Systemic Risk and Regulation

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Abstract

Historically, much of the banking regulation that was put in place was designed to reduce systemic risk. In many countries capital regulation in the form of the Basel agreements is currently one of the most important measures to reduce systemic risk. In recent years there has been considerable growth in the transfer of credit risk across and between sectors of the financial system. In particular there is evidence that risk has been transfered from the banking sector to the insurance sector. One argument is that this is desirable and simply reflects diversification opportunities. Another is that it represents regulatory arbitrage and the concentration of risk that may result from this could increase systemic risk. This paper shows that both scenarios are possible depending on whether markets and contracts are complete or incomplete.

1 Introduction

The experience of banking crises in the 1930s was severe. Before this assuring financial responsibility was primarily the responsibility of central banks. The Bank of England had led the way. The last true panic in England was associated with the collapse of the Overend, Gurney and Company in 1866.

After that the Bank avoided crises by skilful manipulation of the discount rate and supply of liquidity to the market. Many other central banks followed suit and by the end of the nineteenth century crises in Europe were rare. Although the Federal Reserve System was founded in 1914 its decentralized structure meant that it was not able to effectively prevent banking crises. The effect of the banking crises in the 1930s was so detrimental that in addition to reforming the Federal Reserve System the US also imposed many types of regulation to prevent systemic risk. These included capital adequacy standards, asset restrictions, liquidity requirements, reserve requirements, interest rate ceilings on deposits, and restrictions on services and product lines. Over the years many of these regulations have been removed. However, capital adequacy requirements in the form of the Basel agreements remain.

If properly designed and implemented capital regulations can reduce systemic risk. However, the growing importance of credit risk transfer has raised concerns about whether regulation as currently implemented does increase financial stability. The evidence reviewed below suggests that there is a significant transfer of risk from the banks to insurance companies. One view is that this credit risk transfer is desirable because it allows diversification between different sectors of the financial system that cannot be achieved in other ways. On the other hand, if the transfer arises because of ill-designed regulations it may be undesirable. For example, regulatory arbitrage between the banking and insurance sectors could conceivably lead to an increase in risk in the insurance sector which increases systemic risk. The purpose of this paper is to both of these arguments. We consider whether diversification across sectors can improve the allocation of resources and whether poorly designed and implemented regulation can lead to an increase in systemic risk.

Our analysis builds on our previous work on financial crises (see, e.g., Allen and Gale (1998, 2000a-c, 2004a-b) and Gale (2003, 2004)). In Allen and Gale (2004a) we argued that financial regulation should be based on a careful analysis of the market failure that justifies government intervention. We developed a model of intermediaries and financial markets in which intermediaries could trade risk. It was shown that provided financial markets and financial contracts are complete the allocation is incentive efficient. When contracts are incomplete, for example, if the banks use deposit contracts with fixed promised payments, then the allocation is constrained efficient. In other words, there is no justification for regulation by the government. In order for regulation to be justified markets must be incomplete. As in standard theories of government regulation it is first necessary to identify a market failure to analyze intervention.

In this paper we start in Section 2 by considering the institutional background of credit risk transfer. We consider the evidence on how important risk transfers are quantitatively and which entities they occur between. Section 3 develops a model with a banking sector where consumers deposit their funds and firms borrow and repay these loans with some probability. There is also an insurance sector. Some firms have an asset that may be damaged. They require insurance to allow this asset to be repaired if it is damaged. The equilibrium with complete markets and contracts is characterized. In this case complete markets allow full risk sharing. Section 4 develops an example with incomplete markets and contracts and shows how inefficient capital regulation can increase systemic risk. Finally Section 7 contains concluding remarks.

2 Institutional background on credit risk transfer

Credit risk has been transferred between parties for many years. Bank guarantees and credit insurance provided by insurance companies, for example, have a long history. Securitization of mortgages occurred in the 1970s. Bank loans were syndicated in the 1970s and secondary markets for bank loans developed in the 1980s. In recent years a number of other methods of risk transfer have come to be widely used. Institutions transferring risk out are referred to as "risk shedders" while institutions taking on risk on are referred to as "risk buyers".

