Credit Insurance, Bailout and Systemic Risk

October 1, 2019

Abstract

This paper studies the impact of the expectation of bailout of a systemically important credit insurance firm, like AIG, on the *ex ante* investment strategies of the counterparty banks. Failure of the insurance firm may result in subsequent failure of both solvent and insolvent counterparty banks by triggering a run on them. As during the run, the regulator cannot distinguish between solvent and insolvent banks, hence it cannot use targeted policies to bailout the system, such as providing liquidity to the solvent banks to buy the insolvent ones. So the regulator has to bailout the insurance firm. This imperfectly targeted policy incentivizes the banks to make correlated investments *ex ante* and thus create systemic risk. I build a model in which correlated investment by banks, underpriced insurance contracts and a systemically important insurance firm arise endogenously. I further show that the insurance firm instead of diversifying its risk, chooses to invest in the same industry as the banks thereby increasing the size of the bailout. The policy implication is that putting a limit on the size of insurance firm can mitigate the problem of creation of systemic risk and thus prevent bailouts.

Key Words: Banking; Credit insurance; Systemic risk; Financial crisis

JEL Classification: G21, G28, E58; G01

1 Introduction

The financial crisis of 2007 was preceded by financial institutions making large investments in real estate sector, considerable portions of which were hedged by buying credit default swaps (CDS). AIG alone had CDS worth \$533 billion (notional amount) outstanding at the end of 2007. When the crisis started, AIG was unable to meet its obligation and was bailed out, receiving a bailout of worth over \$182 billion.[1] The reason AIG was bailed out was that it was considered a systemically important institution.[2] While AIG was effectively nationalized with the government taking a 79.9% equity stake in it, the benefit of its bailout was mostly enjoyed by its counterparties. For example, Goldman Sachs received \$12.9 billion and Société Générale received \$11.9 billion.[3] So, effectively the banks which would have suffered large losses, had AIG gone bankrupt, got the benefits of the bailout.

It is well understood that systemically important firms under the expectation of bailout may indulge in excessive risk taking. But in our example, it is the counterparties who got the benefit of the bailout. So the question that arises is what is the impact of expectations of such bailouts on the investment strategies of the counterparty banks. Also, why did AIG not have enough funds to meet its obligations once the crisis hit, i.e. why were the CDS contracts underpriced? Apart from writing CDS contracts, AIG had also made large investments in the real estate sector.[4] The question is why did AIG double down on its long positions on real estate assets which it had taken by writing CDS contracts instead of diversifying its risk?

In this paper, I show that the expectation of a bailout of a systemically important insurance firm may *ex ante* lead banks to make investments in the same industry, i.e. they make correlated investments and thus create systemic risk. Failure of the insurance firm may trigger a run on the counterparty banks resulting in subsequent failure of both solvent and insolvent counterparty banks. During a systemic run, it is hard for the regulator to distinguish between a solvent and an insolvent bank. So, it cannot use a targeted policy to bailout the system, such as providing liquidity to the solvent banks to buy the insolvent banks (as in Acharya and Yorulmazer (2007a)). Hence, the regulator has to bailout the insurance firm to prevent a systemic crisis. This imperfectly targeted policy incentivizes the banks to make

[1]For a detailed discussion on failure and subsequent bailout of AIG, see Harrington (2009) and McDonald and Paulson (2015).

[2]Donald L Kohn, Vice Chairman of the Board of Governors of the US Fed, in his testimony said: "The failure of AIG would impose unnecessary and burdensome losses on many individuals, households and businesses, disrupt financial markets, and greatly increase fear and uncertainty about the viability of our financial institutions."

[3]For a complete list of counterparties and the amount they received, see Harrington (2009).

[4]At the end of year 2007, AIG had an investment of \$85 billion in residential mortgage backed securities.

correlated investments *ex ante*. In order to get the benefit of the bailout, banks want their assets to perform poorly *exactly* at the time when the bailout of credit insurance firm is occurring. If their assets are performing poorly at the time of bailout, then payment is due on the CDSs, and the insurance firm uses the bailout money to pay the banks. Which ever bank's assets are performing well will not be able to get the benefit of the bailout. Since all banks want to benefit from the bailout, they all want their assets to perform poorly exactly at the time the bailout is occurring; hence the banks make correlated investments *ex ante*.

I build a model where correlated investments by banks, underpriced credit insurance contracts and a systemically important insurance firm, which needs to be bailed out in bad states, arise endogenously. Given that the banks are making correlated investments, there will be aggregate risks. I show that the banks will only hedge the idiosyncratic risks for the good aggregate state when assets of few banks may perform poorly, and hence the insurance premium will be low. This premium will not be enough to insure them in the bad aggregate state when assets of many banks will have poor performance, hence the insurance firm will not be able to meet its obligations and will announce bankruptcy. The depositors of the banks do not observe the asset returns, and hence do not know which banks' assets have defaulted. So, they will run on all the banks and withdraw their deposits. All banks, including the solvent ones whose assets have not defaulted, will be forced to sell the fraction of assets which are maturing late to outside investors. The price of the assets will be very low because of a large adverse selection discount owing to the bad aggregate state. If the sale price is low enough, then even the solvent banks will not be able to meet its depositors' demands and all banks will fail. This will force the regulator to bailout the insurance firm and the banks will receive the benefit of the bailout. The banks' *ex ante* profits are higher because they are able to insure themselves for both good and bad states even by writing cheap insurance contracts which insure only the good state. Thus, my paper shows that expectations of bailout of a systemically important firm may result in the entire system indulging in moral hazard by making correlated investments and underpricing the risks.

In a financial crisis, there is a systemic run on the banks.[5] Failure of a systemic firm like AIG which is insuring the assets of banks would exacerbate this run and result in failure of not only insolvent but even solvent banks. Bailing out AIG helped all counterparty banks, irrespective of their solvency position. The important thing to note is that this policy is imperfectly targeted. A more targeted policy would allow the regulator to sell failed banks to solvent banks. Such a targeted policy would create an *ex ante* incentive for the banks to survive when a crisis is occurring to be able to buy assets at fire sale price. But an imperfectly targeted policy, such as bailout of AIG, implies that there is no benefit of performing well

[5]See, for example, Gorton and Metrick (2012).

when others are performing poorly. In fact by performing well, they will only miss out on the benefit of bailout. So, the banks prefer to herd and fail together.

There are three main ingredients which drive my results. First, I assume that even the regulator cannot observe the returns of the banks' assets. If the regulator is able to observe the asset returns, then it can act as a lender of last resort to the banks who are solvent and allow the insolvent banks to fail. These failed banks can then be sold to the successful banks at cash-in-market-prices.[6] The successful banks would gain and this will create an incentive to survive when the others are failing and so banks would make uncorrelated investments. The second ingredient is that assets do no mature together. If all assets matured together, then the banks whose assets do not default would not fail as there in no scope of a run. Failed banks can again be sold to successful ones and this would incentivize banks to make uncorrelated investments *ex ante*.

The third friction which drives my result is that the regulator's policy is time inconsistent (similar to Kydland and Prescott (1977)). If the regulator can commit that he will not bailout the insurance firm even if its bankruptcy results in a systemic failure of banks, then the banks will not make correlated investments and underinsure their risk. But the regulator cannot stick to this commitment once the crisis hits.

Next, I analyze policies which can mitigate this problem. I show that the problem of creation of systemic risk can be resolved by putting a cap on the notional value of assets that a single firm can insure. This cap will imply that there are many insurance firms in the market, none of which is systemically important. If the banks still make correlated investments and underinsure their risks, then the regulator can bailout some insurance firms and let others fail. The counterparty banks of these bailed out insurance firms can then buy assets of failed banks at fire sale price and this will create an incentive to *ex ante* invest in uncorrelated assets.

Finally, I show that if the insurer can also choose an industry to invest its premium collected (in the benchmark model it can only invest in cash assets), it will invest in the same industry as the banks. Banks do not want to fail in the good aggregate state because there will be no bailout. So they write the contract with a premium such that if the investment by insurer performs poorly, even then they are covered. So, when the insurer's investment performs well, it has some surplus left and earns positive profits. To maximize its expected profit, the insurer wants to maximize the probability that its assets perform well when the banks are in good state. This will happen if the bank invests in the same industry, because

[6] Other papers where the regulator adopts similar policy to resolve failure of banks are Acharya and Yorulmazer (2007a,b). For more on bank closure policies, see, for example, Mailath and Mester (1994), Freixas (1999), Santomero and Hoffman (1996), Kasa et al. (1999), among others.

when the industry is in good state then it is more likely that the insurer's asset also performs well. The insurer does not care about the bad aggregate state because it will be bailed out irrespective of the industry it chooses to invest in. Thus, the paper explains why AIG chose to invest in real estate sector, the very sector it had written insurance contracts on. If the sector had performed well, it would have made large profits, else it would be bailed out as was the case.

1.1 Related Literature

The fact that expectations of bailout of too-big-to-fail or too-systemic-to-fail institutions can result in excessive risk taking is well known. Several papers starting from Bagehot (1873) have pointed this out.[7] The purpose of this paper is to study how expectations of bailout of a firm which has written insurance contract for other banks, and hence has become systemically important, will affect the investment strategy of the banks.

