Moral Hazard and the Soft Budget Constraint: A game-theoretic look at the primal cause of the sub-prime mortgage crisis

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This paper addresses one of the major causes of the sub-prime mortgage crisis prevalent in large American mortgage houses by the end of 2006. The moral hazard scenario and consequent malpractices are addressed with respect to the soft budget constraint. This analysis is done by first looking at the Dewatripont and Maskin model (1995), and then suitably modifying it to model the scenario at a typical mortgage lender. This simplistic model provides useful insight into how heightened bailout expectations, caused by precedent actions by the Federal Reserve, fueled risky behavior at banks who thought themselves to be "too-large-to-fail."

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INTRODUCTION

Over the last two decades there has been considerable interest in the study of financial crises and instability owing largely to the prevalence of financial crises in the recent past. As Alan Greenspan observed, after the collapse of the Soviet Bloc at the end of the Cold War, market capitalism spread rapidly through the developing world, largely displacing the discredited doctrine of central planning (Greenspan 2007). This abrupt transition led to explosive growth that was at times too hot to handle and inadequately controlled, causing several crises in the Third World, most notably in East Asia in 1997 and Russia in 1998. Additionally, there have been periods of economic tumult in the developed world including the near collapse of Japan in 1990's, the bailout of Long Term Capital Management by the Federal Reserve in 1998, and most recently, the subprime mortgage crisis of 2007-08.

As Dimitrios Tsomocos highlights in his paper on financial instability, "[t]he difficulty in analyzing financial instability lies in the fact that most of the crises manifest themselves in a unique manner and almost always require different policies for their tackling" (Tsomocos 2003). Most explanations, however, are modeled on a game-theoretic framework involving a moral hazard scenario brought about by asymmetric information. This choice of framework has been popular because of its ability to predict equilibrium behavior (under reasonable assumptions) for a given scenario and explain qualitatively and mathematically why and when deviations from this behavior occur.

This paper aims to perform a similar introductory analysis of one of the underlying causes of the current global economic crisis — subprime mortgage lending activity in the US from 2001-07 — in light of the soft budget constraint (SBC). The soft budget constraint syndrome, identified by János Kornai in his study of economic behavior of centrally-planned economies (1986), has been used to explain several phenomena and crises in the capitalist world. While initially used to explain shortage in socialist economies, the SBC has been usefully sought to provide explanations for the Mexican crisis of 1994, the collapse of the banking sector of East Asian economies in the 1990's, and the collapse of the Long Term Credit Bank of Japan.

The soft budget constraint syndrome is said to arise when a seemingly unprofitable enterprise is bailed out by the government or its creditors. This injection of capital in dire situations 'softens' the budget constraint for the enterprise – the amount of capital it has to work with is no longer a hard, fixed amount. There is a host of literature, primarily developed from a model designed by Mathias Dewatripont and Eric Maskin, which focuses on the moral hazard issues brought about when a government or central bank acts as the lender of last resort to financial institutions (Kornai et al. 2003).

BACKGROUND

The subprime mortgage crisis of 2007 was marked by a sharp rise in United States home foreclosures at the end of 2006 and became a global financial crisis during 2007 and 2008. The crisis began with the bursting of the speculative bubble in the US housing market and high default rates on subprime adjustable rate mortgages made to higher-risk borrowers with lower income or lesser credit history than prime borrowers.

Several causes for the proliferation of this crisis to all sectors of the economy have been delineated, including excessive speculative investment in the US real estate market, the overly risky bets investment houses placed on mortgage backed securities and credit swaps, inaccurate credit ratings and valuation of these securities, and the inability of the Securities and Exchange Commission to monitor and audit the level of debt and risk borne by large financial institutions. It would be fair to

say, however, that one of the most fundamental causes of the entire debacle was the lending practices prevalent in mortgage houses in the US by the end of 2006 and the free hand given to these lenders to continue their practices. While securitization produced complex derivatives from these mortgages that were incorrectly valued and risk-appraised, it was ultimately the misguided decisions made by mortgage lenders that caused default rates to rise when the housing bubble burst, eroding the value of the underlying assets and setting off a chain reaction in the financial sector.

