow banking. We then formulate a general model of Fintech-bank partnership shadow banking.

4.1 Networks

Panel 1B of Figure 1 illustrates the structures of most Fintech networks, with the rectangular boxes in both diagrams as the Fintech firms that facilitate the financing platform. "Fintech Network 1" applies when their functions are merely providing technology platforms to enhance financial services, but not as intermediaries. For example, it can represent the e-tailing platform of Alipay. Consumers pay the retailers through their e-wallets managed by Alipay through the e-tailing platform called TaoBao, and retailers make sure the products are delivered to the consumers or else their e-tailing record on TaoBao will be affected through the negative reviews from consumers. Another example of "Fintech Network 1" is the P2P platform.

Funds can also be collected via Fintech firms from one end to the other. Take crowdfunding as an example. Crowdfunding can be classified into "lending-based", "equity-based", "reward-based", or "donation-based". In the first two, investors expect to have returns in the future, whereas "donation-based" crowdfunding, as the name implies, is not associated with payoffs, although investors of "reward-based" crowdfunding hope to have rewards in the future should the venture business "blossom". Hence, a graphical representation of crowdfunding is similar to the "Fintech Network 1", where investors know about the nature of the business ventures of the borrowers through the Fintech crowdfunding platform (the rectangular box). In the case of "donation-based" crowdfunding, the arrows in the Figure point in one direction, from investors to borrowers, because the borrowers do not have to pay back the investors.

In both "lending-based" and "equity-based" crowdfunding, investors expect to earn returns and will take opportunity costs into account, and the Fintech firm will act as the financial intermediary in facilitating collection and distribution of funds. In that case, the network will look like "Fintech Network 2," whereby the Fintech platform is not only an intermediary for facilitating financing, but is also responsible for the banking function of ensuring investors are paid their returns. As mentioned before, some investors would have implicit guarantees from the Fintech platform, as well.

4.2 Shadow Banking

Fintech finance becomes a form of *shadow banking* in cases where investors can join the money market fund, for which the Fintech firm acts as financial intermediary, for instance, to lend to SMEs, and to promise returns to investors. The network looks like the "Fintech Network 2" in Figure 1. For example, investors place their money through deposits in Yu-E Bao of Alibaba, through which Ant Financial lends directly to SMEs (borrowers in the Figure) via its AliLoan branch (the rectangular box in the middle). Ant Financial is now functioning like a traditional bank, funding long-term loans with short-term deposits, and hence performing (shadow) banking functions of maturity transformation, liquidity transformation, leverage, and credit risk transfer (because Yu-E Bao promises an annual interest return).

When Fintech firms create money market funds or WMPs through banks, the Fintech platform is more complicated than "Fintech Network 2" because it will be connected to a banking network, such as that depicted in Panel 2A of Figure 2. As an illustration, a Fintech firm joins two banks, Bank 2 and Bank 3, in the banking network. The Fintech firm collects funds from the investors (such as Yu-E Bao of Alibaba) and passes the funds to Banks 2 and 3 to lend to SMEs that are required to pay higher loan rates than other big corporations (arrows of flow of funds to SMEs are omitted in the Figure). Upon collecting the interest payments, the banks withhold some fees and pass the rest on to the Fintech firm, which then withholds some fees before distributing the rest to the investors as investment return. This return is in general in the form of a promised interest rate that is higher than bank deposit rates.

Panel 2B shows how a banking system can support Fintech in an example of two Fintech finance firms. The dark thick arrows show the connections of Fintech Firm 1 with Banks 2 and 3, and Fintech Firm 2 with Banks 1 and 4. Of course, one bank can also choose to serve more Fintech firms; and not all banks are connected to Fintech firms. Furthermore, the banking network does not have to be a "complete" network. It is the extensive connections between Fintech shadow banking and banking networks, and the potential for significant expansion of Fintech finance, that create contagion risks from the Fintech sector to the traditional banking sector.

5. A Model for a Fintech-Banking System

Here we develop Fintech-shadow banking models and analyze implications to the Fintech-banking system after the occurrence of shocks.

5.1 The Fintech Liability

Borrowing from the notation used in the banking network in Section 2, the cash flow of a Fintech financing firm/platform at any point in time when payments are settled is given by:

$$\sum_{i=1}^{M} x_i^F - X \tag{6}$$

where M is the number of SMEs to which the firm lends, and hence x_i^F is the return from SME i $\forall$ i = 1 to M, and X is the amount of return that the Fintech firm guarantees the investors/depositors. The remaining balance is the surplus of the firm. If some SMEs are not able to make their payments, the Fintech firm can request them to liquidate some of their assets. Suppose sales of assets of T SMEs are triggered (where T is the total number of troubled SMEs), from which full recovery in value cannot be obtained, as in Section 3. Suppose the fraction of recovery is α_j^F and the asset value is A_j^F for SME j, and note that once liquidation is triggered, the SMEs will no longer be able to make the usual payment x_j^F. Then the cash flow of the Fintech firm is

$$\sum_{i=1}^{M-T} x_i^F + \sum_{j=M-T+1}^{M} \alpha_j^F A_j^F - X \tag{7}$$

If the proceeds from these failed SMEs are still not enough, then the Fintech firm will have to use its own cash on hand to cover payments to investors. Suppose c^F is the cash at hand. The Fintech firm will have to default in the worst case if

$$c^F + \sum_{i=1}^{M-T} x_i^F + \sum_{j=M-T+1}^{M} \alpha_j^F A_j^F < X\,. \tag{8}$$