My paper is related to several strands of literature. First it contributes to the literature on systemic risk. In my paper systemic risk arises because banks make correlated investments and then write CDS contracts with a firm which becomes systemically important.[8] A recent related paper is Farhi and Tirole (2012) in which the regulator reduces the interest rate once the crisis hits to increase the size of the investments made by the banks. Reduction of interest rate being an imperfectly targeted policy leads the banks to engage in collective maturity mismatch and make correlated investments so that they get the benefit of reduced interest rates. In my paper the imperfectly targeted strategy which creates incentives to make correlated investment is bailing out the insurance firm to save the banks.

Acharya and Yorulmazer (2007a,b) also present a model where banks make correlated investments. In their paper, when many banks fail together, regulator is forced to bailout the banks and he cannot dilute their equity because of moral hazard. If only a few banks fail then they can be sold to surviving banks. My paper is similar in spirit, but the driving force is that regulators cannot observe the returns of the banks and hence cannot distinguish between solvent banks who are failing because of a run and insolvent banks. To prevent the run it is forced to bailout the insurance firm which allows even the insolvent banks to survive.

Acharya (2009) also shows that banks may make correlated investments because of limited

[7] For surveys on too-big-to-fail-problem, see Stern and Feldman (2004) and Strahan (2013). Rajan (2009) discusses the too-systemic-to-fail problem.

[8] There are may reasons why systemic risk can arise. One reason could be some form of contagion among banks, where one bank's failure can result in failure of other banks (Allen and Gale (2000), Freixas et al. (2000)). For survey on systemic risk, see, for example, De Bandt and Hartmann (2000), Bisias et al. (2012), Freixas et al. (2015).

liability and negative pecuniary externality of one bank's failure on other banks. Other models of bank herding include Rajan (1994) which relies on reputation concerns and Acharya and Yorulmazer (2008) which relies on information contagion.

While the purpose of credit insurance is risk sharing, in my paper credit insurance also results in creation of systemic risk. Allen and Carletti (2006) present another model where credit risk transfer can result in contagion between the banking sector and insurance sector and can be detrimental to welfare. The contagion happens because the banks and the insurance firms invest in the same long term asset. During bad states, these assets are sold at low prices due to cash-in-market-pricing affecting both banking and insurance sectors. Wagner and Marsh (2006) study credit risk transfer between banking and non-banking sector and examine conditions under which efficiency in credit risk transfer markets can reduce financial stability.

There is large literature which highlights how an insured party can indulge in moral hazard when they insure themselves by writing financial contracts.[9] Campello and Matta (2012) show that CDS contracts can lead to risk-shifting by banks. Credit insurance can also affect the bank's incentives to monitor the loans (see Morrison (2005), Parlour and Winton (2013)).[10] Bolton and Oehmke (2011) show that banks have lower incentive to renegotiate the loans after writing CDS contracts because their outside option is higher and this results in excessive liquidation and increases inefficiency. Unlike these papers which study moral hazard by individual banks, my paper studies how banks indulge in collective moral hazard by making correlated investments.

Counterparty risk has become an important concern after the crisis of 2007. There are some recent papers which study moral hazard by insuring agents which generates counterparty risk. Thompson (2010) builds a model where counterparty risk leads insured party to reveal information even in absence of a signaling device.[11] In Biais et al. (2016), the insuring party after observing poor signals can indulge in gambling for resurrection creating counterparty risk and limiting the benefits of risk sharing. In my paper, the counterparty risk is created not because of moral hazard problem on the side of the insurer but because of collective moral hazard on behalf of the banks who write underpriced insurance contracts with competitive insurers. The low premium in underpriced contracts is not enough to cover the bad state and results in counterparty risk.

The rest of the paper is organized as following. Section 2 discusses the model framework. In section 3, I analyze the model and present the main results. Section 4 discusses the policy

[9] For a survey on CDS, see Augustin et al. (2014).

[10] For discussion on use of loan sales as credit risk transfer and its subsequent impact on bank's incentives, see Pennacchi (1988), Gorton and Metrick (2012), Parlour and Plantin (2008), among others.

[11] See, also, Stephens and Thompson (2014, 2017).

implications. Section 5 discusses the investment strategy of the insurer. Section 6 concludes.

2 Model

Consider an economy which has a continuum of banks (normalized to 1), depositors, insurance firms, outside investors and a regulator. All agents in the economy are risk neutral. There are two dates, $t = 0$ and 1. At $t = 0$ each depositor is assumed to receive an endowment of 1 unit and their outside option is storage technology which yields a return of 1 per unit of investment. In other words risk free interest rate is normalized to 1.

The banks can borrow from competitive depositors to invest in a risky asset which requires one unit of investment. The asset can be a portfolio of loans in an industry. It returns R when successful and L when it fails. For simplicity, I assume that $L = 0$. I will consider two cases regarding the maturity of the asset. In the benchmark case all assets will mature at the same time at $t = 1$. In the second case, all assets do not mature together, and rather a fraction $\gamma = 1/2$ of the assets mature at $t = 1$ and the remaining $1 - \gamma$ fraction of assets mature a little later at $t = 1 + \epsilon$ (see figure 1).[12] This case is more realistic as banks invest in long term assets. As we will see later, if the assets mature together at $t = 1$, then there will be no possibility of run on the banking system.

There are infinitely many industries and each bank can invest in one of them. An industry can be in good state with probability q or bad state with probability $1 - q$ (see figure 2). If the industry is in good state, then the probability that the asset succeeds and yields R is α, while if the industry is in bad state, then the probability that the asset succeeds is β. I assume that $\alpha > \beta$. Thus there is an idiosyncratic risk within each industry.

Given our technology, if all banks invest in the same industry, i.e. the correlation denoted by ρ, equals 1, then there are two aggregate states, good and bad. Note that $\rho = 1$ is used to denote investment in the same industry, but this does not necessarily imply that all banks have the same return because there is idiosyncratic risk within each industry. In good state α banks succeed and in bad state β banks succeed. But if the banks invest in different industries ($\rho = 0$), then there is only one aggregate state in which ω banks succeed, where $\omega = q\alpha + (1 - q)\beta$.

The contract between banks and depositors takes the form of a simple debt contract which matures at $t = 1$ irrespective of whether the assets mature together or not. In the case where assets do not mature together, depositors can roll over this debt to $t = 1 + \epsilon$. The assumption of short term debt which matures before all assets do (at $t = 1 + \epsilon$) is necessary

[12] I have assumed $\gamma = 1/2$ to economize on the notations. The results can be generalized to any value of $\gamma < 1$.

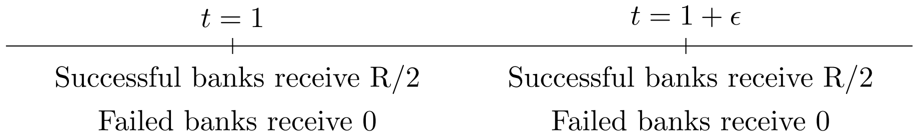

Figure 1: Half of assets mature at $t = 1$ and remaining at $t = 1 + \epsilon$

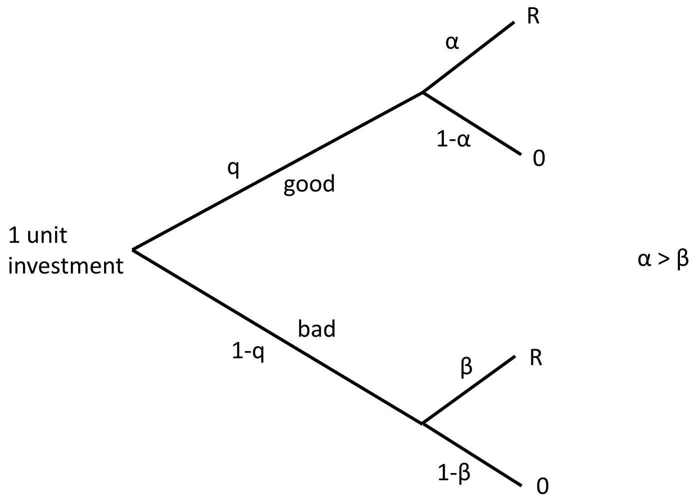

Figure 2: Asset returns

to create a run on the banks. While in this paper I assume short term debt to be exogenously given, there is large literature which provides explanation for why banks finance themselves with short term or demandable debt.[13] The face value of debt is denoted by D. Banks are generally financed with a mixture of insured and uninsured creditors. In this paper, I carry out the analysis assuming that the depositors are uninsured. The model can be extended to the case where some part of depositors are insured. For simplicity I also assume that there is no equity.[14]

If the asset succeeds, then the bank can pay off the creditors and continue their operation. I assume that there is a continuation value of the bank which is denoted by V.[15] If the asset fails, then the bank cannot pay its creditors and goes bankrupt in which case it looses its continuation value.

