Economic Research Paper

Common (Stock) Sense about Risk-Shifting and Bank Bailouts

Linus Wilson* and Wendy Wu**

December 2008

*Assistant Professor of Finance, B. I. Moody III College of Business, University of Louisiana at Lafayette.
**Assistant Professor, Department of Economics, School of Business and Economics, Wilfrid Laurier University.

Common (Stock) Sense about Risk-Shifting and Bank Bailouts

Linus Wilson*
Assistant Professor of Finance
University of Louisiana at Lafayette
B. I. Moody III College of Business
Department of Economics & Finance
214 Hebrard Boulevard, Moody Hall 253
P. O. Box 44570
Lafayette, LA 70504-4570
Phone: (337) 482-6209
Fax: (337) 482-6675
E-mail: linuswilson [at] louisiana [dot] edu
Web: http://www.linuswilson.com

and

Wendy Yan Wu
Assistant Professor
Department of Economics
School of Business and Economics
Wilfrid Laurier University
75 University Avenue West
Waterloo, ON, Canada, N2L 3C5
Phone: (519) 884-0710, ext. 2925
Fax: (519) 888-1015
E-mail: wwu@wlu.ca

December 29, 2008

* Corresponding author

Common (Stock) Sense about Risk-Shifting and Bank Bailouts

If a bank faces potential insolvency, it will be tempted to reject good loans and accept bad loans to shift risk onto its creditors. We analyze effectiveness of buying up toxic mortgages in troubled banks, buying preferred stock, and buying common stock. If bailouts for banks that are deemed "too-big-too-fail" involve buying assets at above market values, then these banks are encouraged *ex ante* to gamble on bad assets. Buying up common (preferred) stock is always the most (least) *ex ante*- and *ex post*-efficient type of capital infusion whether or not the bank volunteers for the recapitalization.

Journal of Economic Literature Codes: G21, G28, G38

Keywords: banks, bailout, lending, risk-shifting, TARP, too-big-to-fail

1. Introduction

On September 15, 2008, Lehman Brothers failed after negotiations to sell the firm to the British bank Barclays Plc. broke down over the previous weekend. At the time of its U.S. Chapter 11 bankruptcy protection filing, Lehman Brothers had assets worth ten times that of Enron, the previous record holder for the largest bankruptcy in U.S. history. The prospect of the disorderly bankruptcy of a formerly mega investment bank was followed by considerable market turmoil.[1] On October 3, 2008, President George W. Bush signed the Emergency Economic Stabilization Act (EESA), which authorized the U.S. Treasury to buy up to $700 billion dollars of troubled assets to stabilize the financial sector. A few weeks later the largest remaining commercial and formerly investment banks received $125 billion dollars from the U.S. Treasury primarily in exchange for preferred stock, which paid dividends far less than preferred stock sales that occurred days or weeks before. Press reports said that Treasury Secretary Henry M. Paulson Jr. told the CEOs of nine of the largest American banks that these stakes were bought to restore confidence to the markets and to encourage the banks to lend.[2]

This paper considers how various types of capital infusions affect banks' incentives to lend efficiently. Unlike the existing literature on the bank bailouts and bank closures, this paper rigorously addresses the question of which securities should be used

[1] David Teather, Andrew Clark, and Jill Treanor "Barclays agrees $1.75bn deal for core Lehman Brothers business," http://www.guardian.co.uk/business/2008/sep/17/barclay.lehmanbrothers1.
[2] Mark Landler and Eric Dash, October 15, 2008, "Drama Behind a $250 Billion Banking Deal," *New York Times*, (Accessed online December 23, 2008) *http://www.nytimes.com/2008/10/15/business/economy/15bailout.html?_*; The move to buy preferred stock was a quick about face for a Treasury secretary who originally argued that the funds from the EESA would be used to buy troubled mortgage securities.

to recapitalized troubled banks. We consider the government's decision to recapitalize a bank that is deemed "too-big-to-fail" by regulators. Sorting out the millions of lending and derivatives transactions associated with a top investment bank or huge commercial bank with investment banking activities may test the limits of the bankruptcy courts, while creating great uncertainty about the credit quality of the failed bank's counterparties.

We assume that the government cannot contract on the firm's lending policy. Instead, the government's primary mechanism for improving the troubled bank's lending decisions is recapitalizing the bank. In this paper, we assume that the troubled bank has a sufficient amount of liquid assets to make new loans. Nevertheless, since the bank is not solvent in all states of the world, it is tempted to shift risk onto its creditors. This paper finds that, in terms of inducing efficient lending, the government's buying new common stock is always at least or more effective than buying toxic mortgage securities or buying preferred stock. We find that the subsidies (overpayment for assets) are always necessary to induce the bank to agree to the recapitalization voluntarily.

Further, it is found that the preferred stock is the least effective form of recapitalization. All the gains from a preferred stock recapitalization come from the implicit government subsidy from purchasing that security. That is, it is only the regulator's overpayment for preferred stock that improves lending incentives. Because both Goldman Sachs and Morgan Stanley issued preferred stock days before and days after for yields higher than the preferred stock sold by the Treasury on October 13, there is strong evidence that the government did overpay for those preferred shares.[3] Yet, they

[3] Randall W. Forsyth, October 14, 2008, "Buffett Drives a Harder Bargain than Paulson: Banks get cheaper financing from Treasury than from Berkshire Hathaway," *Barron's*, (Accessed online October 15,

may not have overpaid enough to improve lending behavior of the banks in question. Moreover, this paper proves that just because a bank agrees to a preferred stock recapitalization that does not imply that the bank's lending behavior will improve. In contrast, as long as the government buys enough common stock, lending incentives improve without a subsidy. We analyze how recapitalizations involving these three different types of asset purchases affect lending incentives.

It is well known that excessive leverage can lead to risk-shifting. Common stockholders with limited liability have incentives to shift much of the risks of speculative projects (loans here) onto their creditors. This problem was laid out in Jensen and Meckling (1976). In this case, some of the returns from safer investments accrue to that company's more senior creditors—preferred stock holders, unsecured bondholders, and secured bond holders—when a company is nearly or actually insolvent. The common stockholders in a company that has excessive leverage are tempted to gamble for resurrection by undertaking speculative projects that are positively correlated with the firm's existing cash flows. Merton (1974) recast the value of a firm's equity as a call option on the firm's assets. In this framework, as the variance of the firm's assets is increased (as the bank takes on speculative loans), its equity is increased. Variance becomes an increasingly important component of the call option's value as the call is at

---

2008), http://online.barrons.com/article/SB122401409814533513.html?mod=g; The first participants in the Troubled Assets Relief Program (TARP) Capital Purchase Program were Goldman Sachs, Morgan Stanley, Merrill Lynch, JPMorgan Chase, Bank of America (which agreed to acquire Merrill Lynch), Citigroup, Wells Fargo, Bank of New York Mellon, and State Street received the first $125 billion dollars of preferred stock purchased with the funds of the Emergency Economic Stabilization Act. On October 13, 2008, the Treasury agreed to purchase preferred stock that had dividend of 5 percent for the first five years and 9 percent thereafter. Treasury's purchase had warrants attached worth 15 percent of the preferred stock's par value. Warren Buffet bought preferred stock with 10 percent dividends and warrants on 100 percent of the purchase weeks prior to the Treasury deal. Just prior to the Treasury's capital infusion, the publicly traded preferred shares of many of the banks receiving funds traded with yields between 9.62 percent and 11.7 percent. Veronesi and Zingales (2008) also estimate that the Treasury overpaid for its preferred stock in those banks.

or well out of the money. That is, when the bank is nearly or actually insolvent, its incentives to gamble for resurrection increase.

There is some evidence that the risk-shifting incentives of insolvent banks can significantly deplete assets. For example, Barrow and Horvitz (1993) studied insolvent savings and loans operated by the now defunct Federal Savings and Loan Insurance Corporation from 1985 to 1988. The firms operated by government conservatorship adopted much less risky strategies and on average depleted the deposit insurance fund less than insolvent savings and loans that were granted regulatory forbearance to operate under existing management.

Several papers have argued that a regulator will not or should not merely close down insolvent or nearly insolvent banks and then take a *laissez-faire* policy. Maliath and Mester (1994) investigate how regulators' policy on bank closure influences bank's portfolio choices and its levels of risk. They find that as the bank's size increases, the regulator's closure policy becomes less credible, while forbearance becomes more credible. Acharya and Yorulmazer (2008) and Acharya and Yorulmazer (2007) argue that the necessities of bailout policy depend on the relative number of failed banks versus surviving banks. When a sufficiently large number of banks fail, granting liquidity to surviving banks so that they can purchase failed banks, dominates a bailout policy that directly assists failed banks. Gorton and Huang (2004) also argue that it is costly for private agents to be prepared to purchase substantial amounts of assets on short notice. In this context, the government can create liquidity and improve welfare. Therefore, they argue that forbearance and bank bailouts are sometimes optimal. Acharya (1996) argues that not all solvent banks should be closed. That paper argues that it is optimal to leave the insolvent banks with sufficiently large charter (going-concern) values open. Cordella and Yeyati (2003) also argue that regulatory forbearance may be optimal if the lost banks' charter values are large. They argue that the optimal bailout policy should be announcing and committing *ex-ante* to bail out insolvent institutions only in times of adverse macroeconomic condition but not otherwise. Rochet and Tirole (1996) analyze how interbank lending provides the link for one bank's problem to transmit to the other and lead to systemic banking system failure. They argue that banks become "too-big-to-fail" when the failure of a single bank can propagate crisis in the entire banking system.