This is what happened to China Credit Trust Co., which claimed that it would have to sell five coal mining properties before it could return the money to the investors (Zhu (2014)). Adding to the complication is that the investment product involved was sold through the Industrial and Commercial Bank of China (ICBC, one of the big four banks of China). However, in this case, ICBC does not have an obligation to repay the investors because it served only as the sales platform of the WMPs.

Notice that even though the China Credit Trust Co. is a shadow bank case, and not related to the Fintech firm, the investment products and channels are similar to what we have discussed before. A recent example related to Fintech finance as shadow banking is the negotiation of Huishan Dairy in China with its eight creditors, including Hongling Capital, a P2P lender, to delay paying its loans (Bloomberg News (2017)). As mentioned earlier,

P2P Fintech financing is just a platform that transfers funds from investors directly to borrowers. However, in many cases, particularly in China, investors are told that their investments have very low risks, if not risk-free, and so investors assume implicit guarantees from the WMP-issuing firms or banks, through which the WMPs are sold (Wee and Guo (2017)).

5.2 Fintech-Bank Partnership

We now connect the Fintech network and the banking network to represent the case where a Fintech finance firm partners with a bank to lend to SMEs, as shown in Panel 2A of Figure 2. The cash flow of the Fintech firm is similar to (6) except that the returns are not from the SMEs directly, but rather from a total of B partnering banks (two banks in Panel 2A). That is, cash flow is given by

$$\sum_{i=1}^{B} X_i^F - X \tag{9}$$

where X_i^F represents the return from the SME investments that bank i pays back to the Fintech firm. For partnering Bank i the cash flow in (2) now includes the return $x_{i,k}^F$ from SME $k \ \forall \ k = 1 \cdots M$, which is separated from its other outside investments because of higher risk, and to highlight the fact that the funds are from the Fintech firm. Formally, cash flow of Bank i becomes

$$c_i + x_i + \sum_{j=1}^{n} P_{ji} + \sum_{k=1}^{M} x_{i,k}^F . \tag{10}$$

Its committed cash flow is now

$$c_i + x_i + \sum_{j=1}^{n} P_{ji} + \sum_{k=1}^{M} x_{i,k}^F - L_i - w_i - X_i^F \tag{11}$$

where $\sum_{k=1}^{M} x_{i,k}^F - X_i^F$ represents what Bank i gains from this partnership.

If T of the M SME loans are not performing, while other outside investments are fine, depending on the partnership agreement with the Fintech firm, the bank does not necessarily have to liquidate its assets even if

$$c_i + x_i + \sum_{j=1}^{n} P_{ji} + \sum_{k=1}^{M} x_{i,k}^F < L_i + w_i + X_i^F \,. \tag{12}$$

If the agreement is for the Fintech firm to be fully responsible, then Bank *i* will liquidate the assets of the *T* non-performing SMEs even if

$$\sum_{k=1}^{M} x_{i,k}^F < X_i^F$$

and the situation goes back to expressions (6) to (8). The Fintech firm will have to default if enough SMEs from the *B* partner banks default, that is if,

$$c^F + \sum_{i=1}^{B} \left(\sum_{j=1}^{M-T} x_{i,j}^F + \sum_{j=M-T+1}^{M} \alpha_{i,j}^F A_{i,j}^F \right) < X \,.$$

In this case the Bank's return through this funding will be minimal. That is, $\sum_{k=1}^{M} x_{i,k}^F - X_i^F$ will be close to zero. At the other extreme, Bank *i* is to bear all credit risks of all external investments, including the loans to SMEs. That situation will be shown in the next section.

5.3 A More Fragile Bank

Suppose Bank *i* is not able to meet its obligations because some (*T*) SMEs in the Fintech-bank partnership default, that is

$$c_i + x_i + \sum_{j=1}^{n} P_{ji} + \sum_{k=1}^{M-T} x_{i,k}^F < L_i + w_i + X_i^F \,. \tag{12'}$$

Then Bank *i* will have to liquidate some of its assets, in addition to liquidating the *T* non-performing SMEs. Suppose only a fraction, α_k^F, of the value of SME investment *k* can be recovered and the market value from the SME investment is $A_{i,k}^F$. Then the liquidation decision for Bank *i* in (3) is modified as

$$l_i = Min\left(\frac{1}{\alpha_i} \left(w_i + L_i + X_i^F - c_i - x_i - \sum_{k=1}^{M-T} x_{i,k}^F - \sum_{k=M-T+1}^{M} \alpha_{i,k}^F A_{i,k}^F - \sum_{j=1}^{n} P_{ji} \right)^+, A_i \right). \tag{13}$$

Note that unlike (3), which can contain investment assets other than loans (and therefore can be added to (13), albeit becoming more lengthy), the two summation terms in (13) are the cash flows from $(M - T)$ SMEs that are performing and those *T* that are non-performing.