Table 1 (BIS (2003)) shows the size of credit risk transfer markets using various instruments from 1995-2002. One important class of instrument is credit derivatives. An example of these is credit default swaps. These are bilateral contracts where the risk shedder pays a fixed periodic fee in exchange for a payment contingent on an event such as default on a reference asset or assets. The contingent payment is provided by the risk buyer. With asset-backed securities, loans, bonds, or other receivables are transferred to a special purpose vehicle (SPV). The payoffs from these assets are then paid out to investors. The credit risk of the instruments in the SPV is borne by the investors. The underlying pool of assets in asset-backed securities is relatively homogeneous. Collateralized debt obligations also use an SPV but have more heterogeneous assets. Payouts are tranched with claims on the pools separated into different degrees of seniority in bankruptcy and timing of default. The equity tranche is the residual claim and has the highest risk. The mezzanine tranche comes next in priority. The senior tranche has the highest priority and is often AAA rated. Table 1 shows the size of credit risk transfer markets using these instruments from 1995-2002.

It can be seen from Table 1 that the use of all types of credit risk transfer has increased substantially. The growth has been particularly rapid in credit derivatives and collateralized debt obligations, however. Despite this rapid growth a comparison of the outstanding amounts of credit risk transfer instruments with the total outstanding amounts of bank credit and corporate debt securities shows that they remain small in relative terms.

Table 2 (BBA (2002)) shows the buyers of credit protection in Panel A and the sellers in Panel B. From Panel A it can be seen that the buyers are primarily banks. Securities houses also play an important role. Hedge funds went from being fairly insignificant in 1999 to being significant in 2001. Corporates, insurance companies and the other buyers do not constitute an important part of demand in the market. From Panel B, it can be seen that banks are also important sellers of credit protection. In contrast to their involvement as buyers, the role of insurance companies as sellers is significant. Securities houses also sell significant amounts while the remaining institutions play a fairly limited role. The results of a survey contained in Fitch (2003) are consistent with Table 2. They found that the global insurance sector had a net seller position after deducting protection bought of $283 billion. The global banking industry purchased $97 billion of credit protection. A significant amount of risk is thus being transferred into the insurance industry from banks and other financial institutions.

As discussed in the introduction, these figures raise the important issue of why these transfers of risk are taking place. Is it the result of financial institutions seeking to diversify their risk? Alternatively, is it the result of regulatory arbitrage and if so can this arbitrage lead to a concentration of risk that increases the probability of systemic collapse?

We turn to the role of credit risk transfer in allowing diversification between different sectors of the economy next.

3 Diversification through credit risk transfer

3.1 The basic model

There are three dates $t = 0, 1, 2$ and a single, all-purpose good that can be used for consumption or investment at each date. There are two securities, one *short* and one *long*. The short security is represented by a storage technology: one unit at date t produces one unit at date $t+1$. The long security is represented by a constant-returns-to-scale investment technology that takes two periods to mature: one unit invested in the long security at date 0 produces $R > 1$ units of the good at date 2 (and nothing at date 1).

In addition to these securities, banks and insurance companies have distinct profitable investment opportunities. Banks can make loans to firms which succeed with probability β. More precisely, each firm borrows one unit at date 0 and invests in a risky venture that produces B units of the good at date 2 if successful and 0 if unsuccessful. There is assumed to be an infinite supply of such firms, so the banks take all the surplus. (In effect, these "firms" simply represent a constant-returns-to-scale investment technology for the banks).

The bank's other customers are depositors, who have one unit of the good at date 0 and none at dates 1 and 2. Depositors are uncertain of their preferences: with probability λ they are *early consumers*, who only value the good at date 1 and with probability $1 - \lambda$ they are *late consumers*, who only value the good at date 2. The utility of consumption is represented by a utility function $U(c)$ with the usual properties. We normalize the number of consumers to 1.

The insurance companies have access to a large number of firms, whose measure is normalized to one. Each firm owns an asset that produces A units of the good at date 2. With probability α the asset suffers some damage at date 1. Unless this damage is repaired, at a cost of C, the asset becomes worthless and will produce nothing at date 2. The firms also have a unit endowment at date 0 which the insurance company invests in the short and long securities in order to pay the firms' damages at date 1.

Finally, we introduce a class of risk neutral investors who provide "capital" to the insurance and banking sectors. Although investors are risk neutral, we assume that their consumption must be non-negative at each date. Otherwise, the investors could absorb all risk and provide unlimited liquidity.