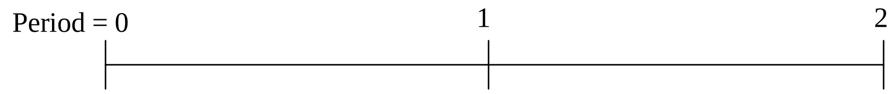
Several empirical studies document that regulators are reluctant to close down banks and will often provide some sort of government assistance during banking crises. Hoggarth, Reidhill, and Sinclair (2004) discuss resolutions adopted in 33 banking crises over the world over the period of 1977 through 2002. They find that during systemic crises, liquidity support from central banks and blanket government guarantees have been granted. Kasa and Spiegel (2008) analyze U.S. bank closures during 1992-1997 and find that only banks performing significantly worse than the industry are closed. Brown and Dinc (2006) analyze failures among large banks in 21 major emerging markets in the 1990s and show that the government decision to close or take over a failing banks depends on the financial health of other banks in that country. Caballero *et al.* (2008) find that regulatory forbearance was the norm in Japan after the crash of its stock market and property price bubble in the 1990s. Over levered banks were allowed to use questionable account adjustments to overstate their health. This in part led these banks to make poor, speculative lending decisions to "zombie" borrowers.

Our study provides a theoretical model that analyzes the relative merit of purchasing toxic mortgages, purchasing preferred shares, and common stock recapitalizations. Chaney and Thakor (1985) argue that bailing out company's (not just banks) with loan guarantees induce those firms to take on speculative undertakings *ex ante*. That paper does not discuss any other types of government capital injections. To our knowledge, the only papers that do specifically mention the securities that should be used in bank bailouts do not rigorously model the optimal security choice of the regulator. For example, Bebchuck (2008a) and Zingales (2008)'s columns do not prove their assertions that common stock is the best way to recapitalize banks. The former advocates mandatory rights offerings to force banks to increase the common stock component of their capital structure. The latter advocates a mandatory debt-for-equity swap in the financial sector to achieve a higher equity-to-assets ratio for banks. Bebchuk (2008b) argues that the Treasury should not overpay for troubled assets and should not mix the buying of distressed assets with direct bank capital injections. The current paper has the government buying distressed assets in the troubled bank only. We find that common equity recapitalizations weakly dominate purchases of troubled assets (toxic mortgages). Harvey (2008) proposes that Troubled Asset Relief Program (TARP) should not pay hold-to-maturity prices for the troubled assets but rather a lower price aiming at providing liquidity for a 3-5 year window. He also suggests that direct capital injection through equity investment is more effective than purchasing troubled assets. The current paper, in proposition 6, supports these papers' intuition that forced common equity recapitalizations are first-best efficient. In contrast, we consider the case where the regulator lacks the credibility or the political will to force recapitalizations. In that case, the current paper still finds common stock cash infusions are weakly the most efficient.

The paper proceeds as follows. First, the model is introduced in section 2. In section 3, we proceed backwards though the game outlined in Figure 1. Here, we give a brief summary of the equilibrium outcomes as we move backward through the game. In section 3, we first explore the Bank *B*'s loan choice decision in period 1c, given that it holds a risky mortgage portfolio. When initial returns to that portfolio are high, then Bank *B* lends efficiently. Yet, when initial returns are low, then Bank *B* takes on the bad loan and rejects the good loan. If initial mortgage returns are high, there is no bailout by the regulator in period 1b. If initial mortgage returns are low, for some parameter values, the government bails out Bank *B* in period 1b. Given that there will be a bailout in period 1b, the regulator always weakly prefers to use common stock. Nevertheless, sometimes the regulator will be indifferent between buying common stock and selectively buying toxic mortgages. Finally, in period 0, Bank *B* decides whether or not to invest in risky mortgages. If the expected subsidy exceeds the overpayment for the mortgage securities and the cost of borrowing its counterparty's, Bank *C*'s, deposits, then Bank *B* buy speculative mortgage assets. Welfare is always the highest if Bank *B* finds it unprofitable to invest in the toxic mortgages. Therefore, the smaller subsidies will lead to the first-best social welfare for more parameter values.

The subgame perfect Nash equilibrium (SPE) for the possible parameter values are outlined at the end of section 3. In section 4, we apply the model to two numerical examples. In the first example, the SPE is that Bank *B* invests in safe assets and welfare is first-best. In the second example, welfare is second-best because Bank *B* invests in mortgage assets and there is a bailout if mortgage returns are initially low. The magnitude of the recapitalizations relative to Bank *B*'s assets must be rather large to induce efficient lending. In section 5, we discuss the results in light of the asset purchases by the Troubled Asset Relief Program (TARP) thus far, and we conclude.

Figure 1: The Sequence of Events



Period 0: Bank *B* decides whether or not to buy speculative mortgage securities, and Bank *C* decides whether to extend credit to Bank *B* to buy those mortgage securities.

Period 1:

a. Mortgage returns are realized as high or low.
b. The government decides whether or not to bail out Bank *B*.
c. Bank *B* chooses between a good loan and a bad loan.

Period 2:

a. Mortgage returns and returns from the bad loan are realized as high or low.
b. Bank *C* is paid back from Bank *B*.

2. Model

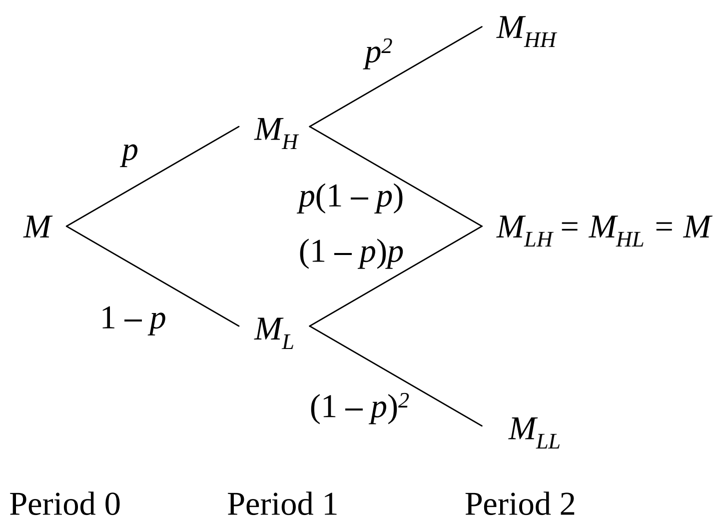
Suppose there are two banks, Bank *B* and Bank *C*. The first is the "bad" bank because it is tempted to make a bad investment in period zero. Bank *B* also has deposits worth *D*. Bank *B* has two choices. One option is that it can invest its deposits in period 0 and earn a safe return of zero in period 2. Alternatively, Bank *B* can underwrite risky mortgages with a present value $M = 2D$. The price of this illiquid mortgage investment is $M + \beta > M$ in risky mortgages. β can represent the transaction costs of this purchase or the fact that this is a bad investment *ex ante*. Certainly the underwriting standards for a large proportion of the U.S. home mortgages originated in 2005 and 2006 would give most people a pause. The no-down-payment, no-documents, and no-stated-income-or-assets loans were unprecedented in the history or mortgage finance and clearly ripe for abuse. These underwriting practices were not a secret to the general public or the banks, taking long positions in these assets. Improper incentive structures, gave many mortgage lenders and many investment bankers securitizing the loans a vested interest in ignoring credit quality of loans that they created.

This mortgage investment has an expected net present value of $-\beta$, where $0 < \beta$. β is a deadweight loss to society. For example, a vacant home may have little social value but takes valuable resources to build and maintain. The present value of these mortgages is a function of a Bernoulli random variable that has a probability of high returns of p and a probability of low returns of $(1 - p)$ in period 1a. This Bernoulli process is repeated in period 2a, such that the mortgage returns are a function of a binomial random variable with probability of success (H) equal to p, and the number of trials equal to 2. The subscripts denote whether or not the value moved to high or low. HH means the value of the mortgage portfolio increased in value in both periods one and two; HL means that the mortgages increased in value and then fell in value; LH denotes that the mortgages declined in value and then rose in value; and LL denotes that the mortgages declined in value in periods 1a and 2a. The expected value of these mortgages is the following:

$$
\begin{aligned}
&M = pM_H + (1-p)M_L, \\
&\text{where } M_L = pM_{LH} + (1-p)M_{LL}, \\
&M_H = pM_{HH} + (1-p)M_{HL}, \text{ and} \\
&M = M_{LH} = M_{HL}. \\
&\therefore \quad M = p^2 M_{HH} + 2p(1-p)M_{HL} + (1-p)^2 M_{LL}
\end{aligned}
\tag{1}
$$

The evolution of value of this mortgage portfolio is visually represented in Figure 2 below:

Figure 2: Evolution of the Value of the Mortgage Portfolio



We will assume that Bank *B* will undertake the risky mortgage investment only if its expected returns *strictly* exceed the returns in the safe asset. In period 0, Bank *B* and Bank *C* decide to make their investments. All players are risk-neutral. The risk-free discount rate between periods is normalized to zero. To capture the impact of counterparty risk that is important to derivatives as well as lending agreements, we will present a stylized story of lending between banks.

