

# Subprime assets and financial crisis: theory, policy and the law<sup>1</sup>

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## Abstract

In this paper, we explore three specific aspects of the US subprime crisis, using both theoretical models and the outcome of subsequent legal proceedings. First, the role of *pecuniary externalities* in amplifying shocks to the quality of MBS held by Investment Banks. Second, the role of *adverse selection* in the marketing of such assets by Investment Banks; and third the role of *financial panic* in making shadow banking disaster prone. The relevance of these differing perspectives is attested by the nature of state support and, more especially, the findings of law courts.

Janet Yellen has recently argued that the vulnerabilities within the US financial system in the mid-2000s were “numerous and familiar from past financial panics”. That the aforementioned threats to stability should be complements and not substitutes is of more than technical interest. It helps to show why the US financial system was so exposed to radical failure.

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*Reality is one, though wise men speak of it variously.* From the Rigveda, 1500 - 1200 BC

## **1. Introduction**

That the period of macroeconomic stability known as the Great Moderation should have ended in a financial cataclysm was a nasty shock – especially for those who believed in the inherent efficiency of financial markets! But how to account for the fact that the spark for the crisis came not from emerging markets but from within the United States itself, where monetary affairs had, for many years, been in the hands of Mr Greenspan, doyen of central bankers?

Earlier financial shocks and external factors doubtless played a role, with US interest rates being cut after the high-tech bubble collapsed in 2000; and then kept low as funds flowed in from the ‘savings glut’ in East Asia. But here we focus on factors specific to US housing finance to see how subprime mortgage lending, sponsored by misguided policy and aided by febrile financial innovation, could undermine the integrity of the US financial system.

The objective in revisiting these issues is not to allocate blame; rather to see how a repeat may be avoided. If the problem was essentially financial panic, for example, as Gary Gorton (2009, 2014) and others maintain, the remedy would be ample provision of liquidity. But if, as Mian and Sufi (2014) contend, policy-makers were using the provision of cheap credit as an elixir to cure growing income inequality and shadow banks ‘joined the party’ with sophisticated products that would only work when house prices were rising, then the analysis and policy response needs to go much deeper. To set the scene, we begin with some institutional and policy background.

### *Housing finance: getting onto the housing ladder*

The development of US banking in the late twentieth century, according to Calomiris and Haber (2014), involved a ‘bargain’ between banks and society: banks were permitted to merge and grow so long as they promoted home ownership for low-income mortgage applicants.

Once branching limits were removed, bankers had ambitious plans for mergers. Their plans were, however, subject to a political constraint: they needed to be judged good citizens of the communities they served in order to gain approval from the Federal Reserve Board. Good citizenship came to be defined as being in compliance with the 1997 Community Reinvestment Act ...For activist groups seeking to direct credit to their memberships and constituencies, the good-citizenship merger criterion was a powerful lever in negotiations with merging banks. The bankers and the activists

forged a coalition that consolidated the American banking industry into a set of megabanks that were too big to fail. Calomiris and Haber (2014, p.208)

Such a deal had the apparent advantage of helping to offset the stagnation of median incomes and growing inequality as earnings at the top of the income distribution raced ahead. Instead of taxes and subsidies to redistribute income, the idea was that those on lower incomes would borrow to get on the housing ladder so – with time and house price appreciation – they could extract equity to increase consumption.

As the authors go on to point out, however:

Other partners had to be drawn into the coalition in order to make it stable. Banks would not make unlimited commitments to their activist partners: Community Reinvestment Act loans implied higher levels of risk for the bank than traditional mortgage loans. Thus, under pressure from activist groups, Congress began to place regulatory mandates on government-sponsored enterprises (GSEs) that purchased and securitised mortgages... Fanny Mae and Freddie Mac, in particular, were required to repurchase mortgage loans made to targeted groups (i.e. individuals who had low incomes or lived in urban locations that were defined as underserved). In order to meet these targets, Fannie and Freddie had to weaken their underwriting standards. Calomiris and Haber (2014, p.209)

Under the Clinton and Bush administrations, the mandate on GSEs for low income housing steadily increased, from 42% of assets in 1995 to 56% in 2004. Indeed, it has been estimated that:

by 2008, the mortgage giants, the FHA and various other government programs were exposed to about \$2.7trillion in subprime and Alt-A loans, approximately 59% of total loans in these categories. ... As money from the government-sponsored agencies flooded into financing or supporting low income housing, the private sector joined the party. ... Unfortunately, the private sector, aided and abetted by agency money, converted the good intentions behind the affordable housing mandate and the push towards an ownership society into a financial disaster. Rajan (2010, p.38, 9)

Despite substantial political pressure to extend home ownership by poorer households, the subprime share of mortgage market remained around 10% until 2003. With the development of private label securitisation (PLS), however, the subprime experiment in 'dynamic credit enhancement' for low-income borrowers accelerated sharply. As can be seen from Fig. 1, the share of subprime mortgages rapidly doubled to over 20% of all mortgage originations in 2006. But when the house price bubble burst, the share of subprime mortgages fell precipitously, with virtually none being securitized in 2008.