The investor's utility function is defined by

$$u(c_0, c_1, c_2) = \rho c_0 + c_1 + c_2,$$

where $c_t \geq 0$ denotes the investor's consumption at date $t = 0, 1, 2$. The constant $\rho > E[R]$ represents the investor's opportunity cost of funds. An investor's endowment consists of a large (unbounded) amount of the good at date 0 and nothing at dates 1 and 2.

We can assume without loss of generality that the role of investors is simply to provide capital to the intermediary through the contract $e = (e_0, e_1, e_2)$. While it is feasible for the investors to invest in assets at date 0 and trade them at date 1, it can never be profitable for them to do so in equilibrium. More precisely, the no-arbitrage conditions ensure that profits from trading assets are zero or negative at any admissible prices and the investor's preferences for consumption at date 0 imply that the investors will never want to invest in assets at date 0 and consume the returns at dates 1 and 2. Now $e_0 \geq 0$ denotes the investor's supply of capital at date $t = 0$, and $e_t \geq 0$ denotes the investor's consumption at dates $t = 1, 2$. An investor's endowment consists of a large (unbounded) amount of the good X_0 at date 0 and nothing at dates 1 and 2. This assumption has two important implications. First, since the investors have an unbounded endowment at date 0 there is free entry into the capital market and the usual zero-profit condition implies that investors receive no surplus in equilibrium. Secondly, the fact that investors have no endowment (and non-negative consumption) at dates 1 and 2 implies that their capital must be converted into assets in order to provide risk sharing at dates 1 and 2.

We can then write the investors' utility in the form:

$$u(e_0, e_1, e_2) = \rho X_0 - \rho e_0 + e_1 + e_2.$$

All uncertainty is resolved at the beginning of date 1, when the banks' firms learn whether they will fail and the insurance companies' customers learn whether they have suffered damage. This is the simplest structure that allows the shock to occur at date 1 when liquidity is an issue. The most plausible structure of uncertainty is one that allows for some diversification and some aggregate risk. This is achieved by assuming that the proportions of damaged firms for the insurance sector and failing firms for the banking sector equal the probabilities α and β, respectively, and that these probabilities are themselves random.

3.2 An Arrow-Debreu equilibrium

Let $s = 1, ..., S$ denote the aggregate states of nature and write the probabilities of damage and failure as $\alpha(s)$ and $\beta(s)$ respectively.

The good at date 0 is the numeraire and the price of one unit of the good at date t in state s is denoted by $q_t(s)$.

Let $c_t(s)$ denote the consumption offered by the intermediary to the consumers at date t in state s. Then the intermediary's decision problem is

$$\begin{array}{ll} \max & E\left[\lambda U(c_1(s)) + (1-\lambda)U(c_2(s))\right] \\ \text{s.t.} & E[q_1(s)\lambda c_1(s) + q_2(s)c_2(s)] \leq 1. \end{array}$$

Let $a_2(s)$ denote the consumption of the owners of the insured firms at date 2 in state s. The decision problem of an insurer is

$$\begin{array}{ll} \max & E\left[U(a_2(s))\right] \\ \text{s.t.} & E[q_1(s)\alpha(s)C + q_2(s)a_2(s) - q_2(s)A] \leq 1. \end{array}$$

The investors' decision problem is written as

$$\begin{array}{ll} \max & E\left[\rho X_0 - \rho e_0 + e_1(s) + e_2(s)\right] \\ \text{s.t.} & E[-e_0 + q_1(s)e_1(s) + q_2(s)e_2(s)] \leq 0. \end{array}$$

Because markets are complete it does not matter who holds the assets. Without loss of generality we can assume a notional producer controls the investment technology, which is represented by a production set Y defined as follows:

$$\theta \geq 0, \psi \geq 0, \theta + \psi \leq 2 + e_0;$$
$$y_1(s) \leq \theta;$$
$$y_1(s) + y_2(s) \leq \theta + \psi R + (2 + e_0 - \theta - \psi)\alpha(s)B.$$

The producer's decision problem is

$$\begin{array}{ll} \max & E\left[q_1(s)y_1(s) + q_2(s)y_2(s)\right] \\ \text{s.t.} & y \in Y. \end{array}$$

An allocation (a, c, e, y) is attainable if

$$\lambda c_1(s) + \beta(s)C + e_1(s) = y_1(s)$$

and

$$a(s) + (1-\lambda)c_2(s) + e_2(s) = y_2(s)$$

for each s. An equilibrium consists of a price system $q = (q_1, q_2)$ and an attainable allocation (a, c, e, y) such that the three decision problems are satisfied.