This second bank will be referred to as Bank *C*. It is potentially the "counterparty" to Bank *B*. If Bank *B* decides against investing in the risky mortgages, then Bank *C* can only invest in safe assets that generate a net return of zero. In contrast, we will assume that there are two options for Bank *C*'s deposits in period 0 if Bank *B* does invest in the risky mortgages. Bank *C* has the opportunity to act as the counterparty for Bank *B*. Bank *C* has deposits of magnitude $D = F$, which Bank *C* can invest in safe assets of magnitude which earn a return of zero, or they can lend them to Bank *B*. Bank

B is willing to promise to pay $F + \gamma > F$ for these borrowings in period 2. If Bank C lends to Bank B, then Bank C is a junior creditor to Bank B's depositors, but is a senior creditor to Bank B's shareholders.

If Bank B only invests in the safe assets that have expected net present value of zero when they mature in period 2, then Bank B has equity capital in the form of cash of $N + \beta + \gamma$, where N, β, and γ are strictly positive. (The assumption that the firm has equity capital of N is not necessary to obtain the risk shifting result. Instead, all that is necessary is that Bank B has available liquid assets to make its investment in the bad loan, because it will be unable to profitably convince new investors to fund it.) Further, let us assume that equity capital is less than total deposits

$$N + \beta + \gamma < D. \tag{2}$$

Bank C has equity normalized to be worth 0 at the beginning of period 0 in the base case where it does not grant credit to Bank B. Banks B has access to a risk-free, positive net present value loan in period 1, which we will call the "good loan." This loan has a present value of π. This loan is extended by Bank B in period 1c, and it will receive the proceeds in period 2a. The net present value of the social benefits from extending the good loan, which do not accrue to the lender, are $\Pi > 0$. The magnitude of the good loan is the size of the cash reserve, N.

Bank B does not have to take on the good loan. Instead, it can take on a speculative, bad loan. The timing of this second lending opportunity is the same as the first. It is assumed that these are mutually exclusive investment opportunities. Bank B can only take on either the good loan or the bad loan. This second type of loan, the bad loan, is negative net present value of a magnitude of $-\lambda < 0$. Suppose the bad loan costs N, and has expected value of $N - \lambda > 0$ where $\lambda > 0$. This loan is perfectly positively correlated with the mortgages securities' returns. In the high demand state, the project returns $N + \sigma - \lambda > N$. In the low demand state, the bad loan returns a positive amount, which less than the principal, $N - \sigma/\phi - \lambda$, where $N > N - \sigma/\phi - \lambda > 0$. The present value of these returns is

$$p(N + \sigma - \lambda) + (1 - p)(N - \sigma / \phi - \lambda) = N - \lambda < N, \tag{3}$$

where

$$\phi \equiv \frac{1 - p}{p} > 0. \tag{4}$$

This loan's net present value is $-\lambda < 0$, and the net present value of social benefits from the bad loan that do not accrue to the lender are normalized to zero. Therefore, the difference in aggregate social benefits from the bad loan and the good loan is $\pi + \Pi + \lambda > 0$.

If Bank B fails to pay back Bank C, it is assumed that there is an exogenous social cost of $-K > 0$. Further, let us assume that the high state net returns for the negative NPV loan exceed the net returns for the positive net present value loan. That is,

$$\sigma - \lambda > \pi. \tag{5}$$

Both Bank *B* and Bank *C* maximize expected returns to shareholders. If either bank defaults on a loan commitment or fails to pay back depositors, their shareholders will be wiped out. Both banks' shareholders have limited liability.

The government is assumed to maximize *ex post* social returns in period 1b. We assume that the government will provide capital to Bank *B* in period 1b if this strictly increases *ex post* social surplus. The government is assumed to have the power to regulate the payment of dividends, share buybacks, or cash acquisitions for any bank accepting government funds. Thus, we will assume that any leverage decreasing capital infusion cannot be undone by capital structure adjustments by the recipient bank. Any expected losses to the government from the capital infusion, which may take the form of a direct or indirect subsidy, leads to deadweight losses from taxation. These losses are proportional to the size of any subsidy. That is, the losses from a subsidy are $\tau|S|, S$, where $S \in (-\infty, \infty)$ and $1 > \tau > 0$. Therefore, all other things being equal, the regulator strictly prefers to offer a subsidy of zero. It seems reasonable that the deadweight losses of any subsidy are substantial, but far less than unity. Ballard *et al.* (1985) estimates that the deadweight losses from taxation are between 13 and 24 percent of every dollar of government revenue. In contrast, Goolsbee (1998) estimates that the deadweight cost of the corporate income tax are between 5 to 10 percent of every dollar raised.

3. Analysis

We will solve this model by backwards induction. Bank *B* is the last player to move in this game in period 1c. Therefore, we will solve Bank *B*'s problem in period 1c.

Next we will solve the government's problem in period 1b. After that, we will solve the Bank *C*'s decision in period 0 to act as a counterparty to Bank *B*, and Bank *B*'s decision to buy speculative mortgage securities.

3.1 Bank *B*'s Problem in Period 1c, Given There Is No Government Intervention

In this subsection, we explore Bank *B*'s decision to underwrite the good loan, the bad loan, or take on no loan at all if there is no government intervention under various potential scenarios. If Bank *B* takes on no loan or the bad loan instead of the good loan, then this will serve as a rationale for government intervention in period 1b to prevent this inefficient lending.

Because $M = 2D = F + D$, and $N > \lambda + \sigma/\phi$ it must be the case that

$$M + N - D - F - \lambda - \sigma / \phi > 0. \tag{6}$$

Further, since $M = M_{LH} = M_{HL}$ according to equation (1), this means that equation (6) is useful for signing a wide variety of realizations of the value of the mortgage assets.

Let us make the following assumption:

$$M_{LL} + N - D - F + \pi < 0 \tag{7}$$

That is, the bank is insolvent with two low demand realizations even with the increase in present value, π, which comes from taking on the good loan.

3.1.1 Bank *B*'s Problem When It Did Not Buy Mortgage Securities in Period 0

When Bank *B* only invested in safe securities in period 0, it would be solvent in both states of the world if it makes the safe loan in period 1. Let us denote the aggregate value of equity after the good loan is undertaken by E_F^+, where the superscript "+" denotes the fact that the good loan has been undertaken and the subscript "*F*" denotes that Bank *B* has chosen risk-free investment for its deposits in period 0.

$$\begin{aligned} E_F^+ &= p\max(N+\beta+\gamma+\pi,\, 0)+(1-p)\max(N+\beta+\gamma+\pi,\, 0) \\ E_F^+ &= N+\beta+\gamma+\pi \end{aligned} \tag{8}$$

It is clear that the value of the old shareholders' claims have risen from $N + \beta + \gamma$ to $N + \beta + \gamma + \pi$.

Alternatively, the value of the troubled bank given that it undertakes the bad loan under these circumstances is the following, where the superscript "-" denotes that the bad loan has been chosen:

$$E_F^- = p\max(N+\beta+\gamma+\sigma-\lambda, 0)+(1-p)\max(N+\beta+\gamma-\sigma/\phi-\lambda, 0) \tag{9}$$

Since $N - \sigma/\phi - \lambda > 0$, the firm is solvent, regardless of the bad loan's returns.

$$E_F^- = N+\beta+\gamma-\lambda \tag{10}$$

The value of Bank *B*'s equity with the good loan in equation (8) exceeds its equity value with the bad loan in equation (10) by $\pi + \lambda > 0$. Therefore, we can conclude that the best response of Bank *B* in period 1c is to accept the good loan and reject the bad loan in this case.

3.1.2 Bank *B*'s Problem in Period 1c When Subsequent Mortgage Returns Were High

The equity in Bank *B* is denoted by *E*. The subscript of *E* denotes the outcome of the history of Bernoulli random trials, which affect the value of the mortgage securities. Let us denote the fact that Bank *B* has taken on the good loan by the superscript "+". The subscript "*H*" denotes that the period 1 mortgage returns were high.

When the period 1 mortgage returns are high, the bank has no risk of default if it takes on the good loan. We know this because equation (6) is positive. That is, even if subsequent mortgage returns are low, Bank *B* is solvent and Bank *C* is paid back in full. The value of the equity of Bank *B* in period 1c, given that both its period 1 mortgage returns are high and that it takes on the good loan, is the following:

$$\begin{aligned} E_H^+ &= p\max(M_{HH} + N - D - F + \pi, 0) + (1-p)\max(M_{HL} + N - D - F + \pi, 0) \\ E_H^+ &= M_H + N - D - F + \pi > 0 \end{aligned} \tag{11}$$

Supposes that Bank *B* considers the "bad loan." If it takes on the bad loan, the value of Bank *B*'s equity is the following:

$$E_H^- = p\max(M_{HH} + N - D - F + \sigma - \lambda, 0) + (1-p)\max(M_{HL} + N - D - F - \sigma/\phi - \lambda, 0) \quad (12)$$

The value of equity is positive in the high and low demand state. We know that $\sigma - \lambda > 0 > -\lambda - \sigma/\phi$. Further, from equation (1) we know that $M_{HH} > M_{HL}$. Therefore, comparing the high period 2 mortgage equity returns to equation (6), it must be the case that $M_{HH} + N - D - F + \sigma - \lambda > M_{HL} + N - D - F - \lambda - \sigma/\phi > 0$. The low state returns are also positive according to inequality in equation (6).

