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CDS as Insurance: Leaky Lifeboats in Stormy Seas

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Abstract

What market features of Credit Defaults Swaps (CDS) exacerbate counterparty risk? To answer this, we formulate a model which elucidates key differences between these and traditional insurance contracts. First, we allow for insurer insolvency with asymmetric information as to its probability. We find that stable insurers become less stable because they are forced to compete on price. When insurer type is known, increased competition among insurers can create instability for the same reason. Second, we allow the insured party to have heterogeneous motivations for purchasing CDS. For example, some may own the underlying asset and purchase CDS for risk management, while others buy these contracts purely for trading purposes. We show that traders will choose to contract with less stable insurers, resulting in higher counterparty risk in this market relative to that of traditional insurance; however, a regulatory policy that removes traders can, perversely, cause market counterparty risk to increase. Finally, we introduce a Central Counterparty (CCP) and show that requiring CDS contracts to be negotiated through CCPs can push stable insurers out of the market, mitigating the benefit of risk pooling.

Keywords: credit default swaps, counterparty risk, insurance, banking, regulation.

JEL Classification Numbers: G21, G22, D82, G18.

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1 Introduction

Counterparty risk in Credit Default Swaps (CDS) has received considerable media attention since the beginning of the credit crisis in 2007.[1] There was public outrage over the use of U.S. tax payer money to pay (in full) the CDS claims that sellers, such as AIG had sold to many major banks. In response to this and other episodes, policy-makers have been under pressure to implement regulatory reforms to mitigate counterparty risk. For example, in 2008 the State of New York tabled legislation to have CDS sellers classified and regulated as insurers.[2] However, it is not clear whether sellers are an insurance provider, or simply a party to a derivative contract as in any other options market. While these issues are of widespread interest, the discourse on CDS is lacking in theoretical perspective. Our analysis provides a simple framework which shows how counterparty risk may increase in CDS markets and illustrates key differences between these contracts and traditional insurance.

We capture the pervasiveness of insurer instability by allowing for the possibility that sellers of CDS contracts become insolvent. We then incorporate three features of the CDS market into a standard model of insurance: First, we introduce privately observed heterogeneity of insurer quality to capture the opacity of the CDS market. With large sellers such as Ambac, MBIA and AIG suddenly and repeatedly downgraded by rating agencies, it would seem prudent to allow for this feature. Second, we consider insured parties who can differ on their motivation to insure. Unlike traditional insurance markets, the CDS market is characterized by buyers who may or may not own the underlying risk. Furthermore, the number of buyers that use CDS purely for trading purposes is roughly equal to those who use them for risk management (Fitch 2009, 2010). Finally, we enrich the model to analyze the consequences of a central counterparty. This is a particularly relevant issue given the increasing prevalence of CCPs and in light of the Dodd-Frank bill in the U.S., which mandates that a sizeable proportion of CDS trades go through clearinghouses.[3]

We find that unstable insurers (i.e., those who are more likely to fail) can exist in equilibrium: either they are able to offer a sufficiently discounted price for the protection they provide, or they are able to camouflage themselves in an opaque market. We show that insurer specific and market counterparty risk (which is defined as the expected probability of insurer default conditional on a claim) can endogenously increase as competition increases among insurers, or when insurer quality is unknown. In addition, we show that when the proportion of buyers that use CDS for trading purposes increases, relative to those using them for risk management, more contracts will

[1] In a credit default swap, an insurer agrees to cover the losses of the insured if pre-defined credit events (e.g., default) happen to some debt instrument. In exchange, the insured agrees to pay an ongoing premium at fixed intervals for the life of the contract. A CDS written on the debt of a single company is typically bought and sold through a dealer. When the underlying debt is more complicated (and so requires a non-standard contract), the CDS is completed directly between the two parties. For example, the CDS contracts that destabilized AIG were mainly direct contracts with major banks, written on complex mortgage related securities. The estimated notional size of the CDS market in 1998 was 180 billion dollars, by 2004 this number had grown to 6 trillion, and by the end of 2008 it was 41 trillion dollars (Stulz 2009). Note that this is a notional amount and no doubt overestimates the absolute economic value of all contracts, but the relative growth has been rapid.

[2] http://ins.state.ny.us/circltr/2008/cl08_19.htm

[3] Europe appears to be moving in a similar direction with the European Market Infrastructure Regulation (EMIR).

be written with unstable insurers. However, removing traders from the market may not decrease market counterparty risk as much as one may expect, and in extreme cases, it may actually increase. Finally, we show that when CDS contracts are cleared through a CCP, stable insurers can be forced out of the market.

The intuition behind our results is as follows. The insured party can choose to contract with a stable ('good') insurer, or with an unstable ('bad') insurer. The choice of insurer boils down to a tradeoff between the price (premium) and the degree of exposure to counterparty risk (probability of insurer insolvency). In our model, the bad insurer makes an investment that earns high returns but is illiquid and so cannot be used to help pay claims. The good insurer makes an investment that earns a lower return, but is liquid, and so can improve its chances of solvency when a claim is made. We assume that the return on the bad insurer's investment is sufficiently high to ensure they are able to charge lower premia than the good insurer. In Section 3, we show that the resulting equilibrium can have good or bad insurers dominate the market. When the insured party is sufficiently averse to counterparty risk, the bad insurer will not be able to cut its premium enough to attract the insured party. In this case, only the good insurer exists, and it can extract positive profits. When the insured party has little aversion to counterparty risk, the bad insurer will control the market as insured parties become premium driven, rather than counterparty risk driven. In Section 3.2, we show that as insurer competition increases, the good insurer may be forced to compete on premium against new entrants, driving profits down and counterparty risk up. This result is similar in spirit to one found in the banking literature in which stability of the system can decrease when competition among banks increases. One mechanism that drives this result is a bank taking on a riskier portfolio as competition increases (see Boyd and De Nicoló (2005) or Vives (2010) for a summary of this literature). In contrast, our insurer's investment selection remains the same, however competition gives them less resources to invest. Returning to the case of two insurers, we show in Section 3.3 how the equilibrium changes when the insured party does not know the insurer's quality. In particular, the good insurer can no longer drive out the bad insurer. This is because the bad insurer can simply charge the same premium as the good insurer and the insured cannot distinguish between the two. Competition between insurers then drives the equilibrium premium down to where the good insurer earns zero profit, thereby increasing counterparty risk.

In Section 4, we enrich the model to allow insured parties to differ on their aversion to counterparty risk, which we associate with having different motivations for using CDS. Recall that the two key factors in the choice of insurer are counterparty risk and premium. Those insured parties who use CDS purely for trading purposes, and perhaps do not even own the underlying asset (i.e., have no insurable interest), are more likely premium driven. On the other hand, buyers who use CDS for risk management/hedging would internalize the counterparty risk more, and would be willing to pay relatively more for stable protection. Traditional insurance markets are usually viewed as having risk averse insured parties. The analogue to CDS would be a market composed entirely of buyers using the contracts for risk management purposes. As more participants use CDS purely for trading purposes, we find that the market will be serviced more by unstable insurers. This is because the traders prefer the lower premium that unstable insurers can offer. However, removing traders from the market may have unintended consequences. Although such a policy can reduce the number of unstable insurers in the market, it can also have the perverse effect of making the otherwise stable insurers riskier. This is because removing buyers from the market creates more competition among sellers. As in the competition result described in Section 3.2, this can drive down premia and increase counterparty risk.