The implicit assumption here is that once an SME is non-performing, it is considered in default and has to be liquidated (this can be easily relaxed, but will lengthen the formulation quite remarkably).

Expression (13) shows how Fintech financing can be harmful to a bank. When the (highly) risky SMEs default, their liquidation values are usually low, as can be realized by a small value for $\alpha_{i,k}^{F}$. Given that the WMPs guarantee high interest return, it is mostly the case that

$$\left(\sum_{k=1}^{M-T} x_{i,k}^{F} + \sum_{k=M-T+1}^{M} \alpha_{i,k}^{F} A_{i,k}^{F} \right) - X_i^{F} < 0$$

is not only true, but big in absolute value. This highlights the fact that the bank involved in Fintech finance will have to liquidate more of its own outside investment assets, inducing more risk to its asset profile.

Paying back the interbank liabilities in the interbank system is not as straightforward as in (4) because, to Bank *i* the interbank system is now *n* banks plus the Fintech firm (referring to Figure 2). The relative liability for Bank *i* now becomes

$$\pi_{ij} = \begin{cases} \dfrac{L_{ij}}{L_i + X_i^{F}} & \text{if } L_i > 0 \\ 0 & \text{otherwise} \end{cases} \qquad \forall\ j = 1 \ldots n,$$

and

$$\pi_{iF} = \frac{X_i^{F}}{L_i + X_i^{F}}.$$

The first expression above gives the relative liabilities for individual interbank loans, while the second one is that for the Fintech firm. The amount to be paid back by Bank *i* to all other banks and the Fintech firm is extended from expression (4) to the following:

$$P_{ij} = \pi_{ij} \left[Min\left(\left(c_i + x_i + \sum_{k=1}^{M-T} x_{i,k}^{F} + \sum_{k=1}^{n} P_{kj} + \alpha_i l_i + \sum_{k=M-T+1}^{M} \alpha_{i,k}^{F} A_{i,k}^{F} - w_i \right)^{+}, L_i + X_i^{F} \right) \right] \qquad (14)$$

where $j = 1 \ldots n, F$. This means that each bank that is connected to Bank *i* with interbank liability receives less than if Bank *i* is not involved in the Fintech financing.

5.4 The Case of Contagion

The total value of the banking system with one bank, call it Bank 1 (i.e. $i = 1$), connected to one Fintech firm now also depends on shocks to the SMEs' businesses. Suppose the random return of investment from SME k is given by a constant $a_{1,k}^F$ and a random term $\varepsilon_{1,k}^F$. Then we have:

$$x_{1,k}^F = a_{1,k}^F - \varepsilon_{1,k}^F$$

where $\varepsilon_{1,k}^F \in \left(a_{1,k}^F - \alpha_{1,k}^F A_{1,k}^F,\ a_{1,k}^F\right)$ such that the return on investment is bounded below by zero and above by the liquidation value. As mentioned before, we assume that SME k defaults, and is hence liquidated, once it experiences a shock. Of course, if Bank 1 defaults completely, then the value of the banking system is the same as that in (6). If Bank 1 does not default, and if it and other banks in the system also experience other shocks, then the total value of the banking system following expression (5) becomes

$$U = \sum_{i=1}^{n}\left(c_i + a_i + A_i - s_i\varepsilon_i - (1-\alpha_i)l_i\right) + \left(\sum_{k=1}^{M-T} A_{1,k}^F - \sum_{k=M-T+1}^{M} \varepsilon_{1,k}^F\right). \tag{15}$$

With the last term in (15), this means that the overall value of the banking system is increased because of the involvement of Bank 1 in Fintech finance, as long as the total loss of those SMEs that experienced shocks is not as big as the value of all other surviving SMEs. On the other hand, if many SMEs experience shocks, the overall value will be smaller than without Fintech financing.

Now suppose, Bank 1 and Bank 2 are both in the Fintech-bank partnership (as Panel 2A of Figure 2). The total value of the banking system in the case of both banks needing to liquidate some assets becomes

$$U = \sum_{i=1}^{n}\left(c_i + a_i + A_i - s_i\varepsilon_i - (1-\alpha_i)l_i\right) + \sum_{j=1}^{2}\left(\sum_{k=1}^{M-T} A_{j,k}^F - \sum_{k=M-T+1}^{M} \varepsilon_{j,k}^F\right). \tag{16}$$

The same applies to an increased number of Fintech firms joining the partnership, which can also be reflected in the form of more SMEs involved (i.e. larger M in expression (16)), or more banks involved, in which case (16) becomes

$$U = \sum_{i=1}^{n}\left(c_i + a_i + A_i - s_i\varepsilon_i - (1-\alpha_i)l_i\right) + \sum_{j=1}^{N}\sum_{h=1}^{H}\left(\sum_{k=1}^{M-T} A_{j,k}^{F_h} - \sum_{k=M-T+1}^{M} \varepsilon_{j,k}^{F_h}\right) \qquad (17)$$

where there are N (with $N \leq n$) banks and H Fintech firms joining the Fintech-bank partnership, allowing the possibility that one bank can partner with more than one Fintech firm, and each Fintech firm can partner with more than one bank.