With housing prices on the rise since 2001, borrowers were encouraged to assume adjustable-rate mortgages (ARM) or hybrid mortgages, believing they would be able to refinance at more favorable terms later. However, once housing prices started to drop moderately in 2006-2007 in many parts of the U.S., refinancing became more difficult. Defaults and foreclosures increased dramatically as ARM interest rates reset higher. During 2007, nearly 1.3 million U.S. housing properties were subject to foreclosure activity, up 75% versus 2006. (US Foreclosure Activity 2007).

Primary mortgage lenders had passed a lot of the default risk of subprime loans to third party investors through securitization, issuing mortgage-backed securities (MBS) and collateralized debt obligations (CDO). Therefore, as the housing market soured, the effects of higher defaults and foreclosures began to tell significantly on financial markets and especially on major banks and other financial institutions, both domestically and abroad. These banks and funds have reported losses of more than U.S. $500 billion as of August 2008 (Onaran 2008). This heavy setback to the financial sector ultimately led to a stock markets decline. This double downturn in the housing and stock markets fuelled recession fears in the US, with spillover effects in other economies, and prompted the Federal Reserve to cut down short term interest rates significantly, from 5.25% in August '07 to 3.0% in February '08 and subsequently down all the way to 0.25% in December '08 (Historical Changes, 2008).

As the single largest mortgage financing institution in the US, Countrywide Financial felt the heat of the subprime crisis more than a lot of the other affected financial institutions. Faced with the double whammy of a housing market crash and the stiff credit crunch, the company found itself in a downward spiral, with a rise in readjusted mortgage rates increasing the number of foreclosures which eroded profits.

In the case of Countrywide Financial and other large finance corporations who considered themselves "too-large-to-fail," the expectation of the downside risk coverage was raised to a level that promoted substantial risk-taking. This expectation was based off of precedent actions by the Federal Reserve in bailing out distressed large firms – dubbed the Greenspan (and now, the Bernanke) put. Thomas Walker (2008), in his article in The Wall Street Journal, aptly says,

> There is tremendous irony, and common sense, in the realization that multiple successful rescues of the financial system by the Fed over several decades will eventually create a risk-taking culture that even the Fed will no longer be able to single-handedly save, at least not without serious inflationary consequences or help from foreigners to avoid a dollar collapse. Eventually the culture will overwhelm the ability of the authorities to make it all better.

Ethan Penner of Nomura Capital provides a succinct and veracious definition of the moral hazard dilemma in saying that, "Consequences not suffered from bad decisions lead to lessons not learned, which leads to bigger failings down the road (Penner 2008)."

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THE DEWATRIPONT MASKIN (DM) MODEL

Mathias Dewatripont and Eric Maskin developed a model in 1995 to explain the softening of the budget constraint under centralized and decentralized credit markets (Dewatripont et al. 1995). The simplest version of their model is a two-period model, with the key players being a banker that serves as the source of capital to each of a set of entrepreneurs that require funding to undertake projects. At the beginning of period 1, each of the entrepreneurs chooses a project to submit for financing, and projects may be defined as one of two types: good or poor. The probability of a project being good is α. The asymmetry in information lies in the fact that once selected, only the entrepreneur knows of the type of the project, i.e. the banker is unable to monitor the project beforehand. The entrepreneur has no bargaining power and the banker, if he decides to finance the project, makes a take-it-or-leave-it offer.

Set-up funding costs 1 unit of capital. The banker is able to learn the nature of a project once he funds set-up during period 1. A good project, once funded, yields a monetary return of Rg (>0) and a private benefit Bg (>0) for the entrepreneur; by the beginning of period 2, gains can be made through private benefits, which may include intangibles such as reputation enhancement. A poor project, on the other hand, yields a monetary return of 0 by the beginning of period 2. If the banker ends up dealing with a poor project, he, at the beginning of period 2, has the option of either liquidating the project's assets to obtain a liquidation value L (>0) while the entrepreneur earns a private benefit BL (<0), since liquidation would imply a loss in reputation. The other option the banker has is to refinance the project, which would require the injection of another unit of capital at the beginning of period 2. Now the gross return is Rp and private benefit to the entrepreneur is Bp (>0).

A graphical representation of the timing and structure of the DM model is shown in Figure 1.

The fairly simple model proposed by Dewatripont and Maskin, when suitably tweaked, may be used to explain a number of phenomena in both capitalist and socialist economies. The model was originally designed to assess how decentralizing the credit market (under some fairly reasonable assumptions about the comparative nature of Rg and Rp) will harden the budget constraint — making markets more efficient — by adding incentive to entrepreneurs to not submit poor projects for financing.