Finally, in Section 5 we further enrich the model to consider the consequences of a central counterparty. A CCP acts as the buyer to every seller and the seller to every buyer. Participants in this market contribute to a fund designed to shelter each other from counterparty risk. Given that the counterparty risk to which an insured party is exposed is now that of the entire pool of insurers (through co-insurance), good insurers lose their comparative advantage. We consider the case in which there are a large number of insured parties and insurers. Given a CCP arrangement, counterparty risk is effectively pooled so that non-failing participants can absorb the losses of the failed ones. Therefore, insuring with a good insurer has little effect on the exposure of the insured to counterparty risk. Consequently, the insured party will contract with the bad insurer to obtain a better premium. In equilibrium, good insurers are pushed out of the market. This occurs because each individual insured party does not internalize the amount that their contract adds to the pooled counterparty risk, yielding an outcome similar in spirit to the classic problem of the commons. However, contrary to a standard problem of the commons, in this case central organization is the cause of and not the cure for this outcome. The solution to this problem is simple: the CCP should condition an insurer's contribution to the risk pool on their quality to the extent possible.

Literature Review

This paper contributes to the literature on counterparty risk, credit default swaps and insurance. Thompson (2010) considers a case with endogenous counterparty risk in financial insurance. It is shown that an insurer has a moral hazard problem and may not invest in the best interest of the insured party. Furthermore, it is shown that truthful revelation of insured type can be attained because revelation affects the investment decision of the insurer, and consequently, the counterparty risk to which the insured is exposed. In contrast, we explicitly model multiple insurers and so can analyze the composition of insurers in the market. In another related paper, Acharya and Bisin (2010) show that due to the opacity of over-the-counter markets (where many CDS trade), counterparty risk can occur because insurers may take positions which increase their likelihood of default. In contrast, we model a situation in which insurers have varying degrees of stability and show that, regardless of whether CDS markets are opaque, unstable insurance can be a feature of the equilibrium. Neither Thompson (2010) nor Acharya and Bisin (2010) analyze the affects of competition among insurers, the motivation to purchase CDS, or the commons problem that arises with a CCP, as is done in this paper.

In insurance economics, there is a small literature on insurer default which focuses mainly on contract size (see among others, Doherty and Schlesinger (1990) and Cummins and Mahul (2003)). For example, Cummins and Mahul (2003) determine the optimal indemnity in the case where the insurer and insured party have different beliefs about the probability that the insurer will fail. This analysis does not apply to our setting because of the inability of insured parties in the CDS market to separate on ex-ante contract size due to the non-exclusivity of contracts (i.e., a seller cannot preclude a buyer from purchasing insurance elsewhere). Therefore, separation à la Rothschild and Stiglitz (1976) cannot generally be achieved. This issue is detailed in Stephens and Thompson (2011).

The paper proceeds as follows: Section 2 outlines the model. Section 3 considers the case when insurers are known, when they are subjected to increased competition, and when they are unknown. Section 4 extends the model to allow insured parties to differ based on their motivation to purchase CDS. Section 5 further extends the model to explore the consequences of a central counterparty and Section 6 concludes. Robustness Section 7 provides a discussion of two of our assumptions and nontrivial proofs can be found in the Appendix.

2 Model: CDS as insurance

This section describes the market for CDS and its participants. The purchaser, whom we refer to as a bank, owns a risky asset which it wishes to insure. We refer to this asset as a loan. We will not model anything unique to a bank, however as banks are the largest purchasers of these types of contracts, we use this terminology for ease of exposition. The providers of CDS are simply referred to as insurers.

2.1 Banks

The fundamental characteristic of a bank is the desire to reduce risk. As in Thompson (2010), if the bank incurs a loss and has not insured this risk, it suffers the cost $Z \geq 0$.[4] If the bank has a loss for which it is insured, but the insurer cannot pay, we assume for simplicity that it also suffers the cost Z. This cost could represent a regulatory penalty for exceeding some risk level, or an endogenous reaction to a shock to the bank's portfolio; however, we will not model this here. It is this cost that makes the bank averse to holding risk.

The bank's loan yields return R_B with probability p, otherwise it defaults with probability $1-p$ and returns nothing. The size of the loan is normalized to 1 and we assume that the bank must insure this amount.[5] Therefore, if a claim is fulfilled, the bank will receive 1 and if it is not fulfilled,

[4] See robustness Section 7.2 for a more formal discussion of Z.

[5] This is done for simplicity. One could imagine that the bank chooses different amounts of insurance depending on the insurer type (note that different insurer types will be discussed in the next subsection). An endogenous contract size will not affect the qualitative results to be presented. Note also that we are ignoring a potential moral hazard, wherein the bank may lose the incentive to monitor its loan when it completely insures. We assume full insurance for simplicity, but all the results of the paper would go through if we assumed that the bank insured only a fraction of its loan. That fraction could then be set such that moral hazard is eliminated. Even in the presence of a moral hazard

the bank is penalized Z. Denoting the premium (price) as P, and the probability that the insurer is solvent as q, the bank's expected payoff is

$$pR_B + (1-p)q - (1-p)(1-q)Z - P. \tag{1}$$

Note that in the event of a claim, the insurer fails with probability $1-q$ and for simplicity, pays nothing to the bank.[6] In other words, the bank is never fully insured against the loss provided $q < 1$.

2.2 Insurers

We allow for the possibility of insurer insolvency (with probability $1-q$), which we refer to as counterparty risk. Importantly, we allow the probability of insurer insolvency to be heterogeneous across insurers. This represents our first departure from the literature. We model this heterogeneity by considering two insurance providers, one relatively stable and the other unstable, referred to simply as "(G)ood" and "(B)ad" insurers.

Both insurers have an exogenous portfolio of assets represented by θ, that pays off at $t = 1$. The portfolio consists of an i.i.d draw from the distribution function $F(\theta)$, in which $\theta \in [\underline{\theta}, \overline{\theta}]$ and $\underline{\theta} < 0 < \overline{\theta}$. To simplify the analysis, we will assume that F is uniform.[7] If an insurer does not sell an insurance contract, it is assumed to fail when its portfolio draw is between $[\underline{\theta}, 0]$. When it sells a contract, the good insurer invests the premium it receives in a risk-free asset with return normalized to one, which is available at $t = 1$. The bad insurer invests in a more profitable, but illiquid risk-free asset which has a rate of return $r > 1$, and is received at $t = 2$.[8] In other words, the bad insurer makes an investment that has no pledgable value at $t = 1$.[9] Insurer $j \in \{G, B\}$ knows the probability that a claim will be submitted, $1-p$, and charges P_j for protection. We write the payoff function for each insurer when they insure a loan of size 1. Note that insurer default is

problem, the only difference in our model would be that either p would decrease, R_B would decrease, or both. The insurer would simply alter its beliefs about the expected cost of a claim and the results of the model would follow through. For a more formal treatment of this moral hazard problem, see Bolton and Oehmke (2010), Parlour and Winton (2009) or Thompson (2007).

[6] A zero recovery value is assumed for simplicity and can be relaxed without changing the qualitative results.

[7] A general distribution function was used in a previous version of the paper wherein the results were the same; however, the analysis was more tedious and less intuitive.

[8] We assume that insurers invest in different assets for reasons outside the model. In Robustness Section 7.1, we detail how the model could be modified to allow the investment decision to be endogenous, as well as other settings that would work equally well.