3.3 The Modigliani-Miller theorem for risk sharing

In an Arrow-Debreu world, risk sharing is mediated by markets. In particular, the capital is provided to the market and not to any specific individual financial institution. Similarly, there are no OTC derivatives traded between banks and insurance companies. Instead, they trade contingent commodities with "the market". One could introduce specific capital contracts between investors and bank or insurers, but these would be redundant securities. In fact, we can establish a Modigliani-Miller theorem for banks and insurers along the lines of Gale (2004). For example, suppose that a bank wants to raise an amount of capital e_0. It will offer investors a contract (e_0, e_1, e_2) under which it promises to pay investors $e_t(s)$ in state s and date t in exchange for the contribution of e_0 at date 0. In order to be acceptable to the investors, the capital contract (e_0, e_1, e_2) will have to satisfy the participation constraint

$$E\left[-\rho e_0 + e_1(s) + e_2(s)\right] \geq 0.$$

The bank's objective function remains the same as before, but now the value of the capital contract is added to its budget constraint. Clearly, the bank will want maximize the value of the contract in order to maximize the "market value" of the bank. Thus, an optimal contract will solve the problem

$$\begin{array}{ll} \max & E[-e_0 + q_1(s)e_1(s) + q_2(s)e_2(s)] \\ \text{s.t.} & E\left[-\rho e_0 + e_1(s) + e_2(s)\right] \geq 0, \end{array}$$

which is the dual of the investor's decision problem above. Because of the linearity of the problem, in equilibrium the market value of the contract is zero and the participation constraint is binding. In other words, the capital contract will have no effect on the bank's budget constraint and no effect on its objective function. Furthermore, the introduction of an explicit capital structure has no effect on the endogenous variables we care about (the allocation of consumption and investment in assets) because the trades implied by the contract are offset in the contingent security markets.

This raises an interesting question, however. Does capital regulation under the Basel Accord recognize these transactions as offsetting or does it treat the raising of capital under the contract (e_0, e_1, e_2) as "on-balance-sheet" and the offsetting transactions as "off-balance-sheet"? Does a notional capital of e_0 count as satisfying the capital requirement if it is offset by side trades, in which case the Modigliani-Miller theorem applies, or does the capital requirement rule look at the net effect of all transactions and explicitly rule out offsetting transactions? It is hard to think about these questions in an Arrow-Debreu economy where every trade is mediated by the market and financial institutions do not have well defined balance sheets. We can perhaps make better progress by considering what happens when markets are incomplete.

3.4 Incomplete markets

Suppose we get rid of all contingent commodities but allow a spot market for assets at date 1 (equivalent to a forward market for consumption at date 1). If we still allow banks and insurers to write complete contracts, then markets are effectively complete because there are only two representative agents (plus the risk neutral investors who receive no surplus). However, in this case, the net effect of risk sharing between investors and the banks or insurance companies must be mediated by an explicit contract and it is this contract that is controlled by capital adequacy regulation. If the bank is required to increase e_0, this will have a real impact on its feasible set and on the value of its objective function. It cannot be offset by side trades because we assume that all trades are governed by pairwise contracts and those between the investors and banks are explicitly regulated.

An increase in capital requirements affects the banks' risk in two ways. First, it imposes an additional cost on risky loans to firms and one imagines this will cause the banks to reduce the amount of loans they hold. Secondly, the additional capital, held in the form of riskless assets, is a substitute for risk sharing derivatives exchanged with the insurance companies. On the one hand, to the extent that the banks and insurance companies were previously able to share risks that are orthogonal, this reduction in risk sharing may be considered an increase in systemic risk. On the other hand, to the extent that the investors can shift risk to the insurance companies, by changing their contracts with the latter, we may once again be faced by a Modigliani-Miller result (assuming that there is no capital regulation of insurers).