For specific application to this study, the model will be used to study the moral hazard scenario that comes about when financial institutions consider themselves "too-large-to-fail." These institutions, Long Term Capital Management in the late 1990's and, more recently, Countrywide Financial, are insured to some measure in the sense that their multi-billion-dollar positions can affect financial markets so heavily that, in the case of a

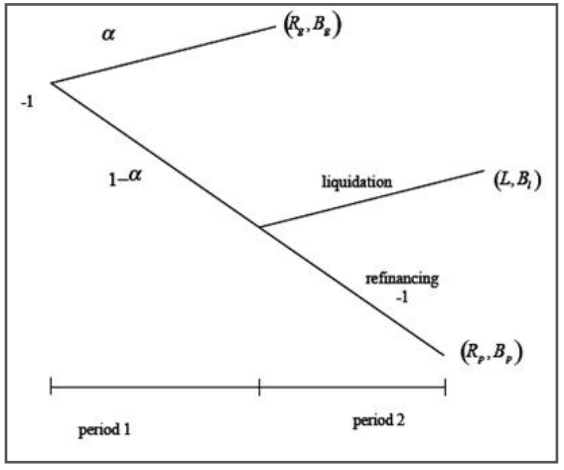

Figure 1. The Structure of the Dewatripont Maskin Model (Source: Kornai et al., 2003)

downturn, large private banks, the central bank, or the government would be forced to bail them out to avoid a financial meltdown. This insurance against downside risk stimulates the moral hazard scenario and gives incentive to these financial institutions to make much riskier bets with higher potential return.

METHODOLOGY

The game-theoretic model used in this study has two key players – the borrowing entity ("borrower") and the lending entity ("the bank"). Additionally, the study looks at the effects of the presence of a lender of last resort. Borrowers, assumed to be identical, can choose from two types of loans offered by the bank – a fixed rate loan with principal L_f and an adjustable rate loan with principal L_a. Customer utility (U(x)) in the typical concave functional form – increasing with decreasing marginal returns (i.e. U'>0, U''<0), is simplified in this model to be the natural logarithm function.

The fixed rate loan has an interest rate r_f. The adjustable rate loan is assumed to have an initial low fixed interest rate r^0a which is readjusted after a period λ. The remainder of the adjustable rate loan is paid off at the rate determined at the end of period λ. If market conditions are good at this time, the interest rate is adjusted to r^1g, and if they are bad, the rate is adjusted to r^1b. Market conditions are represented in the model by an exogenous variable θ, which is the probability of the market conditions being good, i.e. of the interest rate reset to being r^1g.

The bank and customer convene before a loan is offered to discuss the terms of the ARM. Based on the bank's expectations about the economy (i.e. θ) and of the values of r^1b and r^1g, the bank and the customer decide on a fixed initial rate r^0a and a period λ for which the loan is kept fixed. The computation for λ also involves a parameter, δ, which reflects the increase in default rate for bad market conditions. This revenue shrinkage factor (δ) can be thought of as an indicator of the bank's downside risk coverage. In the current framework, it is affected by two key factors:

1. Collateral requirements: Higher collateral would imply more downside risk coverage (i.e. higher δ) but would also reduce the quantity of loans demanded since fewer people would be able to pay the required collateral for the same loan. The bank would therefore evaluate the benefit (potential revenue) of additional loans with the cost (increased risk) to choose the ideal collateral requirement for the ARM. This cost-benefit analysis is however outside the scope of this study, and δ is therefore assumed to be exogenous.

2. Bail-out expectations: Increased expectations of a bail-out (i.e. a cash injection in case of bad market conditions) would also raise the value of δ, but without shrinkage in loan demand.

The game is played between borrowers and the bank with equilibrium being reached by the bank setting λ such that borrowers are indifferent to either of the two loans, and the borrowers opting for a mixed strategy. The indifferent borrower chooses a fixed rate loan with a probability α such that the expected payoff from either loan is the same for the bank.

This study analyzes the equilibrium of this game under two scenarios – with and without the presence of a lender of last resort. The presence of a lender of last resort who is expected to bail the lender out with a cash injection increases the (perceived) value of δ even though the level of protection offered to the bank through collateral remains the same. So, in this case, the revenue shrinkage for the second collection period is reduced (Figure 2).