[9] Note that if the bad insurer fails, it receives nothing from the illiquid asset. This can be relaxed to allow it to be liquidated or borrowed against at $t = 1$, provided that it is done at a sufficient discount.

assumed to result in a payoff of zero, i.e., limited liability.[10]

$$\pi_G = p\left[\int_{-P_G}^{\overline{\theta}} (\theta + P_G)\, dF(\theta)\right] + (1-p)\left[\int_{(1-P_G)}^{\overline{\theta}} (\theta - 1 + P_G)\, dF(\theta)\right] \tag{2}$$

$$\pi_B = p\left[\int_{0}^{\overline{\theta}} (\theta + rP_B)\, dF(\theta)\right] + (1-p)\left[\int_{1}^{\overline{\theta}} (\theta - 1 + rP_B)\, dF(\theta)\right] \tag{3}$$

Examining the limits of integration in the second terms of expressions (2) and (3), we can characterize the counterparty risk for each insurer. The probability that the good or bad insurer is solvent when a claim is made is given by $q_G = 1 - F(1 - P_G)$ and $q_B = 1 - F(1)$ respectively. Importantly, note that the bad insurer's probability of default is independent of the premium. This is not the case with the good insurer, since the probability of defaulting on a claim depends on the premium P_G. It is straightforward to see that if the premium increases, counterparty risk decreases for the good insurer, but remains constant for the bad insurer. This occurs because the good insurer uses the premium to increase the probability of solvency at $t = 1$ when a claim is made, whereas the premium has no effect on the bad insurer's chances of being solvent at $t = 1$. It follows that $q_G > q_B$ whenever the premium is positive.

In the following lemma, we characterize a property of the premia which we use throughout the paper. First, define the zero profit premia P_G^0 and P_B^0, as the premium for which the good and bad insurer earn zero profit from selling a contract respectively.

Lemma 1 *There exists a return r^*, such that for all $r > r^*$, $P_G^0 > P_B^0$.*

Proof. *See Appendix.*

The bad insurer invests the premium it receives from the insurance contract in an illiquid asset and earns a return r. It follows that if r increases, the bad insurer would require a lower premium to attain the same expected payoff. For the remainder of the paper we assume that $r > r^*$ so that $P_G^0 > P_B^0$. In other words, the bad insurer is able to offer lower premia due to its favorable investment opportunity. If this were not true, the good insurer could offer the bank a lower premium *and* lower counterparty risk; trivially excluding the bad insurer from the market. Arora et al. (2009) provide evidence that counterparty risk is in fact priced in CDS contracts, so that premia can vary depending on the quality of the seller as we model here.

2.3 Timing

There are three time periods, in which we assume there is no discounting. At $t = 0$, an insurance contract is written by an insurer on a risky loan owned by the bank. At $t = 1$, the uncertainty about the insured loan and the insurer's portfolio is resolved. In this period, a claim is made if the loan defaults. The insurer either fulfils the claim if it is solvent, otherwise it fails and returns

[10] Limited liability is assumed for simplicity and can be relaxed in the same way as is detailed in the Supplemental Appendix of Thompson (2010).

nothing to the bank. At $t = 2$, the payoff to the two period (illiquid) insurer investment is received. Figure 1 summarizes.

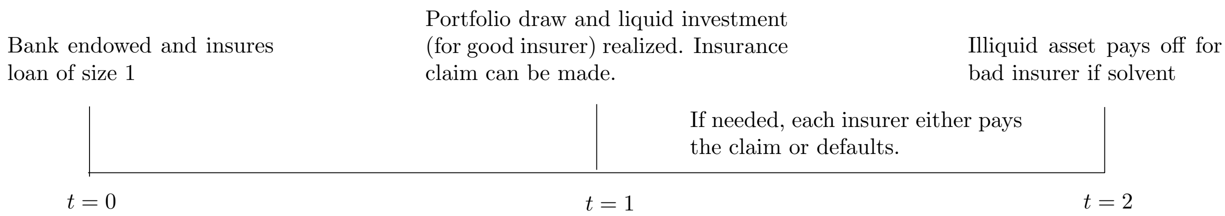

Figure 1: Timing of the Model

3 Equilibrium

3.1 Insurer type known

We begin by assuming that the bank can identify the insurer type. There are two outcomes in this simple insurance market. Either the good or the bad insurer dominates the market, and provides insurance for the bank.[11] Modifying expression (1), we give the bank's payoff function when contracting with insurer type j.

$$\Pi(j) = pR_B + (1-p)q_j - (1-p)(1-q_j)Z - P_j \tag{4}$$

We assume without loss of generality that a bank which is indifferent between contracting with a good and bad insurer opts for the former. Therefore, the good (bad) insurer will dominate the market when $\Pi(G) \geq \Pi(B)$ ($\Pi(B) > \Pi(G)$).[12] The following lemma summarizes these equilibria.

Lemma 2 *There are two types of equilibria in the market for insurance described above, each of which exist uniquely for a given parameter range.*

1. *The good insurer provides insurance when*

$$(1-p)(1+Z)(q_G - q_B) \geq P_G^0 - P_B^0, \tag{5}$$

where the equilibrium premium is $P_G^* = (1-p)(1+Z)(q_G - q_B) + P_B^0 \geq P_G^0$.

2. *The bad insurer provides insurance when*

$$(1-p)(1+Z)(q_G - q_B) < P_G^0 - P_B^0, \tag{6}$$

[11] We are implicitly assuming that the bank does not split its contract over the two insurers. Allowing this would only complicate the analysis and would not change our qualitative results. One can imagine a transaction cost which induces this behavior. Alternatively, a straightforward restriction on the parameter space will also accomplish this.

[12] Here we ignore the participation constraint and assume the bank chooses to purchase insurance. This constraint is required in Section 4 and discussed in Robustness Section 7.2.

where the equilibrium premium is $P_B^* = P_G^0 - (1-p)(1+Z)(q_G - q_B) - \epsilon \geq P_B^0$, for ϵ small.

Proof. *See Appendix.*

The good insurer will dominate the market when the benefit of reduced counterparty risk, the left hand side of expression (5), more than compensates for the additional premia that the bank must pay, the right hand side of expression (5). To derive this case, we set both the good and bad insurer's premia to that which earns zero profit and determine when the good insurer is preferred by the bank. In equilibrium, the good insurer can then raise its premium to P_G^*, the point at which the bank is indifferent between itself and the bad insurer. It is straightforward to see that condition (5) will be true for large values of Z. Conversely, the bad insurer dominates the market when the premium discount it can offer exceeds the cost of the additional counterparty risk it poses to the bank. The bad insurer sets a premium that earns weakly positive profits and is just low enough to force the good insurer out of the market.

For the rest of the analysis in the paper, we describe forces which change the features of the equilibrium described above, with a focus on counterparty risk. It is important to stress that we do not make statements about welfare, as this is beyond the scope of this paper. The reason why counterparty risk in itself should be viewed as an interesting avenue of study is for broader issues like systemic risk and contagion, which we will leave unmodelled (but which would be required for a proper welfare analysis). Also note that for the remainder of the paper, we leave our mathematical expressions in general form and suppress the arguments of P and q as closed formed solutions are not possible. Existence of a parameter space which satisfies our expressions is established in the proofs.

Lemma 2 outlines two possible benchmarks from which this analysis could proceed. Presumably, the most interesting cases are those in which the counterparty risk posed by insurers increases. As we wish to highlight this phenomena, we present the results of this section using the case where the good insurer dominates (as per Lemma 2) as a benchmark; however, we will discuss the results in the alternative case where the bad insurer initially dominates the market.