It is obvious from expression (17) that whether Fintech financing adds value to the banking system in the presence of shocks very much depends on whether the last term

$$\sum_{j=1}^{N}\sum_{h=1}^{H}\left(\sum_{k=1}^{M-T} A_{j,k}^{F_h} - \sum_{k=M-T+1}^{M} \varepsilon_{j,k}^{F_h}\right)$$

is positive, which depends on (1) the quality of assets of, and (2) the shocks experienced by the SMEs involved in the Fintech-bank system. Once there is a wave of failure in SME businesses, this term becomes smaller or even negative, resulting in a reduction in overall value of the banking system.

The risk of contagion follows the argument discussed in Section 2.3, albeit not as straightforward. Recall that contagion happens if the banking system is fragile, while a highly interconnected "complete network" where more banks are resilient in absorbing shocks from failed bank can be safe from contagion. In the case of a Fintech-bank system, as long as the Fintech platforms are strong enough to absorb defaults from some SMEs, or as long as the banks involved can be more resilient to the failures from the Fintech firms, particularly if there is a well-interconnected network, then the overall system is safe in general. However, with a more fragile banking system, once the shock at some point in the SMEs, and/or Fintech platform, is big enough, the impact from contagion will be greater and faster, a kind of *corridor* effect. Further, as seen from the second part of expression (17), more Fintech financing and therefore more SMEs in the pool induce extra fragility to the banks involved.

Contagion is more likely if banks in the system are more interconnected. Interconnectedness can be seen from the liquidation decision term, l_i, in expression (17). Given N banks and H Fintech firms, we have

$$l_i = Min\left(\frac{1}{\alpha_i}\left(w_i + L_i + \sum_{h=1}^{H} X_i^{F_h} - c_i - x_i - \sum_{h=1}^{H}\left(\sum_{k=1}^{M-T} x_{i,k}^{F_h} + \sum_{k=M-T+1}^{M} \alpha_{i,k}^{F_h} A_{i,k}^{F_h} \right) - \sum_{j=1}^{n} P_{ji} \right)^{+}, A_i \right) \tag{18}$$

and

$$P_{ij} = \pi_{ij}\left[Min\left(\left(c_i + x_i + \sum_{h=1}^{H}\sum_{k=1}^{M-T} x_{i,k}^{F_h} + \sum_{k=1}^{n} P_{kj} + \alpha_i l_i + \sum_{h=1}^{H}\sum_{k=M-T+1}^{M} \alpha_{i,k}^{F_h} A_{i,k}^{F_h} - w_i \right)^{+}, L_i + \sum_{h=1}^{H} X_i^{F_h} \right) \right]. \tag{19}$$

Expressions (18) and (19) show that the liquidation decision depends not only on SME performance under the Fintech finance, but also on interbank payments from other banks, which are also affected by the SME performances in their individual portfolio. Hence, more SMEs defaulting across more banks that join the Fintech-bank partnership not only causes more banks to be more fragile, but because of the interconnectedness, the interbank liabilities imply a higher possibility of contagion and destabilizing adjustment through the more fragile banking system. [2]

In other words, as shown in Section 2, a banking system where more Fintech business is involved, particularly if the Too-Big-to-Fail or Too-Systemic-to-Fail banks are also involved, will bear higher potential risk of failure, even if the interconnectedness within the banking system has not changed. Our model can be easily extended to a global perspective. Considering the interconnectedness of banking systems globally, the number of banks involved in Fintech, *N*, and the number of Fintech firms, *H*, can represent a global setting. All our arguments for contagion throughout a banking system can then be extended to contagion across countries. While this sounds remote at the moment, fear and skepticism of contagion leading to another global financial crisis because of Fintech financing is not without ground, given the very rapid development and expansion of Fintech and a history of similar turbulence during the Financials Crisis in 2007 and 2008 in the U.S. that was based on similar structures.

[2] We have ignored in our model the possibility that business defaults among SMEs can be contagious too, which is more likely in economic downturn when few SMEs could perform well, and SMEs forming a supply chain among themselves will spread the failure from the origin throughout the chain.

6. Potential Threat and the Need for Regulatory Policies

From the previous section, we see that, on the one hand, a more rapid and bigger expansion in Fintech increases the funding of SMEs, and more investors can enjoy returns higher than (artificially low) bank deposit rates. On the other hand, because the SMEs are relatively riskier investments, default of a noticeable number of these SMEs can bring about nontrivial losses to investors. This can have a big social impact because many of these investors are small investors who aim for higher return, but are not sophisticated enough to understand that their investments are in risky assets. When Fintech firms also act as financial intermediaries, such SME default might also trigger failure of the Fintech firms, although the banking system will not be affected.