The optimal loan amount for a fixed rate loan (L^*_f) maximizes net utility for the borrower. Net utility is

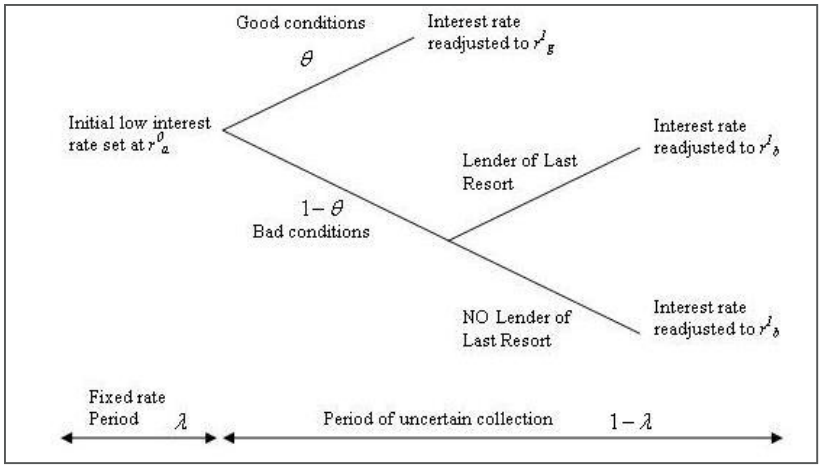

Figure 2. Readjustment of adjustable rate loans after the initial period, λ.

the difference between the utility gained from the loan amount less the total interest paid over the lifetime of the load. The borrower therefore solves,

$$\max_{L_f} \left\{ U\left(L_f\right) - r_f \cdot L_f \right\}$$

i.e.

$$\max_{L_f} \left\{ \ln\left(L_f\right) - r_f \cdot L_f \right\}$$

which yields,

(1)

$$L_f^* = \frac{1}{r_f}$$

With an adjustable rate loan, the interest payment for the average borrower would be

$$L_a \cdot \left(\lambda \cdot r_a^0 + (1-\lambda) \cdot \left(\theta \cdot r_g^1 + (1-\theta) \cdot \delta \cdot r_b^1\right)\right)$$

Therefore, the optimal loan amount for an adjustable rate loan,

(2)

$$L_a^* = \frac{1}{\left(\lambda \cdot r_a^0 + (1-\lambda) \cdot \left(\theta \cdot r_g^1 + (1-\theta) \cdot \delta \cdot r_b^1\right)\right)}$$

In order to ensure that a mixed strategy is employed at equilibrium i.e. to have $0<\alpha<1$, the bank sets λ such that borrowers are indifferent to fixed and adjustable rate loans.

$$U\left(L_f\right) - r_f \cdot L_f = U\left(L_a\right) - \left\{\lambda \cdot r_a^0 + (1-\lambda) \cdot \left(\theta \cdot r_g^1 + (1-\theta) \cdot \delta \cdot r_b^1\right)\right\} L_a$$

Substituting values from (1) & (2), we obtain,

$$-\ln r_f - 1 = -\ln\left(\lambda \cdot r_a^0 + (1-\lambda) \cdot \left(\theta \cdot r_g^1 + (1-\theta) \cdot \delta \cdot r_b^1\right)\right) - 1$$

i.e.

$$r_f = \left(\lambda \cdot r_a^0 + (1-\lambda) \cdot \left(\theta \cdot r_g^1 + (1-\theta) \cdot \delta \cdot r_b^1\right)\right)$$

giving us,

(3)

$$\lambda^* = \frac{r_f - \left(\theta \cdot r_g^1 + (1-\theta)\cdot\delta\cdot r_b^1\right)}{r_a^0 - \left(\theta \cdot r_g^1 + (1-\theta)\cdot\delta\cdot r_b^1\right)}$$

ANALYSIS

In deriving equation (3) above, we also find that, at equilibrium, the net interest rate charged for a fixed loan and an adjustable loan are the same.
i.e.

$$r_f = \left(\lambda \cdot r_a^0 + (1-\lambda)\cdot\left(\theta \cdot r_g^1 + (1-\theta)\cdot\delta\cdot r_b^1\right)\right)$$

Since all interest rates and parameters are positive, and since r^0a is assumed to be less than r_f, the above can only hold true if

(4)

$$r_a^0 < r_f < \left(\theta \cdot r_g^1 + (1-\theta)\cdot\delta\cdot r_b^1\right)$$

Also, it must hold that,

(5)

$$r_a^0 < r_f < r_g^1 < r_b^1$$

This is derived from equation (4) and from the fact that, as market conditions worsen, liquidity becomes harder to obtain and therefore the cost of debt increases.