3.2 Competition

We now analyze how competition affects the equilibrium outlined previously. In addition to the good and bad insurers, let us consider an insurer type $j = M$ (middle), which has the same initial portfolio. Assume that this insurer invests half of its premia in the liquid asset, and half in the illiquid asset. The payoff of the new insurer is then

$$\begin{aligned}\pi_M &= p\left[\int_{-\frac{1}{2}P_M}^{\overline{\theta}} \left(\theta + \frac{1}{2}P_M(1+r)\right) dF(\theta)\right] \\ &\quad + (1-p)\left[\int_{(1-\frac{1}{2}P_M)}^{\overline{\theta}} \left(\theta - 1 + \frac{1}{2}P_M(1+r)\right) dF(\theta)\right]. \qquad (7)\end{aligned}$$

It follows that in the event of a claim, the probability of solvency of insurer type M is given by $q_M = 1 - F(1 - \frac{1}{2}P_M)$, where $q_B < q_M < q_G$. A straightforward extension of Lemma 1 yields $P_G^0 > P_M^0 > P_B^0$, so that the zero profit premium of the middle type is between that of the good and bad insurers. Consider the case in which expression (5) holds so that the bank chooses to insure with the good over the bad insurer. We define market counterparty risk as the expected counterparty risk to which the bank is exposed. The following proposition shows that market counterparty risk increases (weakly) as competition increases.

Proposition 1 *When the good insurer dominates the market (as per Lemma 2), increased competition causes market counterparty risk to increase. This occurs regardless of which one of two possible equilibria arise. In the first case, the good insurer continues to dominate, which occurs (and is unique) when*

$$(1-p)(1+Z)(q_G - q_M) \geq P_G^0 - P_M^0, \tag{8}$$

where the equilibrium premium is $P_G^* = (1-p)(1+Z)(q_G - q_M) + P_M^0 \geq P_G^0$. *Alternatively, the middle insurer dominates (uniquely) when*

$$(1-p)(1+Z)(q_G - q_M) < P_G^0 - P_M^0, \tag{9}$$

where the equilibrium premium is $P_M^* = P_G^0 - (1-p)(1+Z)(q_G - q_M) - \epsilon \geq P_M^0$, *for* ϵ *small.*

These equilibria can be shown to exist in the same way as outlined in the proof of Lemma 2. To gain the intuition behind this result, we consider both situations described in the proposition. Initially, the good insurer provides coverage as described in Lemma 2. Thus, the premium and associated counterparty risk are implied by the equality of (5), which we denote $\widehat{P_G}$ and $\widehat{q_G} = 1 - F(1 - \widehat{P_G})$. First, consider the situation in which the good insurer continues to dominate when another competitor is introduced. Define the equilibrium premium charged by the good insurer when the middle insurer is introduced by $\widetilde{P_G}$ and so $\widetilde{q_G} = 1 - F(1 - \widetilde{P_G})$. In this case, the premium is defined by the equality of (8). Contrasting this with the equilibrium with no middle insurer, it follows that $\widehat{P_G} \geq \widetilde{P_G}$. In other words, the new competitor forces the good insurer to lower its premium, which results in an increase in counterparty risk since $\widehat{q_G} \geq \widetilde{q_G}$. Alternatively, the new competitor may take the market, which occurs when (9) is satisfied. Since $q_M < q_G$, market counterparty risk is always higher in this case. Note that the form of competition is not vital to Proposition 1. Alternatively, we could assume that increased competition comes in the form of additional good insurers. In this case, the premium is driven down to that which earns zero profit à la Bertrand competition. Since counterparty risk of the good insurer increases as the premium decreases, the result follows. Of course, the addition of an insurer that is safer than our safe insurer can decrease counterparty risk.

We can also consider the case when the bad insurer dominates the good insurer initially (expression (6) is satisfied). When this occurs, there will be two possible outcomes when the middle insurer is added. First, the bad insurer dominates the middle insurer and counterparty risk remains unchanged. Although the middle insurer may force the bad insurer to cut its premium, recall that $1 - q_B = F(1)$, so that the risk of insolvency of the bad insurer is independent of the premium. In the second case, the middle insurer will dominate the bad insurer and market counterparty risk will decrease.

3.3 Unknown Insurer

We now return to the case of two insurers (good and bad) and consider the consequences of asymmetric information regarding the quality of the insurance provider. In subsection 3.1, the good insurer can dominate with perfect information. With asymmetric information, the bad insurer can camouflage itself and offer a contract with the same premium as the good insurer. To avoid undue complication with sequential equilibria and off equilibrium path beliefs, we put the following reasonable conditions on the bank's beliefs: Assume that any premia charged above P_G^0 does not allow the bank to update its beliefs so that, from the point of view of the bank, each insurer is equally likely. Conversely, the bad insurer will be revealed if it sets $P_B < P_G^0$ since the good insurer would never offer a contract that earns negative profit. The following proposition characterizes the impact of this informational asymmetry on market counterparty risk.

Proposition 2 *When the good insurer dominates under perfect information (as per Lemma 2), market counterparty risk as well as the individual counterparty risk of the good insurer will increase when insurer type is unknown.*

Proof. *See Appendix.*

The intuition behind this result is as follows. When the insurer type is known and the good insurer dominates, it charges the highest premium such that the bank still prefers to contract with it rather than the bad insurer (who offers the lowest premium it can). When the insurer type is unknown, the good insurer is forced to cut its premium or else give up the entire market to the bad insurer who can undercut it and still not reveal itself. In equilibrium, the premium charged by both insurers is P_G^0. Since the good insurer (weakly) reduces its premium and $1 - q_G = F(1 - P_G)$, it follows that the good insurer becomes individually less stable. Furthermore, bad insurers now participate in the market, so that market counterparty risk unambiguously increases.

When the bad insurer dominates under perfect information, there are two equilibria that can arise when insurer type is unknown (a straightforward condition would determine which one prevails in equilibrium). First, the bad insurer may choose to reveal itself by setting $P_B^* < P_G^0$ and dominate the market. The bad insurer does this to obtain the insurance contract with certainty, rather than charging P_G^0 and allowing the good insurer to stay in the market, thereby reducing the chances it will obtain the contract. Since the counterparty risk of the bad insurer is independent of the premium ($1 - q_B = F(1)$), if it chooses to reveal itself and take the market, market counterparty risk remains unchanged. Conversely, when the bad insurer prefers the higher premium P_G^0 over obtaining the contract with certainty, the presence of the good insurer causes market counterparty risk to fall since the expected counterparty risk to which the bank is exposed decreases.

4 Incentives to Insure

A fundamental difference between a standard insurance market and that for CDS are the incentives for purchasing these contracts. For example, in CDS some buyers may own the underlying loan being insured, while others do not. More generally, some participants may use these contracts entirely for trading purposes, while others may use them for risk management purposes. Fitch (2009, 2010) use surveys to gauge the motivation of global banks to use credit derivatives (of which CDS represents more than 90% (Fitch 2010)). They find that hedging/credit risk management and trading are the two most common reasons to use credit derivatives (with similar prevalence).