An example may help to clarify some of these issues. Suppose that the bank and insurance sectors each receive two independent shocks, labelled α_H, α_L and β_H, β_L. For simplicity, assume $\alpha_L = 0$ and $\beta_H = 1$ and put $\alpha_H = \alpha > 0$ and $\beta_L = \beta < 1$. When we observe $s = (0, \beta)$ or $s = (\alpha, 1)$ the two financial sectors can help each other, but if $s = (\alpha, \beta)$, both have suffered a loss and need the investors to make it up to them. This is costly since the opportunity cost ρ is assumed to be large, but in the Arrow-Debreu model the first-best level of risk sharing is achieved. If the probability of the state (α, β) is small, the amount of risk insured with the investors will be small and so on. A much more important source of risk sharing (because the probability of one of these events is a higher order of magnitude) may be the sharing of risk between the two sectors. By forcing banks to hold more capital, if that is what capital adequacy regulation does (we have to bear in mind the possibility that there may be some backdoor method of reversing the regulation by adjusting the investors' contracts with *both* sectors), it may reduce the amount of direct risk sharing between the two sectors and increase the insurance sector's exposure to systemic risk. This may in turn feed back and increase the systemic risk in the banking sector. We next develop a simple numerical example to show that this can in fact occur.

4 Increased systemic risk from capital regulation

In this section we present a simple to numerical example to illustrate that capital regulation can increase systemic risk. We start by considering the banking sector on its own and then go on to consider the insurance sector in isolation. Without capital regulation we show that there is no incentive to have credit risk transfer. However, with capital regulation where capital can be reduced with if there is credit risk transfer between the sectors we show that this will take place. Moreover the credit risk transfer can increase systemic risk in the banking sector.

4.1 The banking sector

No Capital

To start with we consider what happens if there is no capital available. The return on the long asset is $R = 1.25$.

For the investors providing equity capital for banks $\rho = 1.5$

For depositors in the banks $\lambda = 0.5; U(c) = Ln(c)$

For banks' loans $B = 3$;

Prob. state $H =$ Prob. state $L = 0.5$;

$\beta_H = 1; \beta_L = 0.4$.

Banks investment in the short asset is denoted x and their investment in loans is denoted y. They receive an endowment of 1 so their investment in the long asset is $1 - x - y$.

Consider first the case where there are no runs. Since there is no uncertainty about the banks needs for liquidity at date 1 they will use the short term asset to provide consumption at date 1. The optimization problem of the banks is to choose x and y so that

$$\begin{aligned}&\text{Max } 0.5U(x) + 0.5[0.5U((1-x-y)R + By))\\&+0.5[0.4U((1-x-y)R + By)) + 0.6U((1-x-y)R))]]\end{aligned}$$

or simplifying

$$\text{Max } 0.5U(x) + 0.35U((1-x-y)R + By) + 0.15U((1-x-y)R))]]$$

The first order conditions are:

$$\frac{0.5}{x} = \frac{0.35R}{(1-x-y)R + By} + \frac{0.15}{(1-x-y)}$$

$$\frac{0.35(B-R)}{(1-x-y)R + By} = \frac{0.15}{(1-x-y)}$$

The solution for the equilibrium is

$$\begin{gathered}x = 0.5; y = 0.243; 1 - x - y = 0.257\\(1-x-y)R + By = 1.050; (1-x-y)R = 0.321\\EU = -0.500\end{gathered}$$

In terms of checking that even in the worst state at date 1 that there will not be a run, the late consumers will be better off to keep their funds in the bank if

$$0.5U(x) \leq 0.4U((1-x-y)R + By)) + 0.6U((1-x-y)R))$$

In the example the left hand side is -0.693 and the right hand side is -0.661 so the condition is satisfied.

The Role of Capital

Next consider what happens if there are investors who can make capital available to the banks. Since the investors are indifferent between consumption at date 1and date 2 it is optimal to set $e_1 = 0$ and invest any capital e_0 that is contributed in the long asset. In the case where the loans pay off B it is possible to make a payout e_2 to investors.

$$\text{Max } 0.5U(x)+0.35U((1+e_0-x-y)R+By-e_2)+0.15U((1+e_0-x-y)R))]]$$

In order for the investors to be willing to supply the capital it is necessary that

$$e_0\rho = 0.7e_2.$$

Hence the banks' problem becomes to choose e_0, x and y to

$$\text{Max } 0.5U(x)+0.35U((1-x-y)R+By-e_0(\frac{\rho}{0.7}-R))+0.15U((1+e_0-x-y)R))]]$$