Equilibrium behavior that is of interest is the nature of the change in λ with changes in the exogenous parameters – θ and δ. The rate of change of λ with respect θ to is

(6)

$$\frac{\delta\lambda}{\delta\theta} = \frac{\left(r_f - r_a^0\right)\cdot\left(r_g^1 - \delta\cdot r_b^1\right)}{\left(r_a^0 - \delta\cdot r_b^1 - \theta\cdot r_g^1 + \delta\cdot\theta\cdot r_b^1\right)^2}$$

Given condition (4), the sign on the above expression is dependent on the sign of $(r^1g - \delta\cdot r^1b)$. Therefore, if

$$\delta < \frac{r_g^1}{r_b^1}$$

then the right hand side of equation (6) would be positive, implying that an increase in the probability of a good market conditions would cause an increase in the amount of time that the loan is kept at the low fixed rate r^0a. This makes intuitive sense because if

$$\delta < \frac{r_g^1}{r_b^1}$$

then the bank is not adequately covered against downside risk, so even though the probability of good market conditions increases, the bank keeps the loan at the fixed low rate longer and decreases the length of the period of uncertain collection, which is subject to downside risk. One concern that arises is why the bank takes any risk in the first place by offering an adjustable rate loan even though the payoff for this is the same as that for the less risky fixed rate loan. The reasoning here would be that adjustable rate loans earn higher commissions, which compensates to some level for this risk. Additionally, ARMs are preferred by more customers, and they therefore add intangible value in terms of higher volumes, which may lead to lower costs, better customer satisfaction and a broader clientele. Also, since the function for λ is a rational function in θ (see equation 3), we can see that the values of r^0a, r^1b, and r^1g need to fall within a certain range to ensure that an ARM is feasible i.e. λ lies between 0 & 1.

Conversely, if

$$\delta > \frac{r_g^1}{r_b^1}$$

then the bank is covered against downside risk. The right hand side of equation (6) is now negative, so an increase in the probability of good market conditions extends the length of the period of uncertain collection. Additionally, if

$$\delta = \frac{r_g^1}{r_b^1}$$

then the bank is independent of nature of market conditions i.e. independent of θ. However, since δ is not set arbitrarily by the bank, it cannot always pursue this strategy of hedging against market risk (Figure 3).

As mentioned earlier, the presence of a lender of last resort inflates the value of δ without any collateral increase. From figure 3 we see that as δ increases, there are three ways in which the bank begins to take up more risk. A rise in the value of δ increases the feasibility of adjustable rate loans – loans that were not feasible for a given economic outlook (i.e. θ value) now start becoming feasible even though the bank is not adequately covered against this higher level of risk from its collateral collection. Additionally, a rise in δ decreases the sensitivity of λ with respect to θ. A higher δ therefore prompts less vigilant observation of market conditions as small enough changes in market outlook now mandate less significant changes in loan structure. Finally, if δ is raised to high enough value,

$$\delta > \frac{r_g^1}{r_b^1}$$

then the bank begins to make counter-intuitive decisions, and a decrease in the probability of good market conditions now actually brings about an increase in the period of uncertain collection.

CONCLUSION

This model, albeit simplistic, provides interesting results. The model is designed to mimic the basic setup at a typical mortgage house offering a fixed rate loan and a two-step adjustable rate loan. We are able to show,