To our knowledge, there has not been a paper which analyzes the impact of buyer's incentives on the market for CDS. We can address this issue with a simple extension of the base model developed above, since the incentive to purchase insurance is captured solely by Z. One would expect that those who purchase CDS for risk management purposes will view counterparty risk differently than those who purchase it for trading purposes (i.e., traders will internalize the cost of counterparty risk less). Further, although it does not directly follow that those who purchase CDS for risk management will own the underlying loan, it is reasonable to expect that those who do not own the underlying loan are more likely to purchase CDS for trading purposes than for risk management. This has interesting consequences for policy since ownership of the underlying loan can be easily observed. Consider Germany's recent ban on the practice of buying CDS without owning the underlying risk, and China's intent on creating a CDS market with this same restriction.[13]

Modifying the base model from Section 2, we create a market for CDS as simply as possible. In addition to the good and bad insurers, we let there be two types of banks who differ on Z, which we denote Z_L and Z_H (to be defined below). We will refer to the Z_L bank as a trader and the Z_H bank as a hedger. Note that we do not use the term "speculator" to describe the Z_L bank, as this can be a controversial label. Keynes (1930) and Hicks (1946) present the first treatment of such issues. The key variable that separates hedgers from "speculators" in these papers is risk aversion. Subsequent literature has also emphasized informational asymmetries and beliefs in addition to risk aversion when modeling speculation (see among others, Hirshleifer (1975, 1977), Spiegel and Subrahmanyam (1992) and more recently, Goldstein, Li and Yang (2011)). Given the interpretation of Z in our model as risk aversion (see Robustness Section 7.7.2), we focus on the case in which traders differ solely in this parameter. For simplicity, in our model we interpret those that own the underlying risk as hedgers, and those that do not as traders. Given that a full market microstructure model is beyond the scope of this paper, we simply note that the results below will obtain when there is divergent beliefs, provided that the hedger has a higher willingness to pay due to risk aversion.

[13] http://www.bloomberg.com/news/2010-09-13/china-plans-to-introduce-credit-default-swaps-by-year-end-official-says.html, http://dealbook.nytimes.com/2010/05/19/germany-bans-naked-shorts-and-c-d-s-s/

The following lemma determines the value of Z for which a bank is indifferent between insuring with a good or bad insurer.

Lemma 3 *Define $\hat{Z}$ as the level of Z for which the bank is indifferent between insuring with the good or bad insurer at the zero profit premium for each insurer. Thus, with P_G^0 and P_B^0, a bank with $Z < \hat{Z}$ will prefer to contract with the bad insurer and a bank for which $Z > \hat{Z}$ will prefer the good insurer. The expression for $\hat{Z}$ is given by $\hat{Z} = \frac{P_G^0 - P_B^0}{(1-p)(q_G - q_B)} - 1$.*

Proof. *See Appendix.*

We interpret $\hat{Z}$ by considering the two relevant components of a contract from the perspective of a bank: counterparty risk and premium. A bank trades off a higher premium against increased counterparty risk in its choice of insurer. A bank for which $Z < \hat{Z}$ is less averse to counterparty risk and so insures with the bad insurer, as it is able to offer a lower premium than the good insurer. A bank for which $Z > \hat{Z}$ is sufficiently averse to counterparty risk to compensate for the increase in premium at the good insurer. For what follows, let $Z_L < \hat{Z}$ and $Z_H > \hat{Z}$.

Given the market for CDS we have introduced, we define market counterparty risk as the average counterparty risk to which banks are exposed. Using Lemma 3, we can explore the difference between a market for CDS and that for traditional insurance in a relatively simple way. When modeling a standard insurance market, it is customary to assume that the insured party has exposure to the underlying risk (i.e., has an insurable interest). An insured party is typically modeled as being risk averse and so willing to pay a risk premium when purchasing insurance. As discussed above, in the market for CDS, some buyers purchase protection purely for trading purposes. As the number of traders (i.e., Z_L types) increases, so does the relative amount of insurance sold by bad insurers. It is reasonable to assume that the CDS market has more traders than a traditional insurance market, so it follows that the market for CDS will tend to have lower quality sellers.

The existence of traders and bad insurers implies that CDS markets are generally characterized by higher market counterparty risk. Although this is a “mechanical” consequence of our framework, it adds a new element to the policy debate on the CDS market. Ideally, a policy maker whose mandate is to reduce counterparty risk could simply remove bad insurers; however, the quality of the counterparty is often not observable to the bank, so it is unlikely that it will be observable to a regulator.[14] An alternative may be to remove the Z_L banks from the market, similar to the recent proposals described above which disallow CDS to be purchased by those who do not own the underlying loan. Although it is possible that those who own the loan could purchase CDS for trading purposes, it is more likely that this policy will reduce the number of buyers for which $Z = Z_L$ more than it would for buyers with $Z = Z_H$. Therefore, we analyze the case in which the Z_L bank can be eliminated. We show that removing the bank which demands insurance from the bad insurer may reduce counterparty risk, but there is an opposing force which, in extreme cases, can actually increase it. This result will depend crucially on the competition among insurers in the

[14] For a discussion on this issue see Pirrong (2009).

market before and after the Z_L bank is removed. To highlight the intuition as simply as possible, we will analyze two polar cases: first, the case in which competition is perfect before and after the policy is implemented and second, the case in which there is minimal competition before the policy, but perfect competition after. To this end, we assume that a bank insures with its own insurer, and that the size of each contract is one. Competition among insurers will then be dictated by the number of insurers of each type that are present. With only one insurer of each type in the market, each insurer contracts with one bank and does not compete for the other before the Z_L bank is removed.[15] The two cases to be analyzed are given as follows.

Case 1: Bertrand competition within each insurer type.

Case 2: No Bertrand competition within each insurer type.

We can think of the first case as having multiple good and bad insurers who compete in the market, while in the second case there is only one good and one bad insurer. The following proposition characterizes the impact of removing the Z_L bank from the market, where P_G^* and P_G^{**} are defined as the good insurer's equilibrium premium before and after this is done.

Proposition 3 *In case 1, a policy that removes the Z_L bank will decrease market counterparty risk. In case 2, such a policy will make the good insurer riskier and consequently may increase or decrease market counterparty risk. When $2F(1 - P_G^{**}) > F(1 - P_G^*) + F(1)$, market counterparty risk increases.*

Proof. *See Appendix.*

In the first case, the insurers are driven down to zero profit due to competition within types. When the Z_L banks are removed, the bad insurers cannot compete in the market and so drop out (as per Lemma 3). The good insurers still face Bertrand competition and so profits are zero and the risk of the good insurer remains unchanged. Thus, average counterparty risk in the market falls since bad insurers drop out.

In the second case, the good (bad) insurer contracts with the Z_H (Z_L) bank as in case one; however, there is no Bertrand competition before the Z_L banks are removed. Therefore, both insurers extract positive profits from the contracts. When the Z_L bank is removed, the bad insurer then competes with the good insurer for the remaining bank, thereby eroding profits for both insurers. In equilibrium, the good insurer cuts its premium sufficiently to attract the remaining bank and the bad insurer drops out of the market as in case one. Since its premium is forced down due to competition, the good insurer becomes riskier. Whether the net affect on market counterparty risk is negative or positive depends on how much the good insurer must cut its premium. Market counterparty risk will increase when $2F(1 - P_G^{**}) > F(1 - P_G^*) + F(1)$, where

[15] Allowing each insurer to contract with both banks would create additional competition which would needlessly complicate the model. The results will generalize provided that in case 2, competition increases among insurers when the Z_L bank is removed.

$1 > 1-P_G^{**} \geq 1-P_G^*$. That this condition can be satisfied is established in the proof. It follows that policy makers must be cognizant that eliminating some buyers from the market may drive premia down, working against the reduction of counterparty risk that arises when bad insurers drop out.