Therefore, the value of the bank's equity when both the period one mortgage returns are positive and it takes on the bad loan in period 1c, is the following:

$$E_H^- = M_H + N - D - F - \lambda \quad (13)$$

Comparing equations (11) and (13), it is clear that the value of Bank *B*'s equity is higher if it takes on the good loan versus the bad loan. That is because, $E_H^+ - E_H^- = \pi + \lambda > 0$.

3.1.3 Bank *B*'s Problem in Period 1c When Subsequent Mortgage Returns Were Low

Here we look at the bank's lending decision in period 1c given the mortgages had low returns in period 1a. The subscript "*L*" denotes that the period 1 mortgage returns were low.

$$E_L^+ = p\max(M_{LH} + N - F - D + \pi, 0) + (1-p)\max(M_{LL} + N - F - D + \pi, 0)$$

We know that $E_L^+ = p(M_{LH} + N - F - D + \pi)$ because $M_{LH} + N - F - D + \pi >$ $M_{LH} + N - F - D - \lambda - \sigma/\phi > 0$, but $M_{LL} + N - F - D + \pi < 0$. Therefore, the value of the bank is raised by the good loan, but the debts of Bank *B* are still risky.

The value of the new and old equity with the negative net present loan is denoted by the superscript "-".

$$\begin{aligned} E_L^- &= p\max(M_{LH} + N + \sigma - F - D - \lambda, 0) \\ &+ (1-p)\max(M_{LL} + N - \sigma/\phi - F - D - \lambda, 0) \end{aligned} \tag{14}$$

Since $\sigma - \lambda > \pi$ and $M_{LH} + N - F - D + \pi > 0$, but $M_{LL} + N - F - D + \pi < 0$. This implies that the bank's equity is higher from taking on the speculative loan than from taking on the positive NPV loan. That is,

$$E_L^- = p(M_{LH} + N + \sigma - F - D - \lambda) > E_L^+ = p(M_{LH} + N - F - D + \pi) \tag{15}$$

Since both the good and bad loans are mutually exclusive and $\sigma - \lambda > \pi$, the bad loan will be the loan funded.

Proposition 1
If the period 1 returns to Bank B's mortgage portfolio are low, Bank B will accept the bad loan and reject the good loan.

3.2 Regulatory Remedies

3.2.1 Government's Problem in Period 1b If Bank *B* Does Not Buy Speculative Mortgages or Period 1 Mortgage Returns Are High

When Bank *B* is solvent in all states of the world in period 2, then the government has no incentive to provide a bailout. Therefore, if either Bank *B* invested in safe assets in period 0 or it bought speculative mortgages in period 0, but initial returns on those mortgages were good; then, in this case, social welfare is strictly decreasing in the amount of the subsidy that they provide to Bank *B*. For every dollar that the subsidy is increased, social welfare falls by τ, the marginal deadweight loss from taxation. Therefore, the best response of the government in both these scenarios is to provide a subsidy of zero.

3.2.2 Government's Problem in Period 1b If Period 1 Mortgage Returns Were Low

Let us consider a variety of remedies that a regulator can implement in period 1 that can improve the *ex post* lending of the troubled bank. These remedies will also potentially decrease the deposit insurance liability and reduce the counterparty risk that could hurt the healthy bank.

When period 1 mortgage returns are low without government intervention, then the bank will take on the bad loan and forgo the good loan. In this case, the benefits to the government in period 1 are the social gains from the good loan's being undertaken, $\pi + \Pi$, minus the NPV of the bad loan, λ, minus the expected social costs of Bank C's becoming insolvent, $K(1 - p)$. These benefits, $\pi + \Pi + \lambda + K(1 - p)$, must be weighed against the costs of the deadweight losses from taxation by the subsidy τS. As long as $(\pi + \Pi + \lambda) + K(1 - p) > \tau S$, the government's *ex post* best response will be to bail out Bank B directly, and to bail out its creditor Bank C indirectly. This is similar to the regulator's problem in Frexias (1999). In that model, the regulator supports bailout when the social cost of the bank's insolvency is too high. Unlike, that paper and the existing literature on bank bailouts, this paper specifically analyses the effectiveness of the types of capital infusions used to bail out the problem bank.

3.2.2.1 Buying Toxic Mortgages

The regulator can buy the troubled mortgages at a price $M_L + S_M \equiv \bar{M}$. $S_M \geq 0$ represents the amount above the fair market value that the regulator pays for the mortgage securities. We will see that some such subsidy is often necessary to either induce the bank to lend efficiently or voluntarily participate in the recapitalization or both.

When the regulator buys the risky mortgages, the troubled bank goes from having a risky asset to a safe asset worth $\bar{M}$ in both the high asset value state and the low asset value state. The bad bank will take on the good loan and forgo the risk shifting loan if the expected equity value after the bailout is higher with the good loan than with the bad loan. The value of the bad bank's equity with the good loan and the mortgage bailout is $E_L^{M+} \equiv \bar{M} + N - F - D + \pi$. The bank will only consider taking on the negative net present value loan if its equity is wiped out in the low demand state. That is the case when $M_L + S_M + N - F - D - \sigma / \phi - \lambda < 0$. Given that the bad loan is profitable to the bank's shareholders, then the value of equity with the bad loan is $E_L^{M-} \equiv$ $p(\bar{M} + N - F - D + \sigma - \lambda)$. The good project will be undertaken when $E_L^{M+} \geq E_L^{M-}$.

Lending will be efficient with the mortgage recapitalization if and only if the efficient lending constraint (EL_M) in equation (16) is satisfied.

$$(EL_M) \qquad S_M \geq \frac{1}{\phi}(\sigma - \lambda - \pi) - (M_L + N - F - D + \pi) \equiv \tilde{S}_M \gtreqless 0 \tag{16}$$

The first term in parenthesis on the right-hand side (RHS) is positive because $\sigma - \lambda - \pi > 0$. Yet, the sign of $M_L + N - F - D + \pi$ is ambiguous. The overall sign is ambiguous. Therefore, it is conceivable, for some parameter values, that the inequality in equation (16) is satisfied if the subsidy, S_M, was zero. Therefore, an *ex post* subsidy to troubled banks is not always necessarily to induce efficient lending. If the bank swaps the risky mortgages for a safe asset, then some of the gains from the swap will be realized by the bank's creditors. If Bank *B*'s creditors' gains are not too large, then no subsidy will be needed.

The bank will only sell the toxic mortgages if the value of its shareholders' claims is higher from selling the toxic mortgages and taking on the good loan than keeping the toxic mortgages and taking on the bad loan. That is, for the bad bank to voluntarily sell its toxic mortgages and reduce its risk $E_L^{M+} - E_L^- \geq 0$. Yet, this is not possible unless the subsidy (overpayment) for the mortgages is sufficiently large. Given that the bank takes on the safe loan,

$$E_L^{M+} - E_L^- = (M_L + S_M + N - D - F + \pi) - p(M_{LH} + N - D - F + \sigma - \lambda) \geq 0 \quad (17)$$

This can only be the case if the subsidy is positive. If we rearrange equation (17) and use the inequalities in (5) and (7) to sign the RHS of the inequality below, we can conclude that the subsidy must be strictly positive for the bad bank to volunteer to sell the toxic mortgages. We will denote this as the voluntary participation constraint for the mortgage swap program (VP_M). This constraint says that $S_M \geq \hat{S}_M$, the latter of which is defined below:

$$(VP_M) \quad S_M \geq -(1-p)(M_{LL} + N - D - F + \pi) + p(\sigma - \lambda - \pi) \equiv \hat{S}_M > 0 \quad (18)$$

It is useful to consider whether the EL_M or VP_M constraint binds. The binding constraint determines the minimum subsidy necessary to achieve both efficient lending and voluntary participation. It may not always be the case that the troubled bank's shareholders have to voluntarily participate. Regulators can threaten banks with rescinded charters, less access to the Fed's lending facilities, *et cetra*, unless they participate in the recapitalization program. Nevertheless, regulators may not always take such a tough line. Mailath and Mester (1994) argue that regulators' discretion in pulling bank charters leads to sub-optimal lending decisions by banks. It seems reasonable that the threat to take away the charter or limit access to lending facilities may not be credible, especially for banks deemed "too-big-to-fail." Alternatively, Armstrong *et al.* (1994, p. 92) argues that regulators may be more interested in currying favor with the regulated executives if these public servants envision entering or reentering the banking sector. If voluntary participation is necessary, then both the EL_M and VP_M constraints must be satisfied. In particular, $\max\{\tilde{S}_M, \hat{S}_M\}$ will give us the minimum subsidy such that both constraints are satisfied. The difference between $\hat{S}_M - \tilde{S}_M$ is the following sum:

$$\hat{S}_M - \tilde{S}_M = p\left\{[M_{LH} + N - F - D + \pi - \sigma / \phi] + \frac{1}{\phi}(\lambda + \pi)\right\} > 0 \qquad (19)$$

We know that term on the RHS in square brackets is positive from equation (6). The remaining terms are also clearly positive. Therefore, we know that satisfaction of the voluntary participation constraint means that the efficient lending constraint is slack.