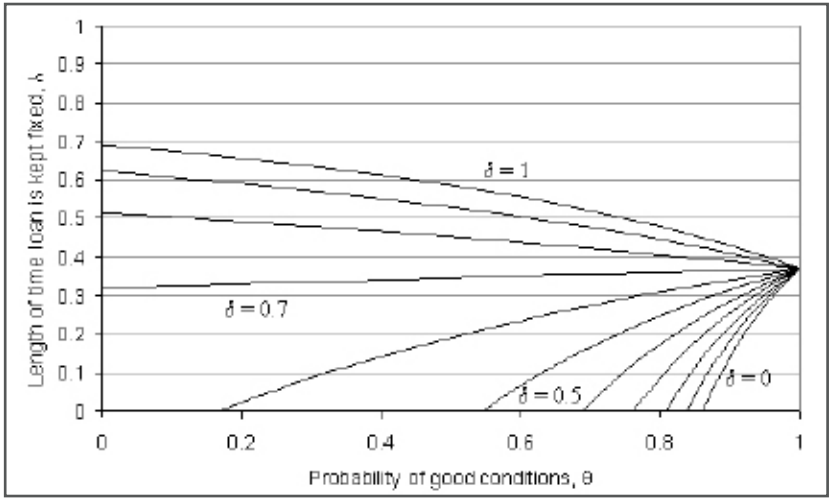

Figure 3. Period of fixed rate collection, λ v/s probability of good conditions, θ; rf = 6.2%, r0a = 4.5%, r1b = 10%, and r1g = 7.2%; δ = 0 to 1, in increments of 0.1.

mathematically, that an increase in the expectation of a bailout by a lender of last resort tends to encourage risky behavior in such mortgage offering agencies in multiple ways. That being said, there is plenty of scope for further elaboration and sophistication of the model. The market structure currently under investigation is both simplistic and insular, but a more elaborate structure of markets and corresponding interactions could be designed. For instance, a good example of possible market stratification is illustrated in Tsomocos (2003). Also, the current loan structure is a two period model with loans changing rates at the end of period one to a new fixed rate for period two. A more complex, multi-period loan structure could be investigated with the adjustable rate set as a random variable and a Markov chain approach used to study the equilibrium behavior in this scenario.

In their investigation of "federalism," Qian and Roland (1988) observe that giving fiscal authority to local governments instead of the central government works to limit the effects of the soft budget syndrome. They propose a three-tiered structure with local governments working between the central government and state and non-state enterprises. The competition among local governments to attract enterprises forces funds to be diverted in infrastructure development, increasing the opportunity cost of a bailout and thereby hardening the budget constraint for enterprises. A similar scenario could be envisioned where the Federal Reserve distributes the decision making authority (and funds) to bailout corporations between the twelve regional Federal Reserve Banks; and would be of interest to study the subsequent change in the behavior of the lending banks.

REFERENCES

Demyanyk, Y & Van Hemert, O. (2008). Understanding the Subprime Mortgage Crisis. Retrieved December 9, 2008, <http://ssrn.com/abstract=1020396>

Dewatripont, M. & Maskin, E. (1995). Credit and Efficiency in Centralized and Decentralized Economies. The Review of Economic Studies, 62(4), 541-555.

Greenspan, A. (2007, December 12). The Roots of the Mortgage Crisis. The Wall Street Journal, p. A19

Historical Changes of the Target Federal Funds and Discount Rates: 1971 - present. (2008). Retrieved December 12, 2008, <http://www.newyorkfed.org/markets/statistics/dlyrates/fedrate.html>

Kornai, J. (1979). Resource-Constrained versus Demand-Constrained Systems. Econometrica, 47(4), 801-819.

Kornai, J. (1980). Economics of Shortage. Amsterdam: North-Holland.

Kornai, J. (1986). The Soft Budget Constraint. Kyklos, 39(1), 3-30.

Kornai, J., Maskin, E & Roland, G. (2003). Understanding the Soft Budget Constraint. Journal of Economic Literature, 41(4), 1095-1136.

Onaran, Y. (2008, August 12). Banks' Subprime Losses Top $500 Billion on Writedowns. Retrieved December 12, 2008, <http://www.bloomberg.com/apps/news?pid=20670001&sid=a8sW0n1Cs1tY>

Penner, E. (2008, April 11). Our Financial Bailout Culture. The Wall Street Journal, p. A17

Qian, Y. and Roland, G. (1998). Federalism and the Soft Budget Constraint. American Economic Review, 88(5), 1143-62.

Tsomocos, D. (2003). Equilibrium analysis, banking and financial instability. Journal of Mathematical Economics, 39, 619-655.

U.S. Foreclosure Activity up 75 Percent in 2007. (2007). Retrieved March 14, 2008, <http://www.realtytrac.com/ContentManagement/RealtyTracLibrary.aspx?a=b&ItemID=4118&accnt=64953>

Walker, T. (2008, April 23). Our Bailout Culture Creates a Huge Moral Hazard. The Wall Street Journal, p. A16