6.1 Bringing Banks In

When banks are involved, the Fintech-bank partnerships, as in expression (17), show higher overall value of the banking system with expansion of Fintech financing, as long as no SMEs fail, as shown by the second grand summation term. However, also shown in Section 5.4, this same term is also the one that induces increased fragility into the banking system. Some banks and Fintech firms might also collapse. In the worst case, investors in the WMPs under the Fintech-bank partnership cannot be repaid. It is therefore crucial to have appropriate governance to avoid regulatory arbitrage, especially because Fintech has grown so rapidly. For example, as of the first half of 2017, funds from Yu'E Bao have surpassed JP Morgan to become the largest money market fund in the world (Lucas (2017)), implying that it has involved a lot of small investors putting their savings (though perhaps small in magnitude, that might represent a major part of their wealth) into the hands of Ant Financial.

A related issue that is not covered in detail in this study is investors' confidence and bank runs. As in most bank run models, this can come from a range of sources, as is modelled in the classic Diamond and Dibvig (1983) paper. Their model has two equilibria, one with confidence and deposits remaining in the bank, and one without confidence, where

depositors move out of deposits. There is no clear preference for one equilibrium over the other, and the bank does not need to be insolvent to experience a run. As long as some depositors lose confidence in the bank, they will withdraw their funds, possibly triggering other depositors to withdraw as well. By the same token, if some of the investors in WMPs in the Fintech-bank partnership panic, then some investors' 'flight to quality' will trigger others to withdraw funds, too. Hence, there do not need to be defaults from many SMEs, or the Fintech firm, in case a bank is not involved, to trigger liquidation of assets in order to meet investors' withdrawals. The more fragile the banking system and/or the Fintech firm, the easier is the collapse of the system due to a bigger magnitude of 'flight to quality' from a big group of Fintech 'investors'.

Depending on accounting regulations, investments do not have to be on the banks' balance sheets if they can form subsidiaries to become their shadow bank branches. As in the Hongling Capital P2P lender example in Section 3, Fintech firms themselves can pose high risk as shadow banks. In China some WMPs are financing "zombie firms" (that do not produce anything or are "dying" companies) or industries experiencing oversupply (e.g. steel and real estate), but the funds are not held on the balance sheets of the banks, because this can be done under some trusts formed by the banks[3]. Such financial intermediation is not governed under normal banking regulations, and there is no deposit insurance to protect investors' funds (worse if investors are told that their investments are mostly very low risk, and they assume implicit guarantees from the Fintech platform or the banks).

Even though some banks claim that they only help to sell the WMP products and have no obligation for the failure of the investments, as long as these banks are large, a valuable reputation might mean that they cannot simply walk away. For example, Minsheng Bank, one of the partnering banks of Ant Financial, has been pointed out as one of the aggressive lenders through WMPs. This is a big alarm not only for the ever growing shadow banking sector in China, but also its Fintech platform, especially when investors assume implicit

[3] As reported by Deutsche Welle Business Column (2017), the Financial Stability Board is very concerned about the growth of shadow banking in China, which is the fourth largest in the world, but the second fastest growth at 31% in 2016.

guarantees. The situation is analogous to that of some structured investment vehicles (SIVs) in the U.S. before the recent crash, which were off balance sheet but which sponsor banks nonetheless felt obligated to support, perhaps for reputation reasons. This can be thought of as a case of "pinky-swear" recourse, where sellers make legally unenforceable promises that are not subject to capital regulations or, perhaps, close scrutiny, and can be broken under stress.[4]

6.2 Policy

Overall, interconnectedness within and among banks, shadow banks, and Fintech, coupled with the very speedy development in technology and innovation are possible sources of amplifying banking risks. There have been a lot of proposals on how to regulate Fintech and shadow banks. Here we suggest "ring-fencing", a proposed remedy to the Global Financial Crisis, as a measure to tackle the risk of financial contagion from Fintech financing. "Ring-fencing" in the Vickers proposal (Independent Commission on Banking of the United Kingdom) [5] refers to separating some banking activities as well as the investors of these activities from the rest of the banking activities and their corresponding risks. In the Liikanen proposal (European Commission)[6], "ring fencing" is meant to restrict banks from taking risks associated with wholesale financial services.

The idea of ring-fencing is to separate the risky investments from the low risk investments to protect investors/depositors' assets from being affected by the failure of those risky investments. When applied to the Fintech-bank partnership, ring-fencing is the dotted oval surrounding the Fintech network and the banks connected to this network in Figure 3. Mathematically, we suggest isolating the Fintech financing for the SMEs, so that the overall value of the banking system in expression (17) will not be affected by

[4] "Pinky swear" refers to a childhood version of sealing a deal by linking small fingers (the pinkies) as a presumably special sort of promise. It was used, for instance, in secondary mortgage markets in the U.S., in part as a way of giving partial recourse without having to hold capital against the ensuing risk.