3.2.2.2 Preferred Stock Infusion

Suppose that the government decides to buy preferred stock in the troubled bank. Nevertheless, the government weakly overpays in the sense that the preferred dividends promised to the government are less than or equal to the present value of what the government paid for the shares. Let us denote the amount paid for the preferred dividends as $\overline{R} \equiv R + S_R > 0$. Further, the present value of the preferred dividends is *R*, where $R \in [0, \bar{R}]$. $S_R \in [0, \bar{R} - R]$ represents the subsidy that the government is giving the troubled bank by accepting weakly less than the full present value of what they paid for the preferred stock as future dividends.

With the preferred stock infusion, the present value of the bad bank, given that it takes on the good loan, is the following:

$$\begin{aligned} E_L^{R+} &= p(M_{LH} + S_R + N - D - F + \pi) \\ &+(1-p)\max\{(M_{LL} + S_R + N - D - F + \pi), 0\} \end{aligned} \tag{20}$$

The value of the equity, given that the bank takes on the bad loan, is the following:

$$\begin{aligned} E_L^{R-} &= p(M_{LH} + S_R + N - D - F + \sigma - \lambda) \\ &+(1-p)\max\{(M_{LL} + S_R + N - D - F - \sigma/\phi - \lambda), 0\} \end{aligned} \tag{21}$$

If the bank's equity is wiped out in the low demand state with the good loan, then the risk shifting loan will be preferred by the bank's shareholders because $\sigma - \lambda > \pi$. Further, if the bank's shareholders are not wiped out in the low demand state with the bad loan, then they will definitely prefer the positive net present value loan. This is the case when $M_{LL} + S_M + N - D - F - \sigma/\phi - \lambda > 0$. The shareholders in the troubled bank will only be indifferent to the two loans when their shares have a positive value in both states of the world with the good loan, and their shares are wiped out in the bad state of the world with the bad loan.

Lending is efficient with preferred stock infusions if and only if the subsidy is sufficiently large and the efficient lending constraint (EL_R) below is satisfied:

$$(EL_R) \qquad S_R \geq \frac{1}{\phi}(\sigma - \lambda - \pi) - (M_{LL} + N - F - D + \pi) \equiv \tilde{S}_R > 0 \qquad (22)$$

The first term in parentheses on the right hand side (RHS) is positive because $\sigma - \lambda - \pi >$ 0. The second term in parenthesis on the RHS is negative because $M_{LL} + N - F - D + N + \pi < 0$. This implies that the subsidy must be strictly positive to be effective in inducing efficient lending.

The troubled bank will only voluntarily accept a preferred stock infusion that leads to efficient lending if $E_L^{R+} - E_L^{-} \geq 0$.

$$\begin{aligned} E_L^{R+} - E_L^{-} &= (M_L + S_R + N - D - F + \pi) \\ &- p(M_{LH} + N + \sigma - F - D - \lambda) \geq 0 \end{aligned} \qquad (23)$$

This relationship can be rearranged to show that the subsidy for preferred stock is strictly positive.

$$(VP_R) \quad S_R \geq -(1-p)(M_{LL} + N - F - D + \pi) + p(\sigma - \lambda - \pi) \equiv \hat{S}_R > 0 \qquad (24)$$

To find out which constraint must bind for both constraints to be satisfied, we will subtract $\hat{S}_R - \tilde{S}_R$ from equations (24) and (22) below:

$$\hat{S}_R - \tilde{S}_R = -p\left[\frac{1}{\phi}(\sigma - \lambda - \pi) - (M_{LL} + N - F - D + \pi)\right] < 0 \tag{25}$$

This implies that $\tilde{S}_R > \hat{S}_R$; thus, the binding constraint is the efficient lending constraint (EL_R), and the slack and satisfied constraint is the voluntary participation constraint (VP_R). Therefore, as long the subsidy is large enough to make lending efficient, the troubled bank's shareholders will want to participate in the program.

3.2.2.3 Common Stock Infusion

Suppose the regulator buys a common equity stake in the troubled bank equal to $\overline{E} \equiv E + S_E$, where E is the market value of the equity stake and $S_E \geq 0$ is the subsidy that taxpayers are giving to the troubled bank's shareholders. The value of the equity in the troubled bank if it takes on the good loan is as follows:

$$\begin{aligned} E_L^{E+} &= p(M_{LH} + N + E + S_E - D - F + \pi) \\ &+ (1-p)\max\{(M_{LL} + N + E + S_E - D - F + \pi), 0\} \end{aligned} \tag{26}$$

Alternatively, if the firm takes on the bad loan after the equity infusion, then the value of equity in the troubled bank will be the following:

$$\begin{aligned} E_L^{E-} &= p(M_{LH} + N + E + S_E - D - F + \sigma - \lambda) \\ &+ (1-p)\max\{(M_{LL} + N + E + S_E - D - F - \sigma/\phi - \lambda), 0\} \end{aligned} \tag{27}$$

Shareholders will only be indifferent between the two investment policies after the equity infusion if $E_L^{E+} = E_L^{E-}$. Indifference between the good and bad loans only occurs if the firm both defaults with the bad loan and the firm is also always solvent with the good loan. Equation (28) below rewrites the inequality $E_L^{E+} - E_L^{E-} \geq 0,$ where both $M_{LL} + N + E + S_E - D - F + \pi > 0,$ and $M_{LL} + N + E + S_E - D - F - \sigma / \phi - \lambda \leq 0.$

If the government buys common equity for a price $\bar{E} \equiv S_E + E,$ lending will be efficient if and only if the efficient lending constraint below (EL_E) is satisfied.

$$(EL_E) \qquad S_E \geq \frac{1}{\phi}(\sigma - \lambda - \pi) - (M_{LL} + N - D - F + \pi) - E \equiv \tilde{S}_E \tag{28}$$

Unlike the case with preferred stock, there is no need for the government to subsidize the common equity infusion to make lending efficient once more. The efficient lending subsidy is positive for some parameter values when the government buys the speculative mortgages. In contrast to that recapitalization, the efficient lending subsidy for buying common equity can be zero for *all* parameter values.

The subsidy required for efficient lending is zero when the equity stake bought by the government must meet or exceed, $\tilde{E},$ which is defined below:

$$E \geq \tilde{E} \equiv \frac{1}{\phi}(\sigma - \lambda - \pi) - (M_{LL} - D - F + \pi) > 0 \tag{29}$$

Let us define $\tilde{S}_E^*$ to be the government's strictly preferred subsidy if the EL_E is the only constraint the government must satisfy. The government strictly prefers to minimize the absolute value of the subsidy because of the deadweight loss of taxation. (A negative subsidy on Bank *B* is a tax which is also associated with deadweight losses!) Therefore, $\tilde{S}_E(\tilde{E}) \equiv \tilde{S}_E^* = 0$ is the strictly preferred subsidy and the government will want to buy an equity stake worth at least $\tilde{E}$.

Let us turn to the question of what subsidy is needed for Bank *B* to volunteer for the government's funds. The bank's old shareholders will only voluntarily take on the new equity if it raises the value of their stake. Without the equity infusion, the value of their stake is $E_L^- = p(M_{LH} + N - F - D + \sigma - \lambda)$. With the equity infusion that leads to efficient lending, the value of the old shareholder's stake is $E_L^{E+} - E =$ $p(M_{LH} + S_E + N - D - F + \pi) + (1-p)(M_{LL} + S_E + N - D - F + \pi)$. The bank's shareholders will volunteer for the equity infusion if $(E_L^{E+} - E) - E_L^- \geq 0$. This relationship can be rearranged to be the following voluntary participation constraint (VP_E):

$$(VP_E) \qquad S_E \geq p(\sigma - \lambda - \pi) - (1-p)(M_{LL} + N - D - F + \pi) \equiv \hat{S}_E > 0. \qquad (30)$$

Thus, the bank's existing shareholders will only agree to the equity infusion if they are given a positive subsidy. If regulators could force banks to recapitalize, then no subsidy would be needed to induce efficient lending. Yet, if they want banks to volunteer for the equity recapitalizations, the subsidy must meet or exceed the right-hand-side (RHS) of equation (30).

To see which constraint between the efficient lending and voluntary participation constraint is sufficient to ensure the bank both lends efficiently and voluntarily participates in the equity recapitalization, let us compare $\hat{S}_E - \tilde{S}_E$:

$$\hat{S}_E - \tilde{S}_E = E - p\left[\frac{1}{\phi}(\sigma - \lambda - \pi) - (M_{LL} - F - D + \pi)\right] \gtreqless 0 \qquad (31)$$

The sign of the equation is ambiguous. Without knowing the relative magnitudes of *E* and the quantity in square brackets (which has only positive terms inside those brackets), we cannot determine which constraint produces the bigger subsidy. Nevertheless, *E* is a choice variable of the regulator. If the regulator is acting in the public interest he or she will want to minimize the subsidy because it creates *ex ante* incentive problems for the bank in period 0. In addition, the regulator will want to minimize the subsidy because it leads to deadweight losses from taxation of magnitude τS_E. Therefore, if equation (31) has a negative sign, the regulator will want to increase the equity stake that it buys until $\hat{S}_E - \tilde{S}_E \geq 0$. This is because increasing *E* reduces the efficient lending (EL_E) subsidy $\tilde{S}_E$, but it does not affect the voluntary participation constraint.

Let us define a minimum best response level of common equity, $\hat{E}$, bought by the regulator such that the voluntary participation constraint binds and the subsidy is minimized. From equation (31) this minimum common equity purchased is the following:

$$E \geq \hat{E} \equiv p\left[\frac{1}{\phi}(\sigma - \lambda - \pi) - (M_{LL} - F - D + \pi)\right] > 0 \qquad (32)$$

If Bank *B* can be forced to participate, then $\tilde{S}_E(\tilde{E}) \equiv \tilde{S}_E^* = 0$ when an equity stake at least as large as $\tilde{E}$ in equation (29) is taken in Bank *B*.