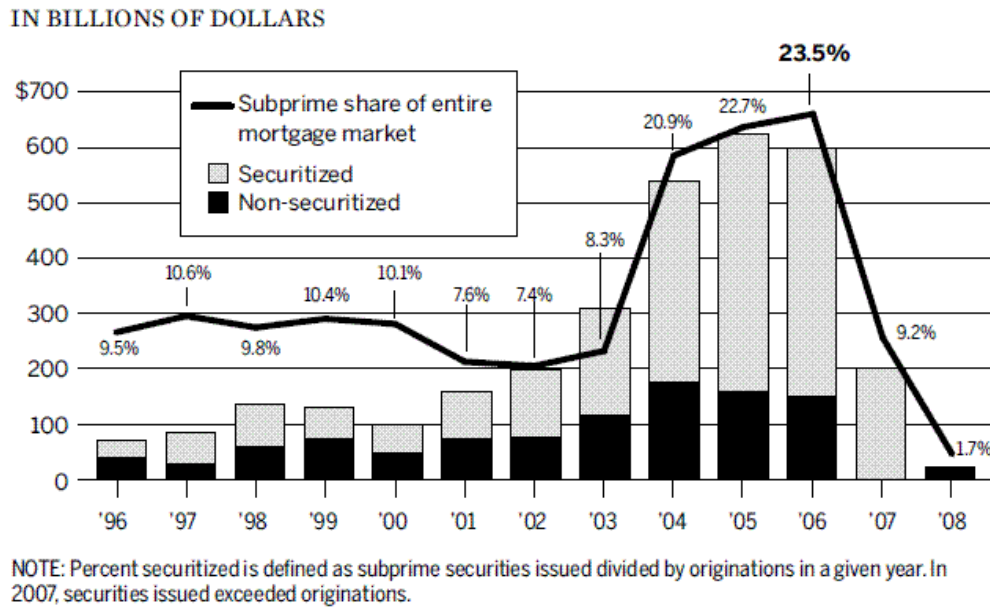


Figure 1 U.S. Subprime mortgage originations.

Source: Financial Crisis Inquiry Commission Report, p.70 Figure 5.2

Could policy makers and regulators not have stopped this vast expansion of subprime lending - by changing the mandates, for example; or by imposing higher prudential capital requirements on such loans? In the view of Calomiris and Haber (2014, p.281):

they could ... but they chose not to do so. Instead, regulators stood by and watched: in essence they subcontracted regulation of banking to private firms that sold ratings and whose incentives were therefore aligned with those issuers and purchasers, who wanted to have inflated ratings.

If this is an accurate assessment of the policy and regulatory framework, then the onset of financial crisis seems as inevitable as the fate of Santiago Nasar in Marquez's *Chronicle of a death foretold*.

*Brief overview of some relevant literature*

In a prescient paper delivered at the Jackson Hole Conference on *The Greenspan Era* in 2005, Raghuram Rajan raised the issue of whether financial innovation was making the world a riskier place. The focus of his concern was on leverage and *asymmetric information* in financial intermediation, and how distorted incentives could lead to excessive risk-taking. Though Rajan's concern was met with general scepticism from other delegates, it was supported by Hyun Shin, on the ground that, even with common knowledge, high leverage could lead to instability on account of '*pecuniary externalities*'. He used the internal dynamics of the Millenium Bridge to illustrate how shocks can be greatly amplified in financial markets - 'the supreme example of an environment where individuals *react* to what's happening around them, and where individuals' actions *affect* the outcomes themselves'. In another influential paper delivered at Jackson Hole soon after the crisis

broke, Gary Gorton (2009) argued that the lack of transparency in financial innovation could trigger *financial panic* in the form of a bank run.

Fostel and Geanakoplos (2012) also stressed the role of financial development; but, in marked contrast to the bank-focussed perspectives just discussed, theirs is a general equilibrium approach. They stress the role of *heterogeneous beliefs* as the driver for leverage as optimists borrow from pessimists; and how the sequential introduction of financial innovations is, in and of itself, enough to cause boom and bust<sup>2</sup>. Another fast-growing branch of the literature, lying between detailed partial equilibrium models of banking and ‘institution free’ general equilibrium, focuses on adding ‘financial frictions’ to DSGE models cast in the Gali/Woodford tradition of modern macroeconomics. We make no attempt to analyse these contributions here. For a good illustration of the DSGE approach, with a helpful summary of other papers in this burgeoning field, the reader may be referred to Coimbra and Rey (2017); and a concise version of the general equilibrium approach is provided in Miller et al. (2016).