[13] See, for example, Diamond and Dybvig (1983), Calomiris and Kahn (1991), Diamond and Rajan (2000, 2001), Brunnermeier and Oehmke (2013), among others.

[14] This assumption is to keep the model simple and to also highlight that equity can be costly to raise because of asymmetric information (Myers and Majluf (1984)).

[15] V can be easily endogenized. For example, I can assume that after paying the creditors, the banks can invest again by borrowing from depositors.

	Mature together	Do not mature together
$\rho = 0$	$\Pi_{\rho=0,T}$	$\Pi_{\rho=0,NT}$
$\rho = 1$	$\Pi_{\rho=1,T}$	$\Pi_{\rho=1,NT}$

Table 1: 4 scenarios corresponding to $\rho \in \{0,1\}$ and assets maturing or not maturing together

3 Model analysis

Banks make investments in an industry and decide whether to write a credit insurance contract in order to maximize their expected profit. I solve the model backwards. First I solve for banks' profits taking as given the correlation of the banks investments. There after I analyze what correlation the banks will choose ex ante. There are four scenarios to consider (see table 1). These scenarios correspond $\rho \in \{0,1\}$ and assets maturing together (benchmark case) and not maturing together. The expected profit of the bank is denoted $\Pi_{\rho,m}$. The subscript $m \in \{T, NT\}$, where $m = T$ denotes the case where assets mature *together* while $m = NT$ denotes *not together*. The subscript ρ denotes the correlation of banks assets.

I will show that if assets mature together, then banks will invest in different industries ($\rho = 0$) and investing in the same industry cannot be an equilibrium. But if the assets do not mature together then, the banks will prefer to invest in the same industry and write underpriced credit insurance contracts. I first analyze the case where $\rho = 0$, and the assets mature together at $t = 1$.

3.1 Banks invest in different industries and assets mature together

Let us first consider the scenario when the banks do not purchase any credit insurance. Since $\rho = 0$, ω banks' assets will succeed and $1 - \omega$ banks' assets will fail. A bank with failed assets cannot pay off its depositors. I also assume that the failing bank cannot raise capital against its continuation value. This assumption will be particularly true when there is a run on the banks and the capital market may be rife with information frictions. Other reason that banks cannot raise money could be that their depositors do not have enough capital at $t = 1$.[16] Thus, when the bank's assets fail, then the bank is in default and its continuation value will be lost. To avoid failure, banks may want to write credit insurance contracts with insurers which will be discussed later.

The regulator's objective is to maximize the social surplus and so, to prevent the con-

[16]Similar assumption is made by Acharya and Yorulmazer (2007a).

tinuation value from being lost, it will take over the banks in the event of bankruptcy. The regulator will then try to sell the failed bank to the successful banks, who in turn pay off the depositors of the failed banks and continue the operations. Thus the net worth of each of the failed banks is $V - D$, that is the continuation value minus the amount thats needs to be paid to the existing depositors before the bank can resume operations.

The liquidity available with each successful bank is $R-D$. So, the total available liquidity with all banks is $\omega(R-D)$. The total liability of all the failed banks is $(1-\omega)D$. If the total liquidity available is large enough such that the successful banks can pay off all the depositors of failed banks, then the regulator can sell all the failed banks to successful ones at a positive price for each unit of bank. I assume that this is the case, which means that the depositors always get paid. They are paid either directly if their bank succeeds or if their banks fail, then they are paid indirectly by the successful banks who purchase their failed bank. Therefore the face value of debt, D, equals 1. So, I am assuming that

$$\omega(R-1) > (1-\omega).$$

I also assume that the fair value of each failed bank is greater than 0, i.e. $V - 1 > 0$, which implies that the successful banks will be interested in buying the failed banks.

The price at which the failed banks are sold will depend on the total liquidity available with the successful banks. To buy the banks at fair price of $V - 1$, the total liquidity available should be at least $(1-\omega)V$ because $(1-\omega)(V-1)$ is needed to buy the banks at fair price and $(1-\omega)$ is needed to pay their depositors. So, if the available liquidity is less than $(1-\omega)V$, then the failed banks will not be bought at fair price and there will be "cash-in-market-pricing."[17] The price of each unit of failed bank will be

$$p = \frac{\omega(R-1) - (1-\omega)}{(1-\omega)}.$$

The numerator is cash available after paying the depositors and the denominator is the number of banks being sold. When there is cash-in-market pricing, then the successful banks will make a positive profit of $V - 1 - p$ for each unit of bank they buy. To summarize, the price is given by (also see figure 3):

$$p = \begin{cases} \frac{\omega(R-1)-(1-\omega)}{(1-\omega)}, & \text{if } (1-\omega) \leq \omega(R-1) < (1-\omega)V. \\ V-1, & \text{if } (1-\omega)V \leq \omega(R-1). \end{cases} \tag{1}$$

To keep the discussion succinct, I assume is that there is enough liquidity to purchase the

[17]For cash-in-market-pricing, Allen and Gale (1994, 1998, 2005).

failed banks at fair price and then pay the depositors in full.

Assumption 1. $\omega(R-1) \geq (1-\omega)V$.

When the banks succeed, which happens with probability ω, their expected profit is equal to $R-1+V$. Note that since the failed banks have been bought at fair price, they do not add to the profits of the successful banks. If the banks fail, then they get zero utility. So the bank's *ex ante* expected utility is

$$\omega(R-1+V). \tag{2}$$

Now let us consider the case when banks buy credit insurance. I assume that there are two insurance firms and they simultaneously offer credit insurance contracts to the banks. These insurance firms compete à la Bertrand and therefore they will charge an insurance premium which will earn them zero profits. The banks then sign the contract with one of the insurance firms.[18] Suppose that the banks fully insure their investment, i.e. they insure up to amount R. Since $(1-\omega)$ banks will fail, the insurance firm will charge a premium denoted by z, where z equals $(1-\omega)R$. Hence, in this case banks will raise $1+z$ from the depositors to finance their investment and also pay for the insurance premium. Since the debt is safe, so the face value D will equal $1+z$. The banks may equally well have insured only up to the face value of debt and the result will be identical.[19]

When the banks buy credit insurance, they are always able to pay their depositors and then also obtain their continuation value. So, their expected profit is $R-D+V$, which equals

$$\Pi_{\rho=0,T} = \omega R - 1 + V. \tag{3}$$

Thus, the banks utility is the net present value (NPV) of the project $(\omega R - 1)$ plus the continuation value. The difference between the *ex ante* expected profits with and without credit insurance is

$$(1-\omega)(V-1). \tag{4}$$

This term equals the profits transfered to the regulator to buy the failed banks when banks

[18] I assume that all banks sign the contract with the same firm because this may give benefits of diversification. While, there is no benefit of diversification if there are a continuum of banks as we have considered, if there are only a few discrete number of banks then benefits of diversification may be significant.

[19] If the banks insure only up to their face value of debt, then z would be $(1-\omega)D$. Since the debt is safe the face value of debt will be equal to $1+z$. So $D = 1/\omega$ and $z = 1/\omega - 1$. Any level of insurance between face value of debt and R will result in the same expected profit.

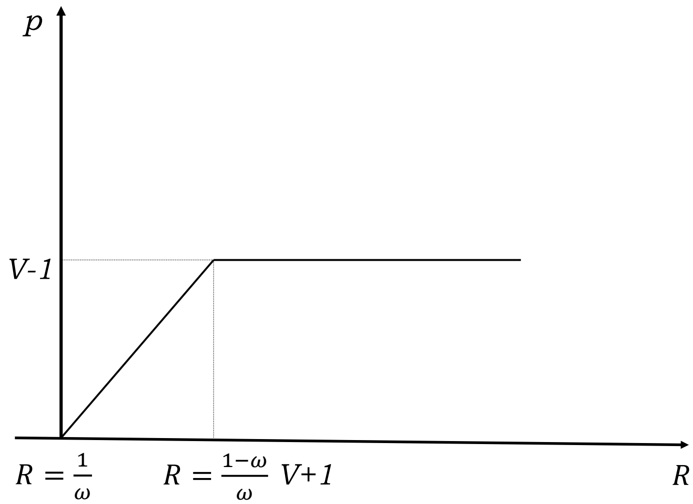

Figure 3: Price as function of R

do not buy the insurance.[20] Recall that when there was no insurance, the $(1-\omega)$ failed banks were sold at the fair price of $V-1$. So, the amount$(1-\omega)(V-1)$ is transfered to the regulator. Thus the banks are better off with credit insurance. If they do not have insurance, then the regulator is able to expropriate part of their profits.

Remark 1: In practice there are many ways in which the regulator may be able to expropriate some value from the banks. For example he may inject equity into the failed banks and take direct ownership. Even if the regulator does not take direct ownership of the bank and sell it to other banks, he can still expropriate some profits. For example, if there has been a run on a bank then the regulator may buy assets at prices below fair value to provide liquidity to the bank. Even if a bank may directly sell itself to other banks without intervention of the regulator preventing any transfer to him, still there may be other reasons to buy credit insurance to prevent bankruptcy. There may be dead weight loss if a bank goes bankrupt. This can be modeled by assuming that the continuation value of the bank is bank specific.[21] To prevent this dead weight loss, the banks may write credit insurance contracts.