3.2.2.4 Comparing the Costs

The voluntary participation constraint is identical across all the different securities used to recapitalize the troubled bank. If we compare equations (18), (24), and (30) to each other, the following relationships emerge in equation (33) and proposition 2.

Proposition 2
The minimum subsidies for which the troubled bank's participation constraints are satisfied are identical whether or not the government buys toxic mortgages, preferred stock, or common stock in that bank.

$$\hat{S}_M = \hat{S}_R = \hat{S}_E \qquad (33)$$

The other major relationship that emerges is that the minimum efficient lending subsidy is different for each of the different securities used to recapitalize Bank *B*. The minimum efficient lending subsidy is given by equations (16), (22), and (28). We know $\tilde{S}_R > \tilde{S}_M$ because when we compare (22) to (16), the following inequality is obtained:

$$\tilde{S}_R - \tilde{S}_M = p(M_{LH} - M_{LL}) > 0 \tag{34}$$

Further from equation (16) we know that $\tilde{S}_R > 0$, which is clearly higher than the government's most preferred subsidy with common stock when the efficient lending is the only relevant constraint, $\tilde{S}_E^* = 0$.

$$\begin{aligned} \tilde{S}_R &> \tilde{S}_M \\ \tilde{S}_R &> \tilde{S}_E^* = 0 \end{aligned} \tag{35}$$

Proposition 3
Regardless of whether voluntary participation is necessary or not, preferred stock recapitalizations are strictly dominated by both common stock recapitalizations and the regulator's buying toxic mortgages.

This follows from equations (35) and (33). The participation constraints for all types of recapitalizations are identical according to equation (33). Yet, the efficient lending constraint for preferred stock is less than both the efficient lending constraint for common equity and the purchases of toxic mortgages according to equation (35). *Q.E.D.*

Proposition 4
If banks must voluntarily participate in the program, then

a. *The regulator acting in the public interest will weakly prefer the strategy of buying a common equity stake such that satisfaction of the voluntary participation constraint implies satisfaction of the efficient lending constraint. This common equity stake will be* $E \in [\hat{E}, +\infty)$*, and the regulator will pay as subsidy* $\hat{S}_E$.
b. *The regulator will only be indifferent to buying toxic mortgages as opposed to buying common equity if the efficient lending constraint for mortgage repurchases is slack or satisfied when the voluntary participation constraint binds.*

Proposition 4 follows from equations (33) and (35). The minimum equilibrium stakes of common equity are (32), if the bank must volunteer for the recapitalization. First, there is no difference between the three types of recapitalizations (buying mortgages, buying preferred stock, or buying common stock) in terms of the voluntary participation constraint, according to equation (33). Yet, there is a big difference between the three alternatives in terms of the efficient lending constraint, according to equation (35). First, if the efficient lending subsidy is higher than the voluntary participation subsidy for buying toxic mortgages, then this form or recapitalization will be strictly dominated by a common equity infusion.

Second, if the voluntary participation by the troubled bank is necessary, the regulator can, under all parameter values, weakly minimize the subsidy by a common equity infusion. This is because the voluntary participation constraint is the same for all recapitalizations for a given set of parameter values, according to equation (33). The efficient lending subsidy for common stock can be zero for all parameter values. Thus, the efficient lending constraint is never the binding constraint for common equity. Yet, for some parameter values, the efficient lending constraint is the binding constraint for toxic mortgage sales. In such cases, the regulator will always strictly prefer common equity recapitalizations over mortgage repurchases and preferred stock infusions. Otherwise, the government will weakly prefer common equity recapitalizations. This supports both parts a and b of proposition 4. *Q.E.D.*

For example, under some parameter values when M_{LH} is high enough, then the regulator will be indifferent between buying up toxic mortgages and buying common equity stakes. The intuition for this is that when the mortgages go through wild swings in value, then the bank's lending can be much improved by taking those very risky assets off Bank *B*'s balance sheet. The regulator will be indifferent to common equity infusions and direct purchases of troubled mortgages from Bank *B* when $\max\{\tilde{S}_M, \hat{S}_M\} = \hat{S}_M = \hat{S}_E$. Yet, we know from proposition 4b that the subsidy will be strictly less with a common equity bailout if the alternative (buying up mortgages) means that the efficient lending constraint binds.

In practice, the government probably will not be indifferent to these strategies even if they lead to the same minimum subsidy for some parameter values. It is much harder to arrive at a fair market value of the toxic mortgages, relative to the banks publicly traded common equity. Therefore, it seems that, in fact, not only is the subsidy weakly lower with common equity versus buying toxic mortgages, but common equity is much easier for the regulators to value.

The most expensive subsidy comes from infusions of preferred stock. In this case the efficient lending constraint is more important than the voluntary participation constraint. That is, $\max\{\hat{S}_R, \tilde{S}_R\} = \tilde{S}_R > \hat{S}_E$. We know this from equation (25). The intuition for this result is that the preferred stock gives the troubled bank similar incentives to debt, because preferred shareholders' claims are senior to common equity. Adding more senior claims to common equity increases the incentives to engage in risk shifting. Further, preferred stock does not reduce the variability of the banks returns, as would purchasing the troubled mortgage assets. Yet, it is easier to determine the fair market value of preferred stock than mortgage securities (but not common equity). Unfortunately, the subsidy with preferred stock is the sole means of increasing the equity value of the troubled bank and reducing the risk of equity returns. Therefore, the preferred stock infusion, if it is to fix lending incentives, must have the largest subsidy of the three types of recapitalizations, and it is a clearly dominated strategy for all parameter values.

3.3 Bank *B*'s Investment Decision in Period 0

Suppose that the government cannot force Bank *B* to participate in the common equity recapitalization. Bank *B* will be bailed out by the government in period 1b when both its period 1a mortgage returns are low and the lowest cost subsidy is less than the marginal costs of not providing the subsidy. That is,

$$\tau \hat{S}_E < \pi + \Pi + (1-p)K + \lambda, \tag{36}$$

then the government will bail out Bank *B* in period one (1 – *p*)*100 percent of the time. Therefore, the present value of Bank *B*'s mortgage investment including the expected subsidy is $M + (1-p)\hat{S}_E$. Given that the bank paid $M + \beta + \gamma$ to buy these assets, it only makes sense for Bank *B* to choose the toxic mortgages over the safe assets if the expected subsidy strictly exceeds the overpayment for these assets $(1-p)\hat{S}_E > \beta + \gamma$. If this inequality is satisfied, Bank *B* will choose to buy the toxic mortgages, and Bank *C* will agree to be its counterparty. If bailouts always occur when there is a low mortgage return in period 1a, Bank *C* can earn a guaranteed profit of γ by lending to Bank *B*.

Proposition 5

If Bank B must voluntarily participate in any bailout, then the subgame perfect Nash equilibrium (SPE) is one of the following, depending on the magnitude of the parameter values:

a. *If both* $(1-p)\hat{S}_E > \beta + \gamma$ *and* $\pi + \Pi + \lambda + K(1-p) > \tau\hat{S}_E$, *then Bank B will borrow from Bank C to buy toxic mortgages. Bank B will be bailed out with common equity if mortgage returns are low worth* $E \in [\hat{E}, +\infty)$ *and receive a subsidy* $\hat{S}_E$. *Regardless of the mortgage returns in period 1, Bank B will undertake the good loan in period 1c, and Bank C will be paid back with certainty.*
b. *If either* $(1-p)\hat{S}_E \leq \beta + \gamma$ *or* $\pi + \Pi + \lambda + K(1-p) \leq \tau\hat{S}_E$, *then Bank B will invest in safe assets, and there will be no bailout.*

Social welfare under these scenarios in proposition 5 is very different. *Ex ante*, period 0 social welfare in scenario *a* is $\pi + \Pi - \beta - \tau(1-p)\hat{S}_E$. This is clearly less than social welfare under scenario *b*, $\pi + \Pi$. Clearly, social welfare would be better off if the government could commit to not bail out Bank *B* when the bank must voluntarily participate.

If the government could force the bank to participate in the bailout, then there is no conflict between *ex post* and *ex ante* welfare maximization for the government. According to proposition 6, the government can buy an equity stake in the troubled bank large enough so that no subsidy is necessary to induce efficient lending.

Proposition 6

If voluntary participation in the bailout is not necessary, then the subgame perfect Nash equilibrium (SPE) is that Bank B will buy safe assets and there will be no bailout, regardless of the parameter values.

We know that the subsidy required to bail out the troubled bank is weakly the smallest when common equity is used and the troubled bank's voluntary participation constraint can be ignored, according to equation (35).