5 Central Counterparties

CDS contracts have been slowly migrating from over-the-counter markets to more formal central counterparty (CCP) arrangements. In the wake of the credit crisis that began in 2007, law makers around the world have been tabling regulations to legally mandate this migration.[16] In the absence of a central counterparty, contracts are bilateral and take one of two forms. First, contracts can be negotiated through a dealer. In these types of transactions, a buyer purchases protection from a counterparty located by a dealer. Second, trading may be done without a dealer, where a buyer approaches a seller directly. In a CCP arrangement the contract is initially between a buyer and seller as per usual, however after the terms have been agreed upon the CCP simultaneously buys the contract from the seller and sells to the buyer. In other words, all transactions flow through a central counterparty which acts as the buyer to every seller and the seller to every buyer. In this arrangement, participants provide capital and post margins (collateral) that the CCP can use to cover default losses.[17] Therefore, a CCP is an attempt to mutualize default risk across participants (or members).

In our model, bad insurers are forced to set a lower premium because they pose a greater risk of default (where we assume that insurer type is known). Importantly, the CCP forces a single premium on the market because traders view counterparty risk as being only that of the CCP. As discussed above, a CCP ordinarily requires capital (for a default fund) and collateral in case of contract non-performance. Typically, CCPs demand capital/collateral according to the quality of the asset being insured, but less so based on the quality of the counterparties (Pirrong 2009). In what follows, we assume that the CCP cannot condition contributions to the CCP based on insurer quality.[18]

A comprehensive analysis of a CCP arrangement is beyond the scope of this paper, however our framework can be used to address an issue that has been largely ignored in the debate thus far. Building on the enriched model from Section 4, we let there be a measure N banks, who each contract with an insurer. Within the banks, assume that there are a measure $N_G \leq N$ for which $Z = Z_H$ and a measure $N_B \leq N$ for which $Z = Z_L$ where $N_G + N_B = N$. As in Section 4, we assume for simplicity that each active insurer contracts with its own bank. Let there be a sufficiently large measure of insurers of both types so that there is Bertrand competition. When there is no CCP, Lemma 3 implies that in equilibrium Z_H (Z_L) banks insure with good (bad) insurers, so that the

[16] See Bliss and Steigerwald (2007) an for an in-depth discussion on CCPs.

[17] In theory, the CCP can require participants to make additional payments if needed to cover losses, however there is no consensus as to how well this mechanism would work in practice.

[18] In practice, CCPs can and sometimes do try to enforce higher capital charges (and higher collateral) to riskier counterparties. The relevance of this assumption is discussed below, but we note that the results of this section will survive provided that the CCP does not perfectly condition on counterparty quality.

measure of good (bad) insurers in the market is N_G (N_B). Furthermore, because of competition, all premia are determined by the zero profit conditions defined in Section 2.2.

We now analyze the imposition of a CCP on this market. To pool risk, we assume that each insurer contributes a fixed amount c, regardless of their quality to a default pool. Given a measure N active insurers, the total size of the pool is then $D = Nc$, where $c \in (0, 1]$. The CCP will pay out claims as long as it is solvent, but fails if the number of insurers which have defaulted on claims is too high. Since we assume that collateral requirements are not insurer specific (and the risk of a claim is the same with every bank), we normalize collateral to zero. We assume for simplicity that the CCP is unable to raise additional funds after insurers have defaulted so that the CCP itself will default when D insurers cannot pay their claim (recall that contracts are of size 1). The default risk of the CCP, denoted $1 - q_{ccp}$, can be characterized as

$$1 - q_{ccp} = \begin{cases} 0 & \text{if} \quad (1 - q_B)\, N_B + (1 - q_G)\, N_G \leq D \\ 1 & \text{if} \quad (1 - q_B)\, N_B + (1 - q_G)\, N_G > D, \end{cases}$$

where $q_B = 1 - F(1)$ and $q_G = 1 - F(1 - P_G^0)$. Since there is a measure of insurers, the counterparty risk of the CCP is deterministic.[19] When faced with claims that cannot be fulfilled by insurers, the CCP either has sufficient funds and never defaults, or always defaults. Given that each insurer must pay c to the CCP to participate, it follows that the cost must be borne by the banks in the form of a higher premium. It is assumed that our zero profit premium for both insurer types contains this fixed charge. When a bank makes a choice of which insurer to contract with, they are too small to change the counterparty risk of the CCP. Therefore, the advantage of the good insurer (lower counterparty risk) is absent so that the bank's choice will be driven solely by the premium. This leads to the main result of this section.

Proposition 4 *In the presence of a CCP, the bad insurers will push the good insurers out of the market.*

Consider one Z_H bank switching from a good to a bad insurer. Given that it has measure zero, default risk of the CCP remains the same. Therefore, the Z_H bank will switch when $P_G^0 - P_B^0 > 0$ which is true since we assume that $r > r^*$ (as defined in Lemma 1). It follows that every Z_H bank will unilaterally switch to the bad insurer, so that in equilibrium $N_G = 0$. This result is similar in spirit to the classic problem of the commons in that the imposition of a CCP results in banks which do not internalize the effect of their decisions on counterparty risk.[20]

It is worthwhile exploring the robustness of Proposition 4. The assumption of an infinite number of insurers implies that risk pooling by the CCP is perfect. Given this, it is easy to show that no bank would wish to contract outside of the CCP. This is because the amount by which the bank's premium increases under the CCP, which is the fee charged to ensure solvency, is sufficiently low.

[19] In a previous version of the paper, we had a finite number of banks which allowed for a probabilistic counterparty risk of the CCP. Our deterministic version provides a substantially less complicated analysis while yielding the same intuition into the problem.

[20] This result can also be interpreted as an example of the Lucas critique, in that policy-makers considering the imposition of a CCP must consider the reaction of market participants to the policy.

This will not necessarily be the case if, for example, the bad insurers are more exposed to aggregate risk than the good insurers. With risk of this form, the CCP will need to charge more. However, Proposition 4 still holds because individual banks do not consider the impact of their decisions on the CCP so that the market will still be serviced solely by bad insurers. In this case, if aggregate risk was sufficiently high, it is straightforward to derive a case in which banks would wish to leave the CCP and contract bilaterally.

To eliminate the outcome described in Proposition 4, the CCPs could charge the bad insurer proportionately more to participate. Since the bad insurer would have to pass this charge to the bank in the form of a higher premium, it would inhibit its ability to undercut the good insurer. In our model, this would be possible if the CCP were able to use premia as a signal of underlying counterparty risk. In reality, CCPs cannot perfectly deduce the quality of insurers in the market. Pirrong (2009) reports that this may not be possible since, even in a dealer market, other dealers can struggle to quantify counterparty risk and it is unlikely that a CCP could do better. If the CCP could use prices to infer insurer type, simple features could be added to the model to ensure that the signal was imperfect. Nonetheless, our analysis suggests that CCPs should condition capital requirements and collateral on the quality of the counterparty to the extent possible.

A note regarding mark-to-market is in order. Currently, much of risk management within CCPs is done by setting collateral charges based on the quality of the underlying asset by marking to market daily. This mechanism is meant to alleviate counterparty risk, however it does so indirectly. With mark to market of this type, the CDS seller would have to post additional collateral if the quality of the underlying asset deteriorates. If, for example, the quality of the insurer falls at the same time as the underlying asset, the increase in collateral will help mitigate the counterparty risk to which the buyer is exposed. However, it could be that the underlying asset becomes safer at the same time as the insurer becomes riskier. In this case, the decrease in collateral exacerbates the counterparty risk. Therefore, it is clear that mark to market on the underlying asset does not invalidate Proposition 4.