Credit insurance prevents the banks from failing. But the banks have to pay a premium for insurance. I now discuss if the banks can rely on the bailout of insurance firm to prevent

[20] If assumption 1 does not hold and there is cash-in-the-market pricing then the profit transfer will be $(1-\omega)p = \omega R - 1 - (1-\omega)$.

[21] Similar assumption is made by Acharya et al. (2012).

themselves from failing. If the regulator will bail out the insurance firm then the benefit to the banks will be that they only have to write an insurance contract with the insurer and pay no or lesser premium.

Let us consider the scenario when the banks only write insurance contract with the insurer with 0 premium and rely on bailout of the insurer. At $t = 1$, assets of $1 - \omega$ banks will fail and they will demand payment from the insurer. Since the insurer has no money, he will declare a bankruptcy. If the regulator does not bailout the insurer then $(1 - \omega)$ banks will fail. As before, the regulator can sell these banks to the successful ones. Hence the regulator has no incentive to bailout the insurance firm. This scenario is same as if the banks had written no credit insurance. Hence the banks cannot rely on the regulator for bailout. Similar analysis will follow if we consider any premium which is greater than 0 but is less than $(1-\omega)R$. The above discussion is summarized in the following proposition.

Proposition 1. *If assumption 1 holds, assets mature together ($m = T$) and the banks invest in different industries ($\rho = 0$), then*

i. the banks prefer to buy fairly priced credit insurance with $z = (1 - \omega)R$. In this case, the expected profit of the banks is $\Pi_{\rho=0,T} = \omega R - 1 + V$.

ii. if they do not buy credit insurance, then their ex ante expected profit is $\omega(R - 1 - V)$ and the regulator is able to expropriate $\omega(V - 1)$

3.2 Banks invest in different industries and assets do not mature together

I now discuss the case when banks invest in different industries, i.e. $\rho = 0$, and the assets do not mature together. Let us first consider what will happen if the banks do not write credit insurance contracts with the insurance firms. At $t = 1$, assets of ω banks will be successful because $\rho = 0$. Since only half of their assets mature at $t = 1$, so they will receive $R/2$ at $t = 1$ and the remaining $R/2$ at $t = 1 + \epsilon$ (see figure 4). The remaining $(1 - \omega)$ bank's assets will fail and so they will receive 0 at both $t = 1$ and $t = 1 + \epsilon$. I assume that $R/2 < 1$, so the bank's with successful assets cannot meet the demand of their depositors only from their assets maturing at $t = 1$.

Assumption 2. $R/2 < 1$.

The banks with failed assets also cannot meet its obligation at $t = 1$ because they receive 0. I assume that the depositors cannot observe the returns of the banks. Since the depositors

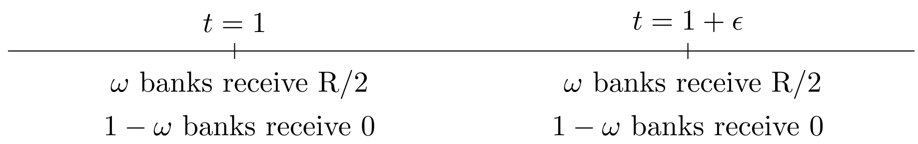

Figure 4: Cash flow when $\rho = 1$ and assets do not mature together

do not observe the returns, they do not know which bank's asset is successful and which is not. So, they will run on all the banks and withdraw their deposits at $t = 1$ (recall that the deposit contracts are short term, i.e. they mature at $t = 1$). If they could see the returns, then the depositors at the successful banks could have rolled over their debt and waited till date $t = 1 + \epsilon$ to withdraw.

Since there is a run on both type of banks, they will have to sell their assets to outside investors. I assume that the outside investors also cannot observe the asset returns and hence, they will pay a price equal to the expected value of the asset, which is ωR. Thus, there is an adverse selection discount. The total cash the successful banks can raise at $t = 1$ is $R/2 + \omega R/2$. If $R/2 + \omega R/2 > D$, then the bank's with successful assets can pay back the depositors and will go bankrupt. The failed banks can only raise $\omega R/2$ at $t = 1$ and hence they will go bankrupt (since $\omega R/2 < 1$ by assumption 2).

As discussed in section 3.1, the regulator maximizes the social surplus and so it will not want the continuation value of the failed banks to be lost. So, it will take over these failed banks and sell them to successful ones, and hence will be able to expropriate some profits. Under assumption 1, as in section 3.1, the successful banks will be able to buy the failed banks at fair price and the regulator will be able to expropriate some profits which will be equal to $\omega(V - 1)$ (see proof of proposition 2). Also, the depositors of both type of banks are always paid, and so $D = 1$. I assume that the bank's with successful assets are indeed able to survive the run and pay its depositors.

Assumption 3. $R/2 + \omega R/2 > 1$. *This implies that the banks with successful assets can pay its depositors.*

Given that the regulator is able to expropriate some profits (under assumption 1, 2 and 3), it can be concluded that the banks will write credit insurance to prevent the regulator from expropriating their profits. It can shown as before that they will write fairly priced insurance contracts with $z = (1 - \omega)R$ and their *ex ante* expected profits will also be the same as before, i.e. $\Pi_{\rho=0,NT} = \omega R - 1 + V$.

It can also be concluded as before that they would not want to buy underpriced insurance contracts to rely on the regulator to bail them out. This is based on the same rationale as discussed in section 3.1. If the banks write an insurance contract with zero premium, then at $t = 1$, the insurance firm will declare bankruptcy. If the regulator does not bailout the insurer then this will be followed by a run on the banks as the depositors cannot observe the returns. The successful banks will sell their assets to pay off creditors and the regulator can sell the failed banks to the successful ones. So the regulator has no incentive to bailout the insurer. The above discussion is summarized in the following proposition.

Proposition 2. *If assumption 1, 2 and 3 hold, the assets no mature together ($m = NT$) and the banks invest in different industries ($\rho = 0$), then*

i. *the banks prefer to buy fairly priced credit insurance with $z = (1 - \omega)R$. The expected profit of the banks is $\Pi_{\rho=0,NT} = \omega R - 1 + V$.*

ii. *if they do not buy credit insurance, then their ex ante expected profit is $\omega(R - 1 - V)$ and the regulator is able to expropriate $\omega(V - 1)$.*

Proof: See appendix.

Note that when $\rho = 0$, the expected profit of the banks is same whether the assets mature together or not. It equals the NPV of the project plus the continuation value. The profits are same in both cases because the banks write fairly priced insurance and the regulator is not expropriating any profits. Also, note that the banks are indifferent between insuring amount R or any other amount above the face value of debt. Next I consider the case where $\rho = 1$ and assets do not mature together.

3.3 Banks invest in the same industry and assets do not mature together

Recall that when banks invest in the same industry, there are two aggregate states, good (probability q) and bad (probability $1 - q$). In the good state, α banks succeed while in the bad state β banks succeed, where $\alpha > \beta$. I will argue that banks will, under certain assumptions, insure only for the good state and not for the bad state, that is in equilibrium the insurance premium will be equal to $(1 - \alpha)R$. They will rely on bailout to insure themselves in the bad state. Also, so far I have argued that the banks are indifferent between insuring the full amount R or insuring up to any amount which is greater than the face value of debt. But in this case, the banks want to insure fully up to amount R so that they can get the maximum benefit of the bailout in the bad state.

Figure 5: Cash flow in bad aggregate state when assets do not mature together

Suppose the banks insure amount R for the good state, i.e. $z = (1 - \alpha)R$. The face value of debt satisfies $D \geq 1 + z$. In the good state the banks will be able to pay off their depositors and no bank fails. In the bad state, assets of β banks are successful and at $t = 1$ half their assets mature. So they will receive $R/2$ at $t = 1$ and $R/2$ again at $t = 1 + \epsilon$ (see figure 5). The assets of $1 - \beta$ banks fail and they receive 0 at both $t = 1$ and $t = 1 + \epsilon$. So at $t = 1$, the failed banks make a claim on insurance firms to remunerate them for half of their failed assets. The total demand by the failed banks is $(1 - \beta)R/2$. I assume that the insurance firm cannot fulfill these claims with the premium collected which is $(1 - \alpha)R$, and so it announces bankruptcy at $t = 1$.

Assumption 4. $(1 - \alpha)R < (1 - \beta)R/2$.

Assumption 4 capture the idea that if the insurance firm writes an underpriced contract then it will run out of money before the time that all its obligations are due. This is what happened with AIG before it was bailed out. On bankruptcy of the insurance firm, if the funds available are distributed equally among the claimant banks, then each bank will receive $\frac{(1-\alpha)R}{(1-\beta)}$. This amount is less than $R/2$ by assumption 4, and I have assumed that $R/2$ is less than 1 (assumption 2). So, the failed banks cannot pay off their depositors and are insolvent.[22] Since the depositors cannot see the returns, as soon as the insurance firm announces bankruptcy at $t = 1$, they will run on all the banks.