Suppose that Bank *B* did buy mortgage securities in period 0. Further, suppose that period 1a returns were low. (We know from proposition 1 that this is the only scenario in which there could be a bailout.) The government could push the subsidy to zero in period 1b. In this scenario, the government will weakly prefer to buy equity $E \in [\tilde{E}, +\infty)$. Thus the subsidy will be zero in all possible states of the world if Bank *B* buys mortgages. Bank *B*'s shareholders must sacrifice $\beta + \gamma > 0$ to underwrite mortgage securities. The cost $\beta + \gamma$ exceeds the benefit, which is the expected subsidy of zero. Therefore, Bank *B* will purchase risk-free assets, and there will be no bailout in equilibrium. *Q.E.D.*

4. Numerical Examples

In this section we will explore a couple of numerical examples. In the first, example the mortgage portfolio does not fluctuate much in value, and Bank *B* will choose to buy safe securities instead of the mortgages because the expected subsidy is too small. Social welfare is the highest in the first example. In the second example, Bank *B* invests in the toxic mortgages, and there is a bailout in equilibrium. The relative magnitude of the minimum subsidy necessary for voluntary participation in this second example is 14.2 percent of period 1a assets if the recapitalization involves common equity. If the recapitalization involves preferred stock in the second example, the minimum subsidy necessary is worth 36.3 percent of period 1a assets. Thus, from these examples, it seems unlikely that regulators will be willing to give enough of a subsidy to troubled banks to lead to efficient lending if they insist on using preferred stock.

Suppose that the following parameter values describe the game.

$$
\begin{aligned}
&\beta = \$46 \\
&\gamma = \$4 \\
&N = \$100 \\
&\tau = 0.1 \\
&K = \$40 \\
&\pi = \$5 \\
&\Pi = \$20 \\
&N = \$100 \\
&D = F = \$500
\end{aligned} \tag{37}
$$

Example 1

Let us specify the probability of success and the evolution of the mortgage values.

$$
\begin{aligned}
&p = 0.4 \\
&\phi = 1.5 \\
&M_{LL} = \$888.\overline{8} \\
&M_{L} = \$933.\overline{3} \\
&M = M_{LH} = M_{HL} = \$1000 \\
&M_{H} = \$1100 \\
&M_{HH} = \$1250
\end{aligned} \tag{38}
$$

In this case, the speculative loan pays $N + \sigma - \lambda$ = \$150 in case of success and $N - \sigma/\phi - \lambda = \$58.\overline{3}$ if returns are low in period 2. Thus, the profits from the bad loan are \$50 in the case of success and $-\$58.\overline{3}$ when returns are low.

Suppose that voluntary participation is necessary for any government recapitalization. The cost of subsidizing the firm to participate in a common equity recapitalization or in a sale of toxic mortgages can be found by inserting the parameter values in equations (37) and (38) into equation (30) below:

$$\hat{S}_E = \hat{S}_M = \$21.\overline{6} \qquad (39)$$

If the government would be prepared to buy common stock worth at least

$$\hat{E} = \$54.\overline{4}, \qquad (40)$$

or about 5.3 percent of the bank's assets $(\hat{E} / [M_L + N] = \$54.\overline{4} / [\$933.\overline{3} + \$100])$, then the government could ensure that the voluntary participation constraint subsidy satisfies the efficient lending constraint. The government would actually be indifferent to buying common equity or toxic mortgages, given that both Bank *B* bought mortgages and period 1a returns were low. If we plug in the parameter values into the efficient lending constraint for buying toxic mortgages in equation (16), then the minimum efficient lending subsidy is $\tilde{S}_M = -\$8.\overline{3}$. Clearly, the efficient lending constraint is slack if the voluntary participation constraint binds. If the regulator buys mortgages, then it would pay the subsidy in (39), $\$21.\overline{6}$, plus their fair market value of $\$933.\overline{3}$ for a total of \$955.

While the subsidy amount is identical under a mortgage bailout and common equity recapitalization, the latter requires a far smaller initial outlay of capital. It seems clear, that $700 billion dollars will go a lot farther towards changing lending behavior to the better if common equity is bought instead of mortgage securities.

Preferred stock recapitalizations are clearly dominated by both mortgage and common equity bailouts. We can obtain the minimum efficient lending subsidy by inserting the parameter values into equation (22). The minimum efficient lending subsidy for preferred stock bailouts is clearly higher in this case (and for all parameter values). That is, $\tilde{S}_R = \$39.\overline{4} > \$21.\overline{6}$ in equation (39).

From the regulator's point of view, it only makes sense to bail out the bank if the expected gains from the subsidy exceeds its cost. If Bank *B* held toxic mortgages and the period 1a mortgage returns were low, then the benefits from bailing out the bank *ex post* would be $\pi + \Pi + \lambda + K(1 - p) = \$54$. The cost would be $\$2.1\overline{6}$. Clearly, the government finds it *ex post* efficient to bail out Bank *B* if that bank holds mortgages that have fallen in value in period 1a. That is, $\tau\tilde{S}_E = \$2.1\overline{6} < \pi + \Pi + \lambda + K(1 - p) = \$54$.

Yet, given that Bank *B* expects a subsidy of $\$21.\overline{6}$, it does not make sense for Bank *B* to buy toxic mortgages at all. The expected subsidy is $(1 - p)\hat{S}_E = \$13$. This must be weighed against the loss of shareholder value for overpaying for the mortgages and the price of renting Bank *C*'s deposits, $\beta + \gamma = \$50$. Therefore, the subgame perfect Nash equilibrium (SPE) for the parameter values in (37) and (38) is that Bank *B* will buy no mortgages, there will be no bailout, and both banks will invest in risk-free securities.

Social welfare will be the first-best, $\pi + \Pi = \$25$. Thus, this example has the subgame perfect Nash equilibrium described in proposition 5b.

Example 2

Suppose that that the mortgage portfolio has the following parameter values:

$$\begin{aligned} &p = 0.6 \\ &\phi = 0.\overline{6} \\ &M_{LL} = \$625 \\ &M_{L} = \$850 \\ &M = M_{LH} = M_{HL} = \$1000 \\ &M_{H} = \$1166.\overline{6} \\ &M_{HH} = \$1250 \end{aligned} \tag{41}$$

Inserting the parameters from equations (37) and (41) into equation (30) the minimum subsidy necessary for Bank *B* to voluntarily participate in the equity recapitalization is

$$\hat{S}_E = \hat{S}_M = \hat{S}_R = \$135. \tag{42}$$

The minimum equity stake that must be purchased by the government to ensure that both the voluntary participation and efficient lending constraints are satisfied is obtained by plugging in the parameters in (37) and (41) into equation (32). That stake is worth

$\hat{E} = \$262.5$ or about 27.6 percent of the period 1a assets, which are worth \$850 + \$100 = \$950.

The cost of the subsidy to the regulator is the deadweight loss of taxation associated with the subsidy in equation (42). The deadweight loss of taxation is \$13.5. The government will weigh this against the *ex post* benefits of the good loan, $\pi + \Pi$, minus the social losses associated with the bad loan, $-\lambda$, plus expected costs of a default on Bank *B*'s obligation to Bank C in period 2, $(1 - p)K$. In total, the *ex post* social benefits of the bailout of \$46 = $\pi + \Pi + \lambda + (1 - p)K$ exceed its cost $\tau\hat{S}_E = \$13.5$. Therefore, the regulator will bail out Bank *B* if that bank holds toxic mortgages that had low returns in period 1a.

Bank *B* will want to buy mortgages in period 0. The lost equity capital associated with buying the mortgages is $\beta + \gamma = \$50$. Yet, the expected subsidy is worth $(1 - \text{p})\hat{S}_E$ = \$54. \$54 > \$50; therefore, Bank *B* will buy the toxic mortgages. Bank *C's* profits from lending its deposits are $\gamma = \$2$. Thus Bank *C* will lend to Bank *B* in period 0. Therefore, the SPE for these parameter values conforms to proposition 5a. Social welfare is reduced by the expected subsidy and the deadweight losses from the mortgage securities. Social welfare is $\pi + \Pi - \beta - (1 - p)\hat{S}_E = -\$75$.

If the government tried to bail out the companies (out of equilibrium) with preferred stock, it would have to offer a subsidy of $\tilde{S}_R = \$345$ to lend efficiently. This is obtained by inserting the parameters in equations in (37) and (41) into equation (22). Thus, using preferred stock to bail out Bank *B* would cost 36.3 percent of Bank *B*'s period 1a assets. This is substantially more than the lowest cost subsidy that would induce both efficient lending and voluntary participation of $135 or 14.2 percent of period 1a assets.

The government will be indifferent in this setup to recapitalizing the bank with common equity or mortgage securities. While the voluntary participation constraint is identical for all the recapitalizations, the efficient lending subsidy differs for each type of security. For these parameter values, the minimum efficient lending subsidy for mortgages is given by inserting the relevant parameters in (37) and (41) into equation (16). The efficient lending subsidy for mortgages, $\tilde{S}_M = \$112.5,$ which is less than the voluntary participation subsidy of $\hat{S}_M = \hat{S}_R = \hat{S}_E = \$135.$ Therefore, with the regulator buying toxic mortgages, the voluntary participation subsidy is sufficient to induce efficient lending. Nevertheless, while the subsidy for the mortgage repurchases and the equity purchases are identical, the amount of initial outlays are larger for the mortgage repurchases. The government would have to put up $M_L + \hat{S}_M$ = \$850 + \$135 = \$985 for the mortgage plan versus $\hat{E} + \hat{S}_E$ = \$262.5 + \$135 = \$397.5. Moreover, as Harvey (2008) argues, the valuation of troubled mortgage portfolios poses several challenges which are not modeled here.