We wish to make clear that this result obtains in a natural extension of our model and highlights a very specific point relevant to the debate over CCPs. There are many factors that should be considered in determining whether such an arrangement would be beneficial to the market. For example, a richer characterization of the benefits of diversification through co-insurance relative to the endogenously lower quality individual insurance that we consider. Further, there are other possible benefits such as netting that CCPs can provide.[21] A full welfare analysis is an interesting direction for future research.

6 Conclusion

In this paper we analyze the features of credit default swaps which can exacerbate counterparty risk. In doing so, we account for features unique to this market relative to that of traditional

[21]For an analysis on the efficiency of netting, see Duffie and Zhu (2011).

insurance. We show that when the counterparty risk of the insurer is unknown to the insured party, unstable insurers can exist in equilibrium and otherwise stable insurers can destabilize. Increased competition among insurers is also shown to potentially destabilize otherwise stable insurers. Furthermore, we show that when some buyers of CDS use the instrument purely for trading purposes (and potentially have no insurable interest), the market will be characterized by more unstable insurers; however, removing these traders can, in extreme cases, cause market counterparty risk to increase. Finally, we use our model to shed light on the ongoing debate over central counterparties. We show that in such an arrangement, the stable insurers can be driven out of the market due to their inability to compete on premia.

7 Robustness

7.1 Insurer Investment Choice

We model heterogeneity between the two insurer types as simply as possible. Given that the insurers are identical before contracts are issued, there is an obvious question of why they would invest in different assets. We recognize that investing in the liquid asset may not be credible for the good insurer, given that it could earn a higher profit investing in the illiquid asset. This could easily remedied by allowing heterogeneity along two dimensions. First, by making our insurers different before contracting and second, by allowing the investment choice to be an optimal decision variable, as in Thompson (2010). For example, instead of endowing both insurers with a portfolio draw from $F(\theta)$, as is done in our paper, let the good (bad) insurer receive a draw from a distribution $\mathcal{G}(\theta)$ ($\mathcal{B}(\theta)$). Next, let the proportion that the good (bad) insurer invests in the liquid asset be given by β_G (β_B), with the remainder invested in the illiquid asset. Each insurer can now solve for its optimal investment decision given its portfolio distribution. Using the usual notation for premia, counterparty risk can now be defined in a similar way as in Section 2, $1 - q_G = \mathcal{G}(1 - \beta_G^* P_G)$ and $1 - q_B = \mathcal{B}(1 - \beta_B^* P_B)$, where the asterisk represents the optimal portfolio choice. We can then impose the appropriate restrictions on the distribution functions to ensure $q_G(\beta_G^*) > q_B(\beta_B^*)$ so that our bad insurer has higher counterparty risk.

More generally, all that is required of the insurers problem to obtain our results is that $q_G'(P) < 0$, namely, that price and counterparty risk move in opposite directions for the good insurer. In the generalized setting discussed above, our results will obtain provided that $\beta_G^* > 0$.[22] It is not even required that $\beta_G^* > \beta_B^* > 0$ provided $q_G(\beta_G^*) > q_B(\beta_B^*)$. More importantly, although the liquid versus illiquid investment choice yields crisp results, we could also have a risky versus riskless choice, or a more complicated portfolio problem involving the choice of assets of varying risk/liquidity, provided that $q_G'(P) < 0$ and $q_G > q_B$.

[22] Note that when $\beta_B^* > 0$, the qualitative results remain unchanged but the analysis becomes more tedious.

7.2 Z and Risk Aversion

It is worthwhile to contrast the parameter Z in our model with standard utility assumptions made in most insurance papers. Typically, a non-linear utility function is used for the insured party that puts different weights/utility value on high and low outcomes. A standard risk averse utility function will put relatively more negative weight on the bad outcomes (e.g., an 'accident') versus the high outcome (e.g., no 'accident'). As such, insurance is purchased to protect the risk averse individual that may cost more than the expected loss from the accident. In our model, we use the simplest formulation possible that captures these motives. In particular, we put a weight Z on the bad outcome (i.e., the loan fails). As such, the utility in the good state (i.e., the loan does not fail) is simply equal to the monetary payoff. In our model we let $Z \in [0, \infty)$. To understand this range, we consider the condition under which a bank (with probability of default 1-p) is indifferent between purchasing and not purchasing insurance, i.e., its participation constraint.

$$\begin{aligned} pR_B + (1-p)q - (1-p)(1-q)Z - P &= pR_B - (1-p)Z \\ \Rightarrow P &= (1-p)q(1+Z) \end{aligned} \tag{10}$$

Therefore, when $Z = 0$, $P = (1-p)q$, which is the actuarially fair premium. In other words, the bank will pay at most the expected value of the coverage. This corresponds to the usual insurance result with a risk neutral agent. When $Z > 0$, the bank is willing to pay greater than the expected value in return for coverage. This represents the risk premium that an insurance provider can extract due to the risk aversion of the insured party.

8 Appendix

Proof of Lemma 1

Setting (3) equal to $\int_0^{\overline{\theta}} \theta dF(\theta)$ and re-arranging yields $P_B^0 = \frac{k}{r}$ where:

$$k = \frac{(1-p)(\int_0^1 \theta dF(\theta) + F(\overline{\theta}) - F(1))}{p(F(\overline{\theta}) - F(0)) + (1-p)(F(\overline{\theta}) - F(1))}. \tag{11}$$

Therefore, $P_B^0 < P_G^0$ whenever $r > \frac{k}{P_G^0}$ so that $r^* = \frac{k}{P_G^0}$.

■

Proof of Lemma 2

We first rule out the undesirable case in which the bank prefers to pay higher premia to reduce the counterparty risk. This implies that the banks payoff must be decreasing in premia. Using the uniform assumption on $F(\cdot)$ we obtain:

$$\frac{(1-p)(1+Z)}{\overline{\theta} - \underline{\theta}} \leq 1. \tag{12}$$

Consider the case in which the good insurer dominates. As Z becomes large, $(1-p)(1+Z)(q_G - q_B) \geq P_G^0 - P_B^0$ must hold, so that the bank prefers the good insurer at the zero profit premium. Using $F(\cdot)$ as uniform, this expression becomes:

$$\frac{(1-p)(1+Z)}{\overline{\theta} - \underline{\theta}} \geq 1 - \frac{P_B^0}{P_G^0}. \tag{13}$$

Therefore, (12) and (13) can be simultaneously satisfied so that a parameter space exists such that the good insurer dominates. The good insurer's optimal premium P_G^*, is that which satisfies (5) with equality, as described in the lemma. The case in which the bad insurer dominates requires:

$$(1-p)(1+Z)(q_G - q_B) < P_G^0 - P_B^0. \tag{14}$$

From the proof to Lemma 1, we can see that P_B^0 becomes arbitrarily small as r becomes large. To prove existence, let this be the case, let $Z = 0$ and replace $q_B = 1 - F(1)$ and $q_G = 1 - F(1 - P_G^0)$ so that (14) becomes

$$(1-p)[F(1) - F(1 - P_G^0)] < P_G^0. \tag{15}$$

Using the uniform assumption on $F(\cdot)$ we obtain:

$$P_G^0 > \frac{(1-p)}{\overline{\theta} - \underline{\theta}} P_G^0, \tag{16}$$

which holds since $(1-p)/(\overline{\theta}-\underline{\theta}) < 1$. Note that $\overline{\theta} > 1$, otherwise the bad insurer would always default when faced with a claim. Also note that for $Z = 0$, (12) is satisfied automatically. The equilibrium premium is then the maximum for which (6) is still satisfied.