The majority of papers on the financial crisis take a partial equilibrium perspective – with a focus on the institutional aspects of ‘shadow banking’ in particular. As is typical for banking models, there is a split between those, like Gary Gorton, who emphasizes the role of *shocks to liquidity* in a setting where fundamentals are essentially well-founded, and those who focus on structural flaws in incentives and/or regulatory structure capable of precipitating *widespread insolvency* due to excess risk-taking.

Prudential regulation to check excess risk-taking by highly-leveraged institutions (HLIs) had been widely discussed well before the subprime crisis, as Goodhart (2011) testifies. A key issue in debate was whether the value at risk (VaR) rules adopted in Basel II to check risk-taking by individual banks would be sufficient to guarantee systemic stability; or whether it could be flawed for ignoring externalities. Danielsson et al. (2001), argued that balance sheet rules, designed to ensure prudential behaviour at the level of the individual bank, could lead to systemic instability when common, ‘macroeconomic’ shocks are amplified by ‘*pecuniary externalities*’ in the form of asset price changes which affect bank equity in pro-cyclical fashion.

A masterly survey of the literature on the problems posed by such externalities is provided by Brunnermeier et al. (2012). They leave on one side, however, the issue of distorted incentives due to *asymmetric information* analysed earlier by Holmstrom and Tirole (1997) and Hellman et al. (2000). How financial innovation could exacerbate these issues, as highlighted by Rajan (2005), was emphasized by Foster and Young (2010) – who showed how financial derivatives could be used by fund-managers of average ability to mimic the

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<sup>2</sup> The innovation that can trigger collapse is the availability of ‘naked’ CDS contracts which allow for insurance against failure, so non-asset holders can ‘short’ investment in risk assets. So-called ‘naked’ CDS contracts do not require ownership of the assets being ‘insured’.

performance of star traders, taking on tail risks to do so<sup>3</sup>. In the context described above, where monitoring of asset quality had been delegated to unregulated, private-enterprise Credit Rating agencies (CRAs), Akerlof and Shiller (2015) argued that investment banks had an alternative strategy for making their investments appear superior: getting them rated as AAA by compliant agencies. As with mimicry, however, getting high returns involved taking on significant risk.

### *Structure of the paper*

These topics – externalities, distorted incentives and creditor panic – are analysed in some detail in Sections 1 and 2, considering in particular whether each one could itself be sufficient to cause banking crisis.

The first threat of insolvency examined in Section 1 involves the role of externalities. We focus in particular on the Investment Banking model of Shin (2010) which emphasises how '*pecuniary externalities*' can amplify unexpected shocks to the quality of investments they hold<sup>4</sup>. To check on the robustness of US-style shadow banking in the face of shocks, we ask: could these externalities prove sufficiently strong that the simple reversal of 'good news' might lead to widespread insolvency and banking collapse?

The second threat of insolvency examined involves the distorted incentives for risk-taking in HLIs, particularly after the switch from partnerships to limited liability in US Investment Banking, as discussed in Akerlof and Shiller (2015). The focus here being on the role of *asymmetric information* in the marketing of and investment in highly risky assets, we apply the adverse selection approach of Akerlof (1970) to the marketing of subprime assets. Relaxing the 'rational expectations' constraint imposed in that paper allows for risks to be concealed by inflated ratings issued by CRAs who are 'mining their reputation' to secure the fees on offer for rating subprime loans; and to lead to financial collapse when it is discovered that these loans were worth a lot less than previously thought.

We note that these two threats are in fact complementary: just as successful exploitation of asymmetric information to take on excess risk underpinned the credit boom, so revelation of the risks sub-prime lending really involved was the downside shock that brought on the crisis.

In Section 2, the '*confidence crisis*' view is discussed and we ask: was the rise in the cost of insuring subprime assets a matter of mindless panic as suggested by Gorton? Or was it not due to a realisation of faulty fundamentals?

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<sup>3</sup> This strategy offers the prospect of high returns for some time followed by substantial losses as tail risks finally materialise.

<sup>4</sup> Such externalities are sometimes discussed under the heading of contagion. See for example Allen and Carletti (2012).