In case of a bank run, the banks with successful assets are forced to sell their assets which have not matured to the outside investors because at $t = 1$, they receive only $R/2$ which is less than 1 (assumption 2) and hence less than D. The banks with failed assets will also do the same. The outside investors do not observe returns and so, the sale price of each unit of asset will be βR. Hence in this case, the total liquid funds that the banks with successful assets can raise at $t = 1$ is $R/2 + \beta R/2$. Recall that for the case $\rho = 0$ and $m = NT$, when banks were selling their assets to outside investors, the price was ωR. Given that β is less than ω, the banks will have to sell their assets at a lower price since the adverse selection

[22]This is because $D \geq 1 + z > 1$.

discount in the bad state is higher. I assume that this sale price is low enough such that even the banks with successful assets will not be able to pay their depositors when they are forced to sell their assets during the run.

Assumption 5. $R/2 + \beta R/2 < 1 + (1-\alpha)R$. *This implies that the banks with successful assets cannot pay their depositors.*

As a result of assumption 5, both type of banks will go bankrupt. Since no bank survives, there is no bank that the regulator can sell the failed banks to, and continuation value of the entire banking sector will be lost. The regulator wants to prevent this continuation value from being lost. Now the regulator has three options, (*i.*) it can bailout the insurance firm to prevent the banks from failing, (*ii.*) it can provide liquidity to the banks with successful assets to withstand the run by the depositors and also buy banks with failed assets, or (*iii.*) it can sell all the banks to outside investors.

I assume that the regulator also cannot sell the banks to outside investors because they may not be best users of the asset. In our model this implies that the continuation value V is bank specific and so selling the banks to outside investors will result in loss of social surplus. This idea is similar to the idea of asset specificity discussed in Shleifer and Vishny (1992).

Remark 2: Note that I have assumed that assets which are to mature are $t = 1 + \epsilon$ and sold to the the outside investors are not bank specific. This assumption is not necessary. If these assets are bank specific, then their sale price will be even lower and we can replace the term $\beta R/2$ with $\kappa\beta R/2$ in assumption 5, where $\kappa < 1$ is a discount factor because of asset specificity. Similarly, the term $\omega R/2$ in assumption 3 can be replaced by $\kappa\omega R/2$.

I also assume that the regulator cannot observe the returns. This is an important assumption because if this assumption does not hold then the regulator can have a more *targeted* policy to prevent the systemic failure. The regulator can act as a lender of last resort to banks with successful assets. These banks are solvent and are failing only because they have to sell their assets at discounted price. If the regulator observes the returns then he can lend these banks taking as collateral the assets which will mature at $t = 1 + \epsilon$. Thus the successful banks will survive and then they can buy the failed banks. This more targeted policy will allow the regulator to expropriate some profits.

Given its importance, the assumption that the regulator cannot bailout the banks because it does not observe their returns merits some discussion. During a banking crisis there is a run on the system. Under such a scenario the regulator does not have the time to evaluate each bank's balance sheet. This is because the bank's assets may be composed of complex assets which are hard to evaluate. The regulator also cannot rely on the market price of these assets to evaluate them because during the crisis the markets are illiquid and the assets may not be trading at fair value.

Remark 3: There can be other reason why the regulator may find it easier to bailout the insurance firm than bailing out many banks. For example, the regulator may find it politically easy to bailout one large institution rather than many large institutions. There can also be a timing issue, in the sense that while the insurance firm is failing, the counterparty banks may appear stable for a while; but after the insurance firm fails the counterparty banks may not be able to withstand a run which may happen later. So, to prevent a larger bailout later which may be more costly, the regulator prefers to bailout the insurance firm.

So, given the assumption that the regulator cannot observe returns and that he cannot sell the banks to outside investors, the only option for him is to bailout the insurance firm. When the regulator bails out the insurer, all banks will be able to pay their depositors in both good and bad state (in good state through insurance and in bad state through bailout), and their expected profit is $R-D+V$. Since the depositors always get paid, $D = 1+(1-\alpha)R$ and the expected profit of the bank is $\Pi_{\rho=1,NT} = \alpha R - 1 + V$.

Note that this profit is higher than the profits when banks were making uncorrelated investments and assets were maturing together ($\Pi_{\rho=0,NT} = \omega R - 1 + V$). The profits are higher by $(1-q)(\alpha-\beta)R$. This term has the following interpretation. In the bad state, the insurance firm owes the $(1-\beta)$ banks with failed assets an amount of $(1-\beta)R$. But the premium available with it is only $(1-\alpha)R$. So, when the insurance firm is bailed out, the regulator transfers the difference between what the insurers owes and what it has, i.e. $(\alpha-\beta)R$, to the banks. This happens only in the bad state which occurs with probability $(1-q)$. The reason for higher profits is that banks are only insuring for the good state and thus paying a lower premium. They rely on the bailout of the insurance firm for the bad state. So, they are able to insure fully even with lower insurance premium. The banks are thus writing underpriced credit insurance contracts with the insurance firm and are receiving a transfer from the regulator.

The insurance firm is ready to accept an underpriced contract, because it survives in both good and bad state and earns zero profits in both of them. The banks will not write a contract with higher insurance premium than $(1-\alpha)R$ because then it will imply that the insurer will earn a positive profit in the good state and so some of the surplus is transfered from the bank's to the insurer. Also, the insurer will not accept any premium less than $(1-\alpha)R$ because then it will earn negative profit in the good state and will go bankrupt.[23] Thus, in equilibrium the premium will be $(1-\alpha)R$. The above discussion leads to the following proposition.

Proposition 3. *If assumption 1, 2, 3, 4 and 5 hold, the assets do not mature together ($m = NT$) and the banks invest in same industry ($\rho = 1$), then*

i. the banks buy underpriced credit insurance with $z = (1-\alpha)R$, and

ii. the regulator bails out the insurance firm in the bad state leaving the banks earns an expected profit of $\Pi_{\rho=1,NT} = \alpha R - 1 + V$.

Having derived the profit of banks when the assets do not mature together for both correlated and uncorrelated investment, I now discuss the ex ante strategy of the banks. Since $\Pi_{\rho=1,NT} > \Pi_{\rho=0,NT}$ as discussed before, from an ex ante point of view when assets do not mature together, the banks will make correlated investments and will write under priced insurance contracts. Thus, they create systemic risk. This is the main result of the paper.

Theorem 1. *If assets do not mature together, then the banks will make correlated investment ex ante ($\rho = 1$).*
Proof: See appendix.

$\rho = 1$ is an equilibrium because no bank will want to deviate and invest in a different industry *ex ante*. This is because if a bank deviates and invests in a different industry then they will have to write more expensive insurance.[24] Also the deviating bank can never buy the continuation value of the other banks because if the good aggregate state is realized then all of them are directly insured and if the bad state is realized, then the regulator bails out the insurance firms and again all banks survive.

The main reason the banks prefer correlated investment is that the crisis resolution policy is imperfectly targeted. The regulator bails out the insurance firm because he cannot observe the asset returns. If he could observe the asset returns, then he could help the solvent banks by providing them liquidity and thereafter selling the failed banks to them. This policy would be beneficial to surviving banks and costly for failed banks and would create an incentive to

[23]Note that the regulator will not bailout the insurer in the good state. The reason is analogous to that discussed for the case when $\rho = 0$ and $m = NT$.

[24]Without insurance the bank may fail and its continuation value will be sold to other banks in both good or bad aggregate state.

survive when others are failing. The imperfectly targeted policy of bailing out the insurance firms creates strategic complementaries in the bank's investment strategy. A bank wants to invest in the same industry if all other banks are making correlated investments because then he can buy a cheaper insurance which insures only the good state and rely on bailout in the bad state. By performing better when others are failing, a banks will only miss out on getting the benefits of the indirect bailout.

Another reason that banks prefer correlated investments is that the regulator faces a commitment problem. If the regulator can commit that he will let all the banks fail, or sell them to outside investors then the banks will not rely on bailout and will insure fully. But regulator cannot make this commitment because it is time inconsistent. Once the banks have made correlated investments with under priced insurance, if the bad state occurs then the regulator will try to prevent the loss of continuation value and hence it cannot keep his commitment.

Proposition 4. *If the regulator can commit to not bailout the banks, then in equilibrium banks will invest in uncorrelated assets* ($\rho = 0$).
Proof: See appendix.

There is one more minor point I discuss for our scenario of $\rho = 1$ and assets not maturing together before discussing the next case. When the banks insure for the good state they will write insurance on the full amount R and not an amount between face value of debt and R. This is because of following reason. Suppose banks insure an amount $X \in [D, R]$ and pay insurance $(1-\alpha)X$. In the good state all banks earn $\alpha R - 1 + V$.[25] But in the bad state they are able to expropriate

$$(1-\beta)X - (1-\alpha)X = (\alpha - \beta)X$$

from the regulator. The term $(1-\beta)R$ is what the insurer owes the banks and the term $(1-\alpha)X$ is the premium with the insurer. So, the banks choose the highest X to be able to expropriate the maximum funds from the regulator.