The first order conditions are now

$$\frac{dEU}{dx} = \frac{0.5}{x} - \frac{0.35R}{(1-x-y)R+By-e_0(\frac{\rho}{0.7}-R)} - \frac{0.15}{(1+e_0-x-y)} = 0$$

$$\frac{dEU}{dy} = \frac{0.35(B-R)}{(1-x-y)R+By-e_0(\frac{\rho}{0.7}-R)} - \frac{0.15}{(1+e_0-x-y)} = 0$$

$$\frac{dEU}{de_0} = -\frac{0.35(\frac{\rho}{0.7}-R)}{(1-x-y)R+By-e_0(\frac{\rho}{0.7}-R)} + \frac{0.15}{(1+e_0-x-y)} = 0$$

The first thing to notice is that these cannot all be satisfied. Since $B > \frac{\rho}{0.7}$ the last two conditions cannot be simultaneously satisfied. What is happening is that the risk neutral investors are supplying the funds for loans and the cost of these funds is less than the return from loans. Banks have an incentive to raise an infinite amount of equity capital and fund loans with this. We assume there is a limited number of loans $y = 0.3$ and the owners of the firms taking the loans therefore obtain the surplus. The amount paid on loans instead of being B will be $\frac{\rho}{0.7}$ in equilibrium. Hence the relevant first order conditions become

$$\frac{0.5}{x} = \frac{0.35R}{(1-x-y)R+\frac{\rho}{0.7}y-e_0(\frac{\rho}{0.7}-R)} + \frac{0.15}{(1+e_0-x-y)} = 0$$

$$\frac{0.35(\frac{\rho}{0.7}-R)}{(1-x-y)R+\frac{\rho}{0.7}y-e_0(\frac{\rho}{0.7}-R)}=\frac{0.15}{(1+e_0-x-y)}$$

Solving these and using the values of the example together with $y = 0.3$ we get

$$\begin{gathered} e_0 = 0.16; e_1 = 0; e_2 = 0.56; \\ x = 0.5; 1 + e_0 - x - y = 0.36 \\ (1 + e_0 - x - y)R + \tfrac{\rho}{0.7}y - e_2 = 0.75; (1 + e_0 - x - y)R = 0.45 \\ EU = -0.567 \end{gathered}$$

The condition for not having a run is then

$$0.5U(x) \leq 0.4U((1+e_0-x-y)R+\frac{\rho}{0.7}(y-e_0))+0.6U((1+e_0-x-y)R))$$

In this case the left hand side is -0.693 and the right hand side is -0.571 so the condition is satisfied and there is no run.

Risk is not eliminated from the depositors' consumption even though the investors providing the capital are risk neutral because capital is costly. The expected utility is lower than with no capital because the firms with the loans get the surplus.

4.2 The insurance sector

We next turn to the insurance sector and consider it on its own. As explained above there are firms that own assets that produce A at $t = 2$. For our example, we assume that $A = 1.3$. The owners of these firms have $U = Ln(c)$.

With some probability $\alpha(s)$ a firm's asset is damaged at date $t = 1$. It costs $C = 1$ to repair the asset in which case it produces A at $t = 2$. Without repair the asset produces nothing. Insurance companies insure these firms.

In state l the probability $\alpha(l) = 0.5$ and this state occurs with probability 0.9. In state h the probability $\alpha(h) = 1$ and this state occurs with probability 0.1.

The cost of an insurance company liquidating long term assets at date $t = 1$ if it goes bankrupt is such that the proceeds are zero. Grace, Klein and Phillips (2003) have found that for a large sample of insurers that went bankrupt from 1986-1999 the average cost of insolvent firms accessing the guarantee funds was \$1.10 per \$1 of pre-insolvency assets. By way of contrast James (1991) found that the figure for banks for the late 1980s was \$0.30.

Each firm has an endowment of 1 at date $t = 0$ that it can use to buy insurance or invest itself.