Finally, social welfare could be higher if the government did not stand ready to subsidize Bank *B* in period 1 in the event that the bank's mortgage assets declined in value. One way to do this would be for the government to commit to not provide a subsidy. Alternatively, if the bank could be forced to participate in the recapitalization, then no subsidy would be needed if period 1a returns were low. Any equity recapitalization must be at least as large as $\tilde{E} = \$437.5$ or about 46.1 percent of period 1a assets to induce efficient lending without a subsidy. This number is obtained by substituting in the parameters from equation (41) and (37) into equation (29). We know from proposition 6 that, if Bank *B* expects no subsidy to be paid, then it will not buy the mortgages at all, and no recapitalization would be necessary in equilibrium. This would lead to welfare being first-best.

5. Discussion and Conclusion

This paper has demonstrated that the securities used to bail out banks, which are perceived as "too-big-to-fail," affects welfare. This paper analyzed recapitalizations involving buying toxic mortgages, buying preferred stocks, and buying common stock. In particular, from both an *ex post* and *ex ante* perspective the least expensive bailout involves the government's buying common equity. Preferred stock is the most expensive security analyzed in terms of its affects on *ex ante* and *ex post* welfare. This casts some doubt on the effectiveness of the Troubled Asset Relief Program, which was passed by Congress and signed by President George W. Bush on October 3, 2008, as it has been implemented up to the time of this writing. In particular, the U.S. Treasury has primarily used preferred stock to recapitalize banks with the first $350 billion that has been was authorized.

Veronesi and Zingales (2008) estimate that the $125 billon in TARP monies given to the first nine institutions included a subsidy worth between $13 and $36 billion dollars to the recipient banks. Whether or not this subsidy was enough to encourage efficient lending is an open question. Nevertheless, our second numerical example indicates that the magnitudes of the subsidy needed to induce efficient lending with preferred stock may be actually very large. This paper has found that if banks are tempted to engage in risk-shifting, the mere fact that banks are voluntarily participating in a preferred stock recapitalization is not sufficient to guarantee that this capital infusion and the taxpayer subsidy that goes along with it will to induce banks to make good loans. (We know this because the voluntary participation subsidy for preferred stock infusions is strictly less than the efficient lending subsidy for preferred stock.) Veronesi and Zingales (2008) can find little evidence that the value of these banks' equity rose with the announcement of the TARP investment. Therefore, a $13 to $36 billion subsidy may have just been barely enough to even guarantee that the voluntary participation constraint was satisfied for the first nine institutions.

There are other concerns about the TARP bailout, which have not been explicitly addressed by this paper, but probably should be addressed by lawmakers or the incoming administration going forward. It could pose some problems that the recipients of the TARP monies are not prohibited from cash acquisitions.[4] Cash acquisitions increase the bank's leverage or reduce the acquirer's cash cushion and thus increase the risk of its equity, all other things being equal. Banks will often be tempted to undo any leverage decreasing transaction, which includes a taxpayer subsidy, with a leverage increasing transaction.

It is somewhat surprising that so many banks have received TARP funds. Certainly, many of those banks are not "too-big-to-fail." As of December 8, 2008, there were 156 financial institutions that had received at least preliminary approval for TARP

[4] The terms of the TARP Capital Purchase Program do specify that the government can veto common dividend increases and share repurchases for the first three years after the recipient bank is awarded funds. Both those actions would increase the bank's leverage and counteract the beneficial effects of the recapitalization. Source: "TARP Capital Purchase Program, Senior Preferred Stock and Warrants, Summary of Senior Preferred Terms" U.S. Department of the Treasury.

program monies totaling $244 billion dollars.[5] Many of the banks due to receive TARP funds probably would not pose systematic risk if they were closed down due to insolvency. It is not clear that the closure of all but the handful of giant commercial and formerly investment banks pose any short or long-term damage to the financial system as a whole. For this reason, the banking sector as a whole may be made healthier if the weaker regional banks were closed down and their assets were sold to stronger institutions. It may be more efficient to close down rather than recapitalize insolvent banks. Nevertheless, Acharya and Yorulmazer (2008), for example, have more to say about how many, and which banks should be bailed out. In contrast, the present paper primarily answers which securities should be used to bail out banks that are deemed "too-big-to-fail."

The present paper is the first to rigorously consider the optimal securities used in bank bailouts from both an *ex ante* and *ex post* perspective. In this paper, the big bank is tempted to shift risk onto creditors when its mortgage portfolio goes sour. The regulator, attempting to maximize *ex post* welfare, chooses among buying the bank's toxic mortgages, recapitalizing the bank with preferred stock, or buying common stock. It is found that common stock recapitalizations always produce the lowest subsidy to the troubled bank. Indeed, no subsidy is needed to induce efficient lending if the troubled bank can be forced to sell common equity at its fair value. Lower subsidies in recapitalizations are more likely to encourage the bank to buy troubled mortgages in the first place. Therefore, common stock recapitalizations always lead to the lowest *ex ante* distortions. Preferred stock recapitalizations are the least efficient and lead to the largest

[5] "Participants in Government Investment Plan," December 19, 2008, *Wall Street Journal Online Edition*, accessed online December 21, 2008 at http://online.wsj.com/public/resources/documents/st_BANKMONEY_20081027.html.

subsidy. Indeed, the implicit subsidy in preferred stock infusions is the only thing that induces efficient lending *ex post*. This paper casts doubt on the effectiveness and the efficiency of the U.S. Treasury's attempts to recapitalize banks through the Troubled Assets Relief Program. In short, because it primarily uses preferred stock to recapitalize over levered banks, it is unlikely to curb incentives to make speculative loans.

References

Acharya, Sankarshan, (1996), "Charter Value, Minimum Bank Capital Requirement and Deposit Insurance Pricing in Equilibrium," *Journal of Banking and Finance*, *20*, 351-375

Acharya, Viral V., and Tanju Yorulmazer, (2007), "Too Many to Fail—An Analysis of Time-Inconsistency in Bank Closure Policies," *Journal of Financial Intermediation*, *16*, 1-31

Acharya, Viral V., and Tanju Yorulmazer, (2008), "Cash-in-the-Market Pricing and Optimal Resolution of Bank Failures," *Review of Financial Studies*, *21*, 2705-42.

Armstrong, Mark, Simon Cowan, and John Vickers, (1994), *Regulatory Reform: Economic Analysis and the British Experience*, Cambridge, Massachusetts: MIT Press.

Ballard, C., J. Shoven, and J. Whalley, (1985), "The Total Welfare Cost of the United States Tax System: A General Equilibrium Approach," *National Tax Journal*, *38*, 125-140.

Barrow, Janice M., and Paul M. Horvitz, (1993), "Response of Distressed Firms to Incentives: Thrift Institution Performance under the FSLIC Management

Consignment Program," *FM: The Journal of the Financial Management Association*, *22* (3), 176-184

Bebchuk, Lucian A., (2008a), "A Better Plan for Addressing the Financial Crisis" *Economists' Voice*, 5 (5), Article 7.

Bebchuk, Lucian A., (2008b), "A Plan For Addressing The Financial Crisis," Working Paper, Harvard University.

Brown, Craig, and Sedar Dinc. (2008), "Too Many to Fail? Evidence of Regulatory Reluctance in Bank Failures When the Banking Sector is Weak," Working Paper, Massachusetts Institute of Technology.

Caballero, Ricardo J., Takeo Hoshi, and Anil Kashyap, (2008), "Zombie Lending and Depressed Restructuring in Japan" *American Economic Review*, *98*, 1943-1977.

Chaney, Paul K., and Anjan V. Thakor, (1985), "Incentive Effects of Benevolent Intervention, the Case of Government Loan Guarantees," *Journal of Public Economics*, *26*, 169-189.

Cordella, Tito, and Eduardo Levy Yeyati, (2003), "Bank Bailouts: Moral Hazard vs. Value Effect," *Journal of Financial Intermediation*, *12*, 300-330

Freixas, Xavier, (1999), “Optimal Bail Out Policy, Conditionality and Constructive Ambiguity,” Working Paper, University Poppeu Fabra.

Goolsbee, Austan, (1998), "Taxes, Organizational Form and the Dead Weight Loss of the Corporate Income Tax," *Journal of Public Economics*, *69*, 143-152.

Harvey, Campbell R., (2008), “The Financial Crisis of 2008: What Needs to Happen After TARP,” Working Paper, Duke University.

Hoggarth, Glenn, Jack Reidhill, and Peter Sinclair, (2004), “On the Resolution of Banking Crises: Theory and Evidence,” Bank of England Working Paper No. 229.

Jensen, Michael C., and Meckling, William H., (1976), “Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure,” *Journal of Financial Economics, 3*, 305-360.

Kasa, Kenneth, and Mark M. Spiegel, (2008), "The Role of Relative Performance In Bank Closure Decisions," *Federal Reserve Bank of San Francisco, Economic Review*, 17-29.

Malaith, George J., and Mester, Loretta J., Mester, (1994), “A Positive Analysis of Bank Closure,” *Journal of Financial Intermediation, 3*, 272-299.

Merton, Robert C., (1974), "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance*, *29*, 449-470.

Rochet, Jean C., and Jean Tirole, (1996), “Interbank Lending and Systemic Risk,” *Journal of Money, Credit and Banking*. *28*, 733–762.

Zingales, Luigi, (2008) “Why Paulson is Wrong,” *Economists’ Voice*, 5 (5), Article 3.

Veronesi, Pietro, and Luigi Zingales, (2008), “Paulson’s Gift,” Working Paper, University of Chicago.