3.4 Banks invest in the same industry and assets mature together

I now discuss the case when $\rho = 1$ and the assets mature together. I will show that if assets mature together then $\rho = 1$ may not be an equilibrium. The banks would ex ante want to

[25] With probability α, banks' assets succeed and their profits is $R - 1 - (1-\alpha)X$, while probability $(1-\alpha)$, their assets fail and their profits are $X - 1 - (1-\alpha)X + V$. So their expected profit is $\alpha R - 1 + V$.

deviate and invest in a different industry and by doing so will be able to earn higher profits. The reason for this is that by investing in a different industry, it can either buy cheaper insurance or will be able to buy continuation value of failed banks at prices below fair value and thus earn positive profits.

Since $\rho = 1$, there will be a good state and a bad state. Now the banks have two options, they can either insure for the bad state which will also provide insurance in the good state or they can only insure for the good state. Let us first consider the case when banks insure for the bad state and pay insurance premium $z = (1-\beta)R$. Now if the bad state occurs all banks will survive. In the good state as well all banks will survive but the difference is that now the insurance firm is able to earn positive profits. This is because in good state only $1-\alpha$ banks fail and the total insurance claim is only $(1-\alpha)R$, leaving a profit of $(\alpha-\beta)R$ to the insurer. The *ex ante* expected profit for the banks is

$$\Pi_{\rho=1,T}|_{z=(1-\beta)R} = \omega R - 1 + V - q(\alpha-\beta)R.$$

The last term is the profit transfer to the insurer which happens with probability q.

Now consider the other scenario when banks only insure for the good state and pay premium $z = (1-\alpha)R$. In that case, they will all survive in the good state. But in the bad state, at $t = 1$ the $(1-\beta)$ banks with failed assets will demand a claim of $(1-\beta)R$ which the insurance firm will not be able to fulfill. If the premium is divided among the banks each of them will receive $\frac{(1-\alpha)R}{1-\beta}$ which is less than 1 as discussed in section 3.3. So these banks will fail. Note that since all assets mature at the same time, the banks whose assets succeed will survive. Hence the regulator can sell the failed banks to surviving banks and there will be no bailout. The total liquid cash available with the successful banks is $\beta(R-D)$. The total cash needed to pay off the depositors of failed banks is $(1-\beta)D$. I assume that the total liquidity available is larger than total liability of the failed banks. This implies $D = 1+z$ and I have assumed $\beta(\alpha R - 1) > (1-\beta)(1+(1-\alpha)R)$. The total cash needed to pay off the depositors of failed banks and buy them at fair price is $(1-\beta)V$, so if liquidity available is greater than this amount, then the failed banks will be sold at fair price. If liquidity is less than $(1-\beta)V$, then there will be cash-in-market-pricing. The ex ante expected profit of the banks will be

$$\Pi_{\rho=1,T}|_{z=(1-\alpha)R} = \omega R - 1 + V - min\{\beta R - 1, (1-\beta)(V - 1 - (1-\alpha)R)\}(1-q).$$

The last term is the value expropriated by the regulators. If there is cash-in-the-market pricing, then the value expropriated is

$$\beta(\alpha R - 1) - (1-\beta)(1 + (1-\alpha)R) = \beta R - 1.$$

Else the value expropriated is $(1-\beta)(V - 1 - (1-\alpha)R)$.[26] In summary, if the banks will insure for the bad state, then they transfer profits to the insurance firm. If they insure only for the good state, then they transfer profits to the regulator. They will choose between the two to maximize their profits.

Because there is always some loss to the banks, ex ante this will create an incentive to invest in a different industry. If a bank invests in a different industry and buys a fairly priced insurance from a different firm with premium $z = (1-\omega)R$, then its profit will be $\omega R - 1 + V$. If the other banks choose to insure only for the good state and there is cash-in-the-market pricing then the bank which deviated ex ante can buy failed banks at below fair price and increase his profit even higher. Thus this will provide the banks an incentive to deviate ex ante. I get the following result.

Theorem 2. *When the assets mature together then $\rho = 1$ cannot be an equilibrium.*

The two cases of bankruptcy results in different ex ante correlation by the banks. When assets mature together some banks will always succeed. This allows the regulator to adopt a failure resolution policy that is targeted and bank specific. When the assets do not mature together, failure of some banks can lead to a run on all banks and a systemic failure. Since the regulator does not observe the returns, he is forced to bail out the insurance firm. This is imperfectly targeted policy and incentivizes the banks ex ante to herd together to be able to get the benefit of bailout.

4 Policy implications

I study the impact of two policies on bank's incentive to make correlated investments. I first show that putting a cap on size of insurance firm can prevent banks from making correlated investments. I then discuss how a central clearing counterparty may aid the bank in creating systemic risk.

[26]The depositors of the failed banks need to be paid $(1-\beta)D$. The resource available with the insurers is $z = (1-\alpha)R$. So, when there is cash in market pricing, total amount paid is $\beta R - 1$. When the price is fair, then the total amount paid is $(V - 1 - z)(1-\beta)$.

4.1 Size cap on insurance firms

There are many policies which have been suggested to solve the problem of lack of commitment to bailout a systemically important institution. One such policy is to put hard constraints on the size of the financial firms. For example, Johnson and Kwak (2011) suggest putting a cap any one bank's liabilities to 4% of GDP. Such size restrictions would put limits on the amount of spillover that one bank may create. In my model, a similar policy can prevent the banks from making correlated investments ex ante. I will show that putting a cap on the notional value of credit default swaps issued by a single insurance firm can help mitigate the problem of systemic risk.

When there are many insurance firms and all of them are failing together, then the regulator has an option of bailing out only some of them. The counterparty banks of the bailed out insurance firms will succeed while the counterparty banks of the failed insurance firms will go bankrupt. The failed banks can then be sold to successful banks and there will be a profit transfer to the regulator resulting in ex ante loss of profits to the banks. This may create an incentive to write fully insurance contracts in which case banks may prefer to make uncorrelated investments ex ante. Also, depending on the liquidity available, the failed banks may be sold at fire sale price. This will create an incentive for the banks to survive at the time others are failing so that they are be able to buy assets at fire sale price. I formalize these ideas next.

Suppose the regulator has put a cap, equal to R/n, on the notional value of credit default swaps issued by each insurance firm. So there will be n insurance firms in the market each insuring $1/n$ fraction of banks. I will only discuss the case when assets do not mature together. Consider the scenario when banks have made correlated investments and each bank has insured only the good aggregate state by paying a premium of $z = (1 - \alpha)R$. If the bad aggregate state occurs, then all the insurance firms will announce bankruptcy at $t = 1$ which will be followed by a run on all the counterparty banks. When there was only one insurance firm, the regulator had no option but to bail it out. But now the regulator can bailout only a few insurance firms and allow the others to fail. Suppose the regulator bails out m out of the n insurance firms. This will imply that m/n fraction of the banks will succeed and the remaining $(1 - m/n)$ will fail.

The regulator can sell these failed banks to surviving ones. The liquidity available with the surviving banks, given that $D = 1 + z$, is $\frac{m}{n}(\alpha R - 1)$.[27] To buy the failed banks this available liquidity must be larger than the obligations of the other failed banks, which is $(1 - m/n)D$. I assume that m/n is large enough such that this holds true. The sale price

[27] $D = 1 + z$ because the depositors always get paid either directly by their own banks or indirectly by the banks who will be buy their banks. So liquidity available with each bank is $R - D = \alpha R - 1$.

of the banks will be equal to the fair price $(V - D)$ if the liquidity available is greater than $(1-m/n)V$, else there will be cash in market pricing and banks will be sold at fire sale price. Let us consider the scenario where m is *just* large enough such that the banks are sold at fair price, i.e. m is the lowest value which satisfies

$$\frac{m}{n}(\alpha R - 1) \geq (1 - \frac{m}{n})V. \tag{5}$$

Given that the regulator bails out m insurance firms, the ex ante expected profit of the banks will be

$$\omega R - 1 + V + (1-q)[\frac{m}{n}(\alpha - \beta)R - (1 - \frac{m}{n})(V - 1 - \alpha R)].$$

The first term in the square bracket is bailout subsidy received by the banks and the second term is the profit transfered to the regulator to buy the failed banks. If the difference of these two terms is negative then, the a bank is better of deviating ex ante and investing in a different industry and writing a fair priced insurance. This gives the deviating bank a profit of $\omega R - 1 + V$. So, $\rho = 1$ cannot be an equilibrium. If the term in the square bracket is positive then the regulator can reduce m which will result in cash in market pricing. If The banks that survive will make profits from the sold banks. If m is low enough then the transfer from the regulator will be dominated by the profits from buying the assets at fire sale price. This will also create an incentive *ex ante* to survive and a bank may *ex ante* invest in a different industry. I get the following result.

Proposition 5. *The regulator can choose m and n such that banks will not make correlated investments ex ante.*

Thus, I have shown that putting a size cap on the insurance firms can prevent the banks from making correlated investments *ex ante*. An important point to note is that insurance is more efficient to with more diversification. So, putting a can on the size of insurance firms can reduce the benefit of diversification. In my model, I have not taken cost into account. But the regulator will take this cost into account when it decides the optimal size of the insurance firm.