The insurance industry is competitive so the companies do not earn any profits. The insurance companies can offer partial or full insurance to firms. If they offer partial insurance they charge 0.5 at date $t = 0$. Suppose the firms put the other 0.5 of their endowment in the long term asset (it will be shown this is optimal shortly). In order to have funds to repair the damaged assets the insurance companies must invest in the short asset so that they have liquidity at date $t = 1$. In state l the funds they need for claims to repair the damaged assets are $\alpha(l)C = 0.5$. They have funds of 0.5 and can pay all the claims to repair the damaged assets. The utility of the owners of the firms is therefore $U(A + 0.5R)$. In state h the insurance companies receive claims of $\alpha(h)C = 1$. They don't have sufficient funds to pay these so they go bankrupt. With partial insurance there is thus systemic risk in the insurance industry. When the insurance companies go bankrupt their assets are distributed equally among the claimants. The firms receive 0.5 from the insurance companies' liquidation. They can't repair their assets so these produce nothing. In state h the utility of the owners of the firm is therefore $U(0.5 + 0.5R)$.Their expected utility is

$$EU_{partial} = 0.9U(A + 0.5R) + 0.1U(0.5 + 0.5R) = 0.601.$$

Notice that if the firms put the other 0.5 of the endowment in the short rather than the long asset they would be able to repair the assets in state h but they would only receive 0.5in state l from their investment. Hence their expected utility would be

$$EU = 0.9U(A + 0.5) + 0.1U(A) = 0.555,$$

so they would be worse off.

If the insurance company offered full insurance they would charge 1 at $t = 0$ and could meet all of their claims in both states. At $t = 1$ in state l they would have 0.5 left over. Since the industry is competitive they would pay this out to the insured firms. In this case

$$EU_{full} = 0.9U(A + 0.5) + 0.1U(A) = 0.555.$$

Again this is worse than partial insurance.

Thus the optimal scheme is for the insurance industry to partially insure firms and to charge 0.5 at $t = 0$. The firms put the remaining part of their endowment in the long asset.

The Role of Capital

In this case there is no role for capital in the insurance sector. Capital providers charge a premium. They would have to invest in the short asset. There are potentially enough funds from customers to do this but it is simply not worth it. If there is a premium to be paid it is even less worth it. Capital will not be used in the insurance industry.

4.3 Bringing together the banking and insurance sectors

Now consider what happens if we consider the two sectors together and look at possible interactions. We start with the situation where there is no regulation and then go on to consider what happens with regulation.

No Regulation

Without any regulation both sectors have the same equilibrium as when they are considered on their own. There are no incentives for the insurance sector to insure the banking sector and have credit risk transfer. All the insurance sector could do is to hold the long term asset and pay off when the loans default. But the banking sector can do this on its own. In fact with insurance the systemic risk means that there would be a strict loss in this case. The value of the long term asset would be lost in this case.

There is no gain for the banking sector to bear the risk of the insurance sector. They would have to hold the short term asset but the insurance sector can do this just as efficiently.

The Equilibrium with Inefficient Capital Regulation in the Banking Sector

Now suppose that the government requires banks to have a certain minimum amount of capital. There is no role for capital regulation in our model so it can have no benefit. It may be harmless if the required level is below the optimal level. The more interesting case is when it set at too high a level.

Suppose in our example that the government requires banks to have $e_0 = 0.3$ compared to the level of 0.16 which is optimal. The optimal solution

$$e_0 = 0.3; e_1 = 0; e_2 = 0.643;$$
$$x = 0.5; 1 + e_0 - x - y = 0.5$$
$$(1 + e_0 - x - y)R + \frac{\rho}{0.7}y - e_2 = 0.625; (1 + e_0 - x - y)R = 0.625$$

$$EU = -0.582$$

The condition for not having a run is then

$$0.5U(x) \leq 0.4U((1+e_0-x-y)R+\frac{\rho}{0.7}(y-e_0))+0.6U((1+e_0-x-y)R))$$

In this case the left hand side is -0.693 and the right hand side is -0.594 so the condition is satisfied and there is a run.

Welfare is reduced by the inefficient regulation. The extra funds are put in the long term asset but this is inefficient because there is no welfare gain and there is a premium on the cost of equity capital.