[5] The Final Report of the Independent Commission on Banking is available from http://bankingcommission.independent.gov.uk/

[6] High-level Expert Group on Reforming the Structure of the EU Banking Sector Chaired by Erkki Liikanen FINAL REPORT Brussels, 2 October 2012, available from http://ec.europa.eu/internal_market/bank/docs/high-level_expert_group/report_en.pdf.

$$\sum_{j=1}^{N}\sum_{h=1}^{H}\left(\sum_{k=1}^{M-T}A_{j,k}^{F_h}-\sum_{k=M-T+1}^{M}\varepsilon_{j,k}^{F_h}\right).$$

It is true that the banking system value is now smaller, provided this term is positive (i.e. more performing SMEs than the non-performing ones), but it is also true that the system will be healthier in the face of shocks because l_i, and P_{ij}, in expressions (18) and (19) will be free from

$$\sum_{h=1}^{H}X_i^{F_h},$$

and

$$\sum_{h=1}^{H}\left(\sum_{k=1}^{M-T}x_{i,k}^{F_h}+\sum_{k=M-T+1}^{M}\alpha_{i,k}^{F_h}A_{i,k}^{F_h}\right)$$

will depend on the performances of the SMEs under the Fintech financing.

There are several ways of ring-fencing in this case. A direct way is to separate the Fintech finance sector completely away from the banking system, so that it will not be affected by whether there are any bail-ins or bail-outs of the Fintech firms. When banks are involved an approach is to separate the SME business from their core business, which is less risky. This is similar to the Volcker's Rule for shadow banking branches of banks. This, however, requires very clear regulation in identifying and separating the risky investments with SMEs from other bank investments. Otherwise, opaque differences will make actual implementation of ring-fencing difficult. A third approach is to allow only some banks, typically smaller ones, to be involved, so that these banks are completely ring-fenced from the rest of the banking system. In times of trouble, it would be up to the regulatory bodies to determine if bail-ins or bail-outs for these small banks were appropriate.

Bernard *et al.* (2017) proposes a model that determines when government bail-ins or bail-outs (or threat not to intervene) are the best solutions. Our model can be adjusted to fit their bail-in/out decisions. In any case, the regulatory bodies will be dealing with only a sub-sector of the banking system, rather than having the problem contagious across the whole system. Ring-fencing loses its effectiveness, however, when many banks, big and small, join Fintech financing. Hence, ultimately, clear regulations should be set up as to the kind

of SMEs with specified types and levels of risk that could be funded through Fintech financing, so as to obtain a high positive value for

$$\sum_{j=1}^{N}\sum_{h=1}^{H}\left(\sum_{k=1}^{M-T}A_{j,k}^{F_h}-\sum_{k=M-T+1}^{M}\varepsilon_{j,k}^{F_h}\right)$$

with higher probability. This will however restrict the original characteristics of the free entry and innovation of Fintech.

We note here that we do not consider the role of liquidity in our model, because our focus is on the impacts of defaults of SMEs on the Fintech-banking system, rather than the liquidity issues of the banks. Further, one may consider the situation of the government being the lender of last resort. This could easily be incorporated into the model in terms of enlarging the left hand side of expression (12') such that liquidation of some assets does not have to take place.

7. Conclusion

There has been a rapid expansion in China of Fintech firms as a source of financing, especially for SMEs, particularly because of the availability of big data, making asset evaluation (particularly regarding credit risk) much easier and faster, and because of easy entry/exit into the market, which traditional banking cannot provide. Much of this is not new and bears a strong resemblance to the U.S. private label mortgage market not too long ago. That market also grew quite rapidly, before exploding.

The tools used in the U.S. then, particularly the use of technology for analysis and pricing of credit risk of pools of loans (automated underwriting), and the use of special purpose vehicles and the Repo market for funding are quite similar to tools being used now in China. An issue then was overly enthusiastic application of technology. It is clear in the U.S. that loan originators and sellers, as well as borrowers, gamed the newly evolved automated underwriting systems by exploiting things not covered in the models and/or by outright

lying and cheating. It is also clear that risk was often hidden in the complicated structures that were used to fund the pools.

A question is whether China is headed for a similar experience. These are reasonable worries for China. Problems with how those structures handled shocks and fragility are similar to issues about *corridors* in networks raised above, inside of which adjustment to shocks is stable, but outside of which adjustment is unstable. We note though that in China Fintech and shadow banking are still quite small relative to the size of the Chinese economy. There do not appear to be data that can shed light on the likelihood of China being similar to the U.S., and we have no insight into how policy-makers might react to fragility from Fintech.

The main purpose of the paper is to look at how Fintech financing is linked to the traditional banking system, and to consider how to model whether Fintech creates more value or risk to society. The paper suggests a general network model that can be flexibly applied to Fintech financing, with and without involvement of the banking sector, given various forms of interconnectedness. We show how the expansion of Fintech financing and its extension to shadow banking can create contagion to the banking sector when many borrowers (e.g., SMEs) default.