4.2 Central clearing counterparty

I now discuss if a central clearing counterparty which acts a mediator between counterparties in a derivatives transaction can prevent banks from creating of systemic risk. CCPs have become increasingly important as the derivatives transaction have gradually moved from

OTC market to CCPs after the financial crisis. I will argue that, in the context of my model, the CCPs may do more harm than good.

One of the key assumptions of my model is that the banks are able to coordinate their action of writing CDS contracts with only one insurance firms which makes the insurer systemically important. If there are many insurers, then as discussed above none of them will be systemically important and so the regulator will be able to adopt a more targeted policy resulting in the banks making uncorrelated investment *ex ante*. Since the OTC markets are opaque, banks may find it more difficult to coordinate their action to write contracts with just one insurer. With the CCPs, banks know the position of each insurance firm. So they can coordinate their action better. If one insurance firm has a larger portfolio than the others, then the banks may start herding together and write insurance contracts with only that insurer making it systemically important. Thus, higher transparency, without a regulatory cap on portfolio size, may hurt financial stability by helping banks coordinate their action better.

Also in my model, competition among insurance firms results in them writing underpriced contracts while relying on bailout in the bad state. The same thing may happen if there is competition among CCPs. The CCPs may charge a low collateral when are competing with each other and thus become systemically important. Stein (2010) tries to predict the next crisis and makes a similar argument.[28]

5 Investment strategy of the insurance firm

So far I have assumed that the insurance firm can only invest in cash assets (or store) the premium it has received and it cannot invest it in any industry. I will now relax this assumption and show that the insurance firm will also make correlated investments, that is it will also prefer to invest in the same industry as the banks.

Let us consider the scenario when assets so not mature together and so banks have made correlated investments to get the benefit of the bailout in equilibrium. After receiving the premium the insurance firm can invest in industry $i \in \{s, d, c\}$, where $i = s$ denotes that the insurer invests in the same industry, $i = d$ denotes investment is different industry and $i = c$ denotes investment in cash. To keep the analysis simple, I assume that in good state

[28] In this rather tongue-in-cheek article, the author predicting the next financial crisis writes, "The clearinghouse industry has been another victim of the crisis. Clearinghouses grew rapidly in the wake of 2010 reforms that targeted the over-the-counter derivatives market. Clearinghouses were meant to bring a greater level of stability and transparency to derivatives trading. But this industry has become more fragmented than originally envisioned, and some argue that competition among clearinghouses has led to a "race to the bottom" whereby the clearinghouses require insufficient collateral from the SWIFTs they deal with."

	R	L
$i = s$		
Good state	$q\alpha$	$q(1-\alpha)$
Bad State	$(1-q)\alpha$	$(1-q)(1-\alpha)$
$i = d$		
Good state	$q\omega$	$q(1-\omega)$
Bad State	$(1-q)\omega$	$(1-q)(1-\omega)$

Table 2: Probability of occurrence of state of bank's industry and return of insurer's asset

all the assets mature together while in bad state the assets do not mature together. Also, to keep the algebra simpler so far I have assumed that $L = 0$, but now I relax this assumption, i.e I assume $0 < L < 1 < R$. When the insurer invests in an industry there can be 4 scenarios corresponding to whether the insurer's asset returns R (succeeds) or L (fails) and whether the bank's industry is in good state or bad state. Table 2 show that probability of occurrence of each scenario. The two panels correspond to the insurer investing is same or different industry as the banks. To illustrate, the probability that the banks' industry is in good state and the insurer's asset returns R is $q\alpha$ ($q\omega$) if $i = s$ ($i = d$), and so on.

I now discuss the intuition for why insurers would prefer to invest in same industry. In bad state, irrespective of the industry the insurer will invest in, he will not be able to meet its obligations and will be bailed out, thus earning zero profits. In the good state, the banks want to insure that they do not fail so that the regulator is not able to expropriate the profits. So, they will write a contract with premium such that even when the insurer's asset fails (returns L), the resources with the insurer is *just* enough so that they do not go bankrupt. Now when the insurer's asset succeeds (returns R) it may have more resources than its obligations when banks' industry is in good state and will thus earn a positive profit. The joint probability of occurrence of good state and insurers asset returning R is larger when $i = s$ than when $i = d$ since $q\alpha > q\omega$ and so the insurer prefers to invest in the same industry as the banks. I formalize these ideas next.

If the banks know that the insurer will invest in an industry and not cash, it will write a contract with premium z such that insurer pays enough so that banks are able to pay its depositors even when insurer's asset returns L. The resources with the insurer is zL. The amount the $1-\alpha$ banks with failed assets need to pay their depositors is $(1-\alpha)(1+z-L)$ (since $D = 1 + z$). So, z satisfies $zL = (1-\alpha)(1+z-L)$ and is given by,

$$z = \frac{(1-\alpha)(1-L)}{L-(1-\alpha)}. \tag{6}$$

I assume $L > (1-\alpha)$ so that $z > 0$. Now if the insurer's asset returns R then it can earn positive profit. The profit of the insurer is $zR - (1-\alpha)(R-L)$ and equals

$$\frac{(1-\alpha)[(1-L)R - (L-(1-\alpha))(R-L)]}{L-(1-\alpha)}. \tag{7}$$

If this profit is positive then the bank would prefer $i = s$. I assume that this is so while gives the following result.

Proposition 6. *If the expression in (7) is greater then 0, then in equilibrium the insurer invests in the same industry as the banks and earns a positive profit.*
Proof: See appendix.

AIG had a huge securities lending business. It invested a large part of collateral (about 60% of the U.S. pool) it received from lending securities in MBS. At the end of year 2007, AIG has an investment of $85 billion in residential mortgage backed securities. Thus, AIG had invested a large amount in the very asset that it was insuring. My paper provides an explanation for why AIG had large investments in MBS.

6 Conclusion

The main contribution of my paper is to highlight the risk taking incentives of the counterparties of a too-systemic-to-fail institution. While too-systemic-to-fail problem is very well recognized by academicians and regulators, there is very limited understanding of how existence of such an institution affect the actions of other agents in the economy. In my paper, the systemically important institution which insures credit risk, and correlated risk taking by the banks arise endogenously.

The main driving force is that the regulators at the time of crisis do not have the capability to evaluate the problem of each bank separately and so is looking for a systemic solution. In my model this solution takes the form of bailing out the insurance firm. While credit insurance markets are relatively new and not well developed in many countries, they are here to stay as they provide the benefit of risk sharing. My paper argues that it is important to understand that a systemically important firm which provides credit insurance cannot be allowed to fail and may create systemic risk in the economy.

References

Acharya, V. V. (2009). A theory of systemic risk and design of prudential bank regulation. *Journal of financial stability*.

Acharya, V. V., Gromb, D., and Yorulmazer, T. (2012). Imperfect competition in the interbank market for liquidity as a rationale for central banking. *American Economic Journal: Macroeconomics*.

Acharya, V. V. and Yorulmazer, T. (2007a). Cash-in-the-market pricing and optimal resolution of bank failures. *The Review of Financial Studies*.

Acharya, V. V. and Yorulmazer, T. (2007b). Too many to fail—an analysis of time-inconsistency in bank closure policies. *Journal of financial intermediation*.

Acharya, V. V. and Yorulmazer, T. (2008). Information contagion and bank herding. *Journal of money, credit and Banking*.

Allen, F. and Carletti, E. (2006). Credit risk transfer and contagion. *Journal of Monetary Economics*.

Allen, F. and Gale, D. (1994). Limited market participation and volatility of asset prices. *The American Economic Review*.

Allen, F. and Gale, D. (1998). Optimal financial crises. *The journal of finance*.

Allen, F. and Gale, D. (2000). Financial contagion. *Journal of political economy*.

Allen, F. and Gale, D. (2005). From cash-in-the-market pricing to financial fragility. *Journal of the European Economic Association*.

Augustin, P., Subrahmanyam, M. G., Tang, D. Y., Wang, S. Q., et al. (2014). Credit default swaps: A survey. *Foundations and Trends® in Finance*.

Bagehot, W. (1873). *Lombard Street: A description of the money market*. Scribner, Armstrong & Company.

Biais, B., Heider, F., and Hoerova, M. (2016). Risk-sharing or risk-taking? counterparty risk, incentives, and margins. *The Journal of Finance*.

Bisias, D., Flood, M., Lo, A. W., and Valavanis, S. (2012). A survey of systemic risk analytics. *Annu. Rev. Financ. Econ.*

Bolton, P. and Oehmke, M. (2011). Credit default swaps and the empty creditor problem. *The Review of Financial Studies*.

Brunnermeier, M. K. and Oehmke, M. (2013). The maturity rat race. *The Journal of Finance*.

Calomiris, C. W. and Kahn, C. M. (1991). The role of demandable debt in structuring optimal banking arrangements. *The American Economic Review*.

Campello, M. and Matta, R. (2012). Credit default swaps and risk-shifting. *Economics Letters*.