Inefficient Capital Regulation in Banking and Credit Risk Transfer from the Insurance Sector

Next consider what happens if we allow for the possibility of credit risk transfer from the banking sector to the insurance sector. It is supposed that the shocks to the two sectors are independent. The regulation is such that the existence of hedging of credit risk allows a reduction in the capital requirement. We suppose that by purchasing an insurance contract with cost of $G = 0.041$ and payoff of $0.041 \times R = 0.0513$ when loans do not payoff it is possible for a bank to reduce its capital requirement to the optimal level of 0.16. The idea here is that the regulation does not work effectively since banks can use their own risk models. Notice that in order for this insurance contract to be such that the insurance companies break even, which is necessary because of competition, they will also provide a payment of 0.0513 when the loans do payoff. They use it to buy the long term asset and then pay out the proceeds when they are solvent. When they are not solvent the long term asset is wasted. The only point of the credit risk transfer is to arbitrage the inefficient capital regulation in the banking sector. The key issue is whether the gain from this inefficient risk transfer outweighs the inefficiency of the capital regulation. It can be shown that in this case it does.

$$
\begin{aligned}
EU &= 0.5U(x) + \\
&\quad 0.5[0.7(0.9U((1-x-y-G)R+By-e_0(\frac{\rho}{0.7}-R)+GR)+ \\
&\quad 0.1(0.9U((1-x-y-G)R+By-e_0(\frac{\rho}{0.7}-R)) \\
&\quad +0.3(0.9U((1+e_0-x-y-G)R+GR)+0.1U((1+e_0-x-y-G)R))] \\
&= -0.571
\end{aligned}
$$

So the expected utility of the banks depositors is improved relative to the case with no insurance policy but of course they are not as well off as in the case with no regulation.

As far as the no run condition is concerned the relevant state is where it is known loans have a low probability of paying off in the banking industry and there is default in the insurance industry.

$$0.5U(x) \leq 0.4U((1+e_0-x-y-G)R+\frac{\rho}{0.7}(y-e_0))+0.6U((1+e_0-x-y)R))$$

In this case the left hand side is -0.693 and the right hand side is -0.695 so the condition is not satisfied and there is a run.

A key question is what happens if there is a run on the bank. For simplicity assume the bank can liquidate its assets for their market value. Grace, Klein and Phillips (2003) do point out that the cost of liquidating bank assets is much lower for banks than insurance companies and we take this as the extreme case. We could of course allow for some small loss of asset value and all the results above would hold. The more inefficient the banking regulation the greater this loss can be.

We have thus shown what we set out to namely that with inefficient banking regulation credit risk transfer can increase systemic risk.

5 Concluding remarks

In this paper we have developed a model of banking and insurance and shown that with complete markets and contracts intersectoral transfers are desirable. However, with incomplete markets and contracts credit risk transfer can occur as the result of regulatory arbitrage and this can increase systemic risk. The key question going forward of course is which view of credit risk transfer is empirically relevant.

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Table 1: Size of Credit Risk Transfer Markets (in billions of US $)

Instrument	1995	1996	1997	1998	1999	2000	2001	2002
Loan trading (turnover)								
- US Market	34	40	61	78	79	102	118	117[1]
(Loan Pricing Corporation)								
Credit Derivatives (outstanding)								
- BIS triennial survey				108			693	
- US OCC[2]				144	287	426	395	492[3]
- British Bankers Association			180	350	586	893	1,189	1,952[4]
- Risk Magazine						810	1,398	
- ISDA							919	1,600[4]
Asset-backed securities								
- US market (outstanding)	315	403	517	684	816	947	1,114	1,258[6]
(Bond Market Association)[5]								
- European market (issuance)								
(Moody's)[7]					68	80	134	50[8]
- Australian market (outstanding)	7	10	15	19	27	33	38	54
(Australian Bureau of Statistics)								
Collateralised debt obligations								
- US market (outstanding)	1	1	19	48	85	125	167	232[6]
(Bond Market Association)								
- European market (issuance)								
(Moody's)					42	71	114	70[8]
Total bank credit	23,424	23,576	23,309	26,018	26,904	27,221	27,442	29,435[9]
(outstanding)[10]								
- IMF								
Corporate debt securities[11]	3,241	3,373	3,444	4,042	4,584	4,939	5,233	5,505[9]
(outstanding)								
- BIS								

Footnotes: [1]First three quarters of 2002, annualised. [2]Holdings of US commercial banks. [3] Second Quarter of 2002. [4]Forecast for 2002. [5]Excluding CB)os/CDOs. [6] September 2002. [7] ABSs and MBSs. [8]First half of 2002. [9] June 2002. [10] Domestic and international credit to non-bank borrowers (United States, United Kingdom, Japan, Canada, Euro area). [11] Debt securities issued in international and domestic markets, non-financial corporates.

Source: BIS (2003).