We contribute to the literature by providing, to the best of our knowledge, the first study that models Fintech financing using network models and which is applied to the Chinese economy. We show how the network reacts to increases in Fintech firms and/or banks involved in the Fintech-bank partnership. This will be crucial for regulatory bodies to determine policies to mitigate increased risks and yet allow financing to SMEs. The network models can also be applied for consideration of bail-ins and bail-outs of the banking/financial system due to Fintech. Finally, we suggest ring-fencing as a way to isolate Fintech financing from the rest of the banking business, so that failure in the Fintech finance need not be contagious to the rest of the system, particularly as sophisticated tools for capital and risk management are not currently available.

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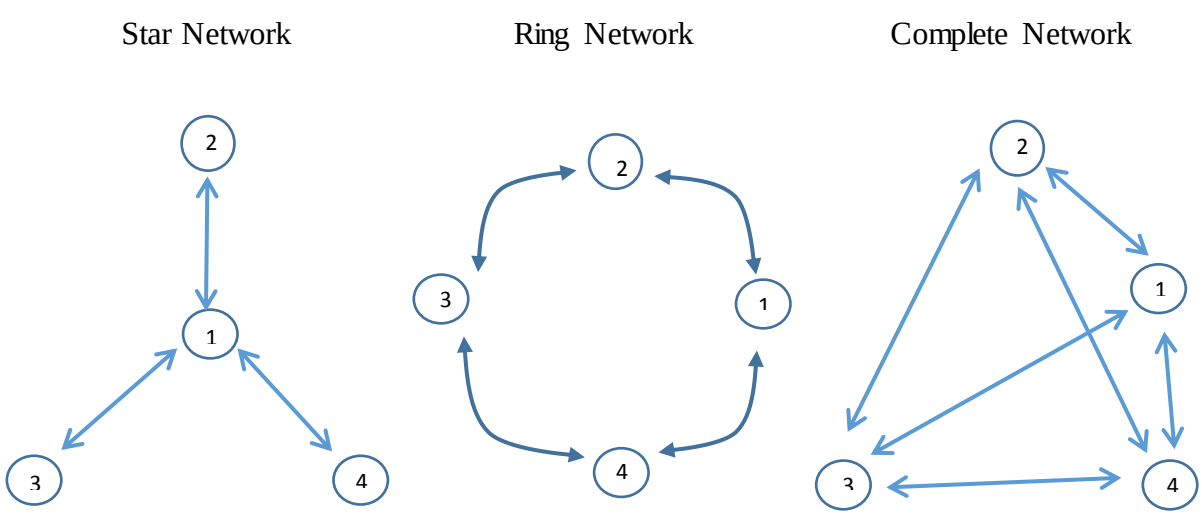
Figure 1 Examples of Types of Network Connections in Banks and Fintech