De Bandt, O. and Hartmann, P. (2000). Systemic risk: a survey.

Diamond, D. W. and Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. *Journal of political economy*.

Diamond, D. W. and Rajan, R. G. (2000). A theory of bank capital. *The Journal of Finance*.

Diamond, D. W. and Rajan, R. G. (2001). Liquidity risk, liquidity creation, and financial fragility: A theory of banking. *Journal of political Economy*.

Farhi, E. and Tirole, J. (2012). Collective moral hazard, maturity mismatch, and systemic bailouts. *American Economic Review*.

Freixas, X. (1999). Optimal bail out policy, conditionality and constructive ambiguity.

Freixas, X., Laeven, L., and Peydró, J.-L. (2015). *Systemic risk, crises, and macroprudential regulation*.

Freixas, X., Parigi, B. M., and Rochet, J.-C. (2000). Systemic risk, interbank relations, and liquidity provision by the central bank. *Journal of money, credit and banking*.

Gorton, G. and Metrick, A. (2012). Securitized banking and the run on repo. *Journal of Financial economics*.

Harrington, S. E. (2009). The financial crisis, systemic risk, and the future of insurance regulation. *Journal of Risk and Insurance*.

Johnson, S. and Kwak, J. (2011). *13 bankers: The Wall Street takeover and the next financial meltdown*. Vintage.

Kasa, K., Spiegel, M. M., et al. (1999). The role of relative performance in bank closure decisions. Federal Reserve Bank of San Francisco.

Kydland, F. E. and Prescott, E. C. (1977). Rules rather than discretion: The inconsistency of optimal plans. *Journal of political economy*.

Mailath, G. J. and Mester, L. J. (1994). A positive analysis of bank closure. *Journal of Financial Intermediation*.

McDonald, R. and Paulson, A. (2015). Aig in hindsight. *Journal of Economic Perspectives*.

Morrison, A. D. (2005). Credit derivatives, disintermediation, and investment decisions. *The Journal of Business*.

Myers, S. C. and Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial economics*.

Parlour, C. A. and Plantin, G. (2008). Loan sales and relationship banking. *The Journal of Finance*.

Parlour, C. A. and Winton, A. (2013). Laying off credit risk: Loan sales versus credit default swaps. *Journal of Financial Economics*.

Pennacchi, G. G. (1988). Loan sales and the cost of bank capital. *The Journal of Finance*.

Rajan, R. G. (1994). Why bank credit policies fluctuate: A theory and some evidence. *The Quarterly Journal of Economics*.

Rajan, R. G. (2009). Too systemic to fail: consequences, causes and potential remedies. *Written statement to the Senate Banking Committee Hearings*, 6.

Santomero, A. M. and Hoffman, P. (1996). *Problem Bank Resolutions: Evaluating the Options*. Working Paper, University of Pennsylvania.

Shleifer, A. and Vishny, R. W. (1992). Liquidation values and debt capacity: A market equilibrium approach. *The Journal of Finance*.

Stein, J. (2010). The next financial crisis. *The Harvard Crimson*.

Stephens, E. and Thompson, J. R. (2014). Cds as insurance: Leaky lifeboats in stormy seas. *Journal of Financial Intermediation*.

Stephens, E. and Thompson, J. R. (2017). Information asymmetry and risk transfer markets. *Journal of Financial Intermediation*.

Stern, G. H. and Feldman, R. J. (2004). *Too big to fail: The hazards of bank bailouts*. Brookings Institution Press.

Strahan, P. E. (2013). Too big to fail: Causes, consequences, and policy responses. *Annu. Rev. Financ. Econ.*

Thompson, J. R. (2010). Counterparty risk in financial contracts: Should the insured worry about the insurer? *The Quarterly Journal of Economics*.

Wagner, W. and Marsh, I. W. (2006). Credit risk transfer and financial sector stability. *Journal of Financial Stability*.

Appendix A

A.1 Proof of Proposition 2

Let us first consider what happens if the banks do not write credit insurance contracts. At $t = 1$, ω banks whose assets succeed will each be able to raise $R/2 + \omega R/2$. So, the liquidity available with each of them after paying the depositors is $R/2 + \omega R/2 - 1$ and the total liquidity available is

$$\omega(R/2 + \omega R/2 - 1).$$

The $(1 - \omega)$ banks with failed assets can raise $\omega R/2$ and which they will use to pay the depositors. But they cannot meet their obligations because $\omega R/2 < 1$ since $\omega < 1$ and $R/2 < 1$ (assumption 2). So $(1-\omega)$ banks will go bankrupt and will be sold to the successful banks by the regulator.

The successful banks will be able to buy the failed ones at fair price if the total liquidity available is enough to pay the depositors of the failed banks and then buy then pay fair price $(V-1)$. The remaining obligation of the depositors of the failed banks is $(1-\omega)-(1-\omega)\omega R/2$. The second term is the amount already paid by their banks by selling their assets. So, the condition for sale at fair price is

$$\underbrace{\omega(R/2 + \omega R/2 - 1)}_{\text{total liquidity}} \geq \underbrace{(1 - \omega)(V - 1)}_{\text{fair price}} + \underbrace{(1 - \omega) - (1 - \omega)\omega R/2}_{\text{remaining obligations}}$$

Rearranging the equation, I get $\omega(R - 1) \geq (1 - \omega)V$ which is same as assumption 1. Hence the banks will be sold at fair price and the regulator will expropriate $(1 - \omega)(V - 1)$.

Now let us consider what happens of the bank write the fairly prices insurance contract with $z = 1$. Since the assets are fully insured so their value is R. Both types of banks will be able to meet its obligations and there will be no run. Each bank earns $R - D + V$, where $D = 1 + z$. So, the profits are $\omega R - 1 + V$. Hence banks prefer to buy credit insurance.

A.2 Proof of Proposition 3.

The equilibrium insurance premium will not be less than $(1-\alpha)R$ because then the insurance firm will earn negative profits in good state and zero profit in bad state. So, it will not accept the contract. The premium will not be greater than $z = (1 - \alpha)R$ because then the insurer earns positive profit in good state. Also, the profits of the banks will be lower because some profits are extracted by the insurer and also the transfer received from the regulator in the bad state will be lower. The transfer received in the bad state is $((1 - \beta)R - z)$.

The banks will also not write a CDS contact on value less than R to maximize their profit. Suppose banks insure an amount $X \in [D, R]$ and pay insurance $(1-\alpha)X$. In the good state all banks earn $\alpha R - 1 + V$. With probability α, banks' assets succeed and their profits is $R - 1 - (1-\alpha)X$, while probability $(1-\alpha)$, their assets fail and their profits are

$$X - 1 - (1-\alpha)X + V.$$

So their expected profit is $\alpha R - 1 + V$. But in the bad state they are able to expropriate

$$(1-\beta)X - (1-\alpha)X = (\alpha - \beta)X$$

from the regulator. The term $(1-\beta)R$ is what the insurer owes the banks and the term $(1-\alpha)X$ is the premium with the insurer. So, the banks choose the highest X to be able to expropriate the maximum funds from the regulator.

A.3 Proof of Theorem 1

To prove that $\rho = 1$ is an equilibrium, I show that no bank with want to deviate *ex ante* and invest in an industry different from other banks. Suppose the bank deviates and invests in a different industry. Fist consider what happens when he does not write an insurance contract. In this case if its assets fail, then it will be sold to other banks in the good aggregate state and bad aggregate state. If its assets succeed, then it cannot buy the assets of the other banks. This is because if the good state is realized then the other banks are insured and no one fails. In bad state the insurer is bailed out and all banks survive. Thus its profits are lower without insurance.

When the bank insures itself, then it will pay a higher premium $z = (1-\omega)R$. With insurance, the bank's always survives but again it cannot buy assets of the other banks. So, its profit is $\omega R - 1 + V$ which is lower than $\Pi_{\rho=1,NT}$. Hence the bank has no incentive to deviate.

A.4 Proof of Proposition 4

Suppose the regulator can commit not to bailout the banks. Also suppose that the banks make correlated investment and write an insurance contract with $z = (1-\alpha)R$. In the good state all banks will survive. But in the bad state all banks will fail because there will be no bailout and they will loose their continuation value V. Since the are not receiving any transfer from any agent, their expected profit is

$$\omega R - 1 + V.$$

$(1-q)V$ is lost because there is no bailout in bad state.

If a bank deviates ex ante and writes a separate insurance contract, then its profit is $\omega R - 1 + V$. So, $\rho = 1$ cannot be an equilibrium. Hence, the banks will invest in different industries and $\rho = 0$ will be the equilibrium.

A.5 Proof of Proposition 6

First, the bank will not invest in cash because if the banks believe that the insurer is investing in cash and the premium covers the obligations of the banks and $z = (1-\alpha)R$ and the insurer makes 0 profit. But if this premium is charged then, the insurer will deviate and invest in the risky asset and earn positive profits if the asset succeeds.

If the insurer invest in an industry then, clearly if the expression in (7) is greater than zero then it will invest in the same industry to be able to earn a positive profit with larger probability since $q\alpha > q\omega$.