■

Proof of Proposition 2

Provided that the premium exceeds P_G^0, the bank believes that each insurer is equally likely, so will insure with whichever charges the cheapest premium. Given this, the insurers will compete on premia until it falls to P_G^0. Below this premium, the bad insurer would be revealed and thus drop out of the market (since the good insurer dominates with perfect information). Thus, the equilibrium is characterized as one in which both insurers offer coverage at the premium P_G^0, and the bad insurer earns a positive profit.

With perfect information over insurer type and all insurance provided by the good insurer, the premium is $P_G^* \geq P_G^0$ such that (5) holds with equality. The market counterparty risk is then given by $1-q_G = F(1-P_G)$. It follows that,

$$\frac{d(1-q_G)}{dP_G} = -dF(1-P_G) \leq 0. \tag{17}$$

With asymmetric information over insurer type, $P_G^* = P_G^0$. Thus counterparty risk for the good insurer is (weakly) higher with asymmetric information. Coupled with the participation of the bad insurer, market counterparty risk unambiguously increases.

■

Proof of Lemma 3

The bank's payoff from insuring with the good and bad insurers are given as follows.

$$\Pi(G) = pR_B + (1-p)q_G - (1-p)(1-q_G)Z - P_G \tag{18}$$

$$\Pi(B) = pR_B + (1-p)q_B - (1-p)(1-q_B)Z - P_B \tag{19}$$

We now define $\hat{Z}$ as that which equates these expressions.

$$\hat{Z} = \frac{P_G - P_B}{(1-p)(q_G - q_B)} - 1 \tag{20}$$

Inserting the zero profit premia yields the expression characterized in Lemma 3.

■

Proof of Proposition 3

Case 1: Given that there is Bertrand competition within each type of insurer, the premium is always that which earns zero profit. Initially, market counterparty risk is given by $(2 - q_B - q_G)/2$, where $q_B = 1 - F(1)$ and $q_G = 1 - F(1 - P_G^0)$. Once the Z_L bank is removed from the market, the bad insurer drops out (by Lemma 3), but the good insurer cannot alter its premium. Therefore, market counterparty risk is now $1 - q_G$. Since q_G is unchanged, and $q_G > q_B$, market counterparty risk decreases.

Case 2: We begin by defining the initial equilibrium and then characterize the change in market counterparty risk when the Z_L bank is removed. Initially, there are two banks and two insurers. The Z_H bank is most attractive to both insurers, as this type is willing to pay a higher premium for insurance, yet poses no additional risk. Thus, by Lemma 3, we restrict our attention to the case when the good insurer contracts with Z_H and the bad insurer with Z_L. Given this, a unique set of equilibrium premia are determined by the following set of participation and incentive constraints.

$$q_B(1-p)(1+Z_L) \geq P_B \tag{PCL}$$

$$q_G(1-p)(1+Z_H) \geq P_G \tag{PCH}$$

$$P_G - P_B \geq (1-p)(1+Z_L)(q_G - q_B) \tag{ICL}$$

$$P_G - P_B \leq (1-p)(1+Z_H)(q_G - q_B) \tag{ICH}$$

The Inequality PCL (PCH) ensures that the Z_L (Z_H) bank will purchase insurance from the bad (good) insurer, rather than go without. Inequality ICL (ICH) ensures that the Z_L (Z_H) bank contracts with the bad (good) insurer rather than the competitor. Expanding ICH, we have

$$P_G \leq q_G(1-p)(1+Z_H) - [q_B(1-p)(1+Z_H) - P_B]. \tag{21}$$

The second term on the right hand side is negative since

$$q_B(1-p)(1+Z_H) - P_B > q_B(1-p)(1+Z_L) - P_B \geq 0, \tag{22}$$

where the second inequality follows from PCL. Thus, (21) shows that PCH is redundant and can be ignored. Furthermore, in equilibrium, ICH must be satisfied with equality, otherwise the good insurer could increase the premium and still attract the Z_H bank. This implies

$$P_G - P_B = (1-p)(1+Z_H)(q_G - q_B) > (1-p)(1+Z_L)(q_G - q_B), \tag{23}$$

so that ICL can also be ignored. Finally, in equilibrium the bad insurer will increase its premium until the Z_L bank is just indifferent to purchasing the contract or not so that PCL is satisfied with equality. To summarize, the equilibrium premia in this situation are $P_B^* = q_B(1-p)(1+Z_L)$ and $P_G^* = (1-p)(q_G - q_B)(1+Z_H) + P_B^*$.

We now consider the equilibrium when the Z_L bank is removed. From Lemma 3, this will drive the bad insurer out of the market but changes the equilibrium premium of the good insurer. With only one bank to compete over, the bad insurer cuts its premium to P_B^0. Thus, the good insurer sets $P_G^{**} = (1-p)(q_G - q_B)(1+Z_H) + P_B^0$. Since $P_G^{**} \leq P_G^*$, the good insurer will become (weakly) less stable.

Market counterparty risk in the initial equilibrium is $(2-q_B-q_G)/2$, where q_B and q_G are implied by the premia P_B^* and P_G^* defined above. When the Z_L bank is removed, market counterparty risk is simply $1-q_G$, which is defined by the premium P_G^{**}. Since $P_G^{**} \leq P_G^*$, and the default risk of the good insurer is decreasing in the premium, the affect on market counterparty risk is ambiguous. Using the definition of q and the relevant premia, we can derive the following condition under which market counterparty increases (as stated in the proposition).

$$2F(1-P_G^{**}) > F(1-P_G^*) + F(1) \tag{24}$$

Assuming uniformity of $F(\cdot)$, condition (24) is simply $2P_G^{**} < P_G^*$. Using the expressions for P_G^* and P_G^{**} we write

$$2P_G^{**} - P_G^* = (1-p)(1+Z_H)(2q_G(P_G^{**}) - q_B - q_G(P_G^*)) + 2P_B^0 - q_B(1-p)(1+Z_L). \tag{25}$$

Inserting expressions for q_G and q_B assuming uniform $F(\cdot)$ yields:

$$2P_G^{**} - P_G^* = \frac{(1-p)(1+Z_H)}{\overline{\theta} - \underline{\theta}}(2P_G^{**} - P_G^*) + 2P_B^0 - q_B(1-p)(1+Z_L) \tag{26}$$

Therefore,

$$2P_G^{**} - P_G^* = \frac{(\overline{\theta} - \underline{\theta})[2P_B^0 - q_B(1-p)(1+Z_L)]}{\overline{\theta} - \underline{\theta} - (1-p)(1+Z_H)}. \tag{27}$$

To show that the parameter space such that this expression is satisfied is non-empty, consider the case in which r becomes arbitrarily large, so that $P_B^0 \to 0$ as shown in Lemma 1. It follows that when $Z_H < \frac{\overline{\theta} - \underline{\theta} - (1-p)}{1-p}$, then $2P_G^{**} < P_G^*$. Note that $\overline{\theta} > 1$ and $\underline{\theta} < 0$ (if $\overline{\theta} < 1$, the bad insurer would always default when faced with a claim).

■

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