Panel 1A Banking Networks



Panel 1B Fintech Networks

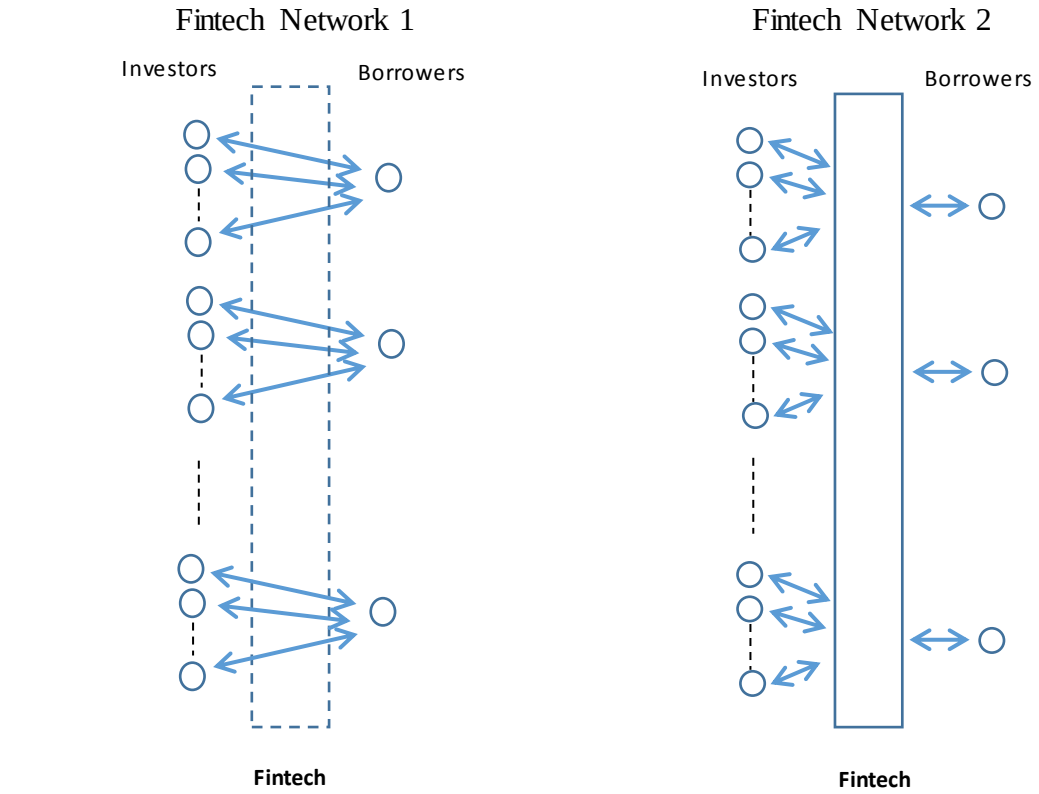
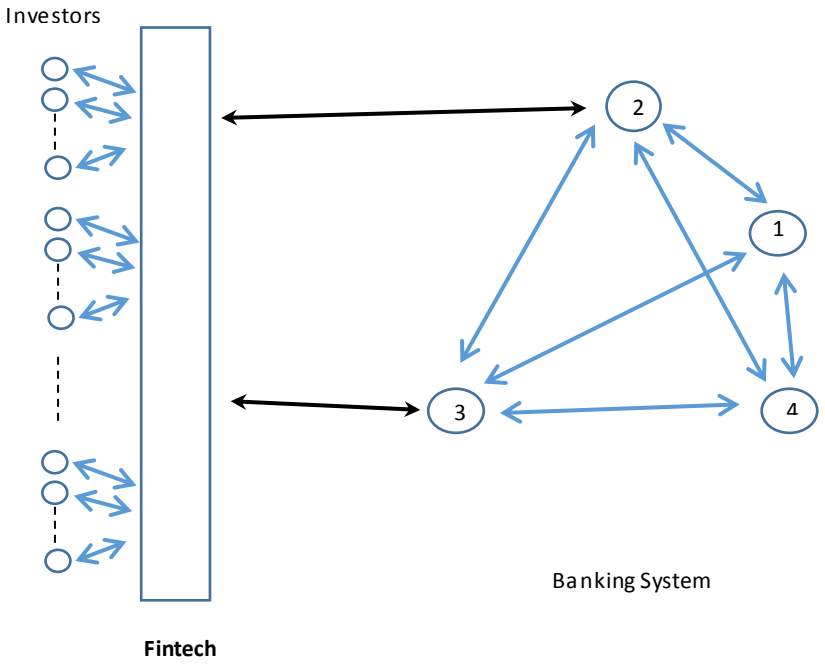


Figure 2 **Network with Fintech Shadow Banking and Banking System**

Panel 2A ***Simple Fintech-Banking Network***



Panel 2B ***Multiple Fintech-Banking Network***

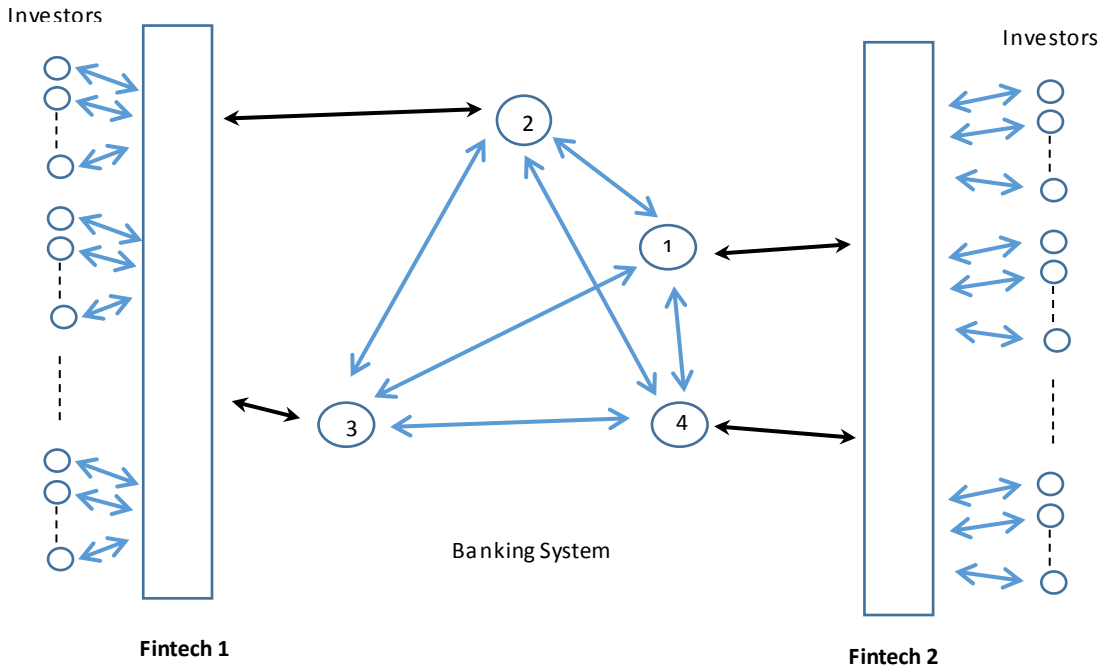


Figure 3 A Ring-fenced Fintech Shadow Banking Network