But what if these various perspectives are high-lighting different aspects of a complex reality? This may recall the ancient Hindu parable of the blind men and the elephant, where the former – each guided only by touching a different part of the animal, be it a tusk, the tail, an ear, or a leg – give a series of correct but partial characterisations of the noble beast. The conclusion in the Rigveda, cited above, namely that *Reality is one, though wise men speak of it variously*, tempts one to ask: should these seemingly conflicting accounts not be combined? For an answer we turn not to theory, nor to econometric tests of theory, but to the evidence of law courts and the actions of policy-makers in the Fed and Treasury. What did the extraordinary policy actions taken by these agencies reveal about the nature of the crisis? Did those charged to dispense justice find evidence of misbehaviour sufficient to prosecute the players involved?

To balance these three perspectives – and to see whether in practice they proved complementary – Section 3 summarizes key official policy actions taken in response to the crisis; and subsequent findings in the law courts against both CRAs and Investment Banks<sup>5</sup>. In some versions of the parable a sighted observer appears to reconcile the various conflicting perspectives. In this spirit, the view-with-hindsight of the current chair of the Federal Reserve, as expressed at Jackson Hole 2017, is also cited.

After a brief account of possible steps to increase risk-sharing in housing finance, section 4 concludes.

## **Section 1 The risk of insolvency - two views**

### **1.1 Insolvency with Value-at-Risk: common shocks and ‘pecuniary externalities’**

In this section, the Investment Banking model of Shin (2010) and Adrian and Shin (2011) is used to examine the contention<sup>6</sup> that VaR based regulation is no guarantee of systemic stability. We find by simulation that the representative Investment Bank could become insolvent when a significant upgrade in risky asset quality is followed by a subsequent reversal.

In what, for convenience, will be referred to simply as the Shin model, there are two groups of investors; (1) risk averse agents with mean-variance preferences, who do not use leverage to finance investments such as pension funds and mutual funds; and (2) risk neutral investors, who can finance investments with leverage subject to a Value-at-Risk (VaR) constraint. For present purposes, we will treat the latter as homogenous and highly-leveraged investment banks. But, in reality, such active leveraged investors include hedge funds and foreign banks, as well as U.S. investment banks.

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<sup>5</sup> Why the legal settlements have taken the form of ‘deferred prosecution agreements’ with the companies involved, rather than the criminal prosecution of high-level individuals, is also discussed.

<sup>6</sup> Made by Shin and others in “An academic response to Basel II”, Danielsson et al. (2001).

There are two assets: (1) a riskless bond with its rate of return normalized to 0; and (2) a risky asset with random payoff  $Q$ , uniformly distributed over  $[q - z, q + z]$  where  $q > 0$ , with moments denoted by:

$$E[Q] = q$$

$$Var(Q) = \frac{z^2}{3}$$

Both types of investors are endowed with initial equity equal to  $e$ . Investors' portfolio payoff (end of period wealth) is  $W \equiv Qy + (e - py)$ , where  $y$  represents quantity of the risky asset holdings and  $p$  is the price of the risky asset.

#### *Passive investors*

As they do not borrow to finance their investments, risk averse investors are categorised as passive. Their 'mean-variance' preferences are described by

$$U(W) \equiv E(W) - \frac{1}{2\tau} \sigma_W^2$$

where  $\tau$  represents risk tolerance and, since their portfolios comprise of only riskless bonds and risky asset, portfolio variance is  $\sigma_W^2 = \frac{y^2 z^2}{3}$ . Risk averse investor's optimization thus becomes:

$$\max_y \left( qy + (e - py) - \frac{y^2 z^2}{6\tau} \right)$$

The demand function of passive investors becomes:

$$y_p = \begin{cases} \frac{3\tau}{z^2}(q - p) & \text{if } q > p \\ 0 & \text{if otherwise} \end{cases} \quad (1)$$

Note that because of the assumption on mean-variance preferences, the demand for risky asset by the passive investors is independent of their wealth.<sup>7</sup>

#### *Active investors: Investment Banks*

Risk neutral investors are active as they use leverage to finance their investments, subject to a VaR constraint. Specifically, investment banks' optimization is described as:

$$\max_y E(W) \quad \text{s.t.} \quad VaR = (p - q + z)y \leq e$$

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<sup>7</sup> In Shin's model, the specific formulation of VaR implies no default ex post as the distribution of  $Q$  has bounded support. However, if the support of  $Q$  is not bounded, ex post default is possible; so the wealth of the passive investors may be affected. But with these mean-variance preferences, the determination of equilibrium asset prices is not affected.



where  $E(W) = (q - p)y + e$  and the VaR constraint implies the borrowing is no greater than the worst realized payoff on the risky asset,  $py - e \leq (q - z)y$ .

[In a more general case where the distribution of  $Q$  has unbounded support, the VaR constraint becomes probabilistic: i.e.  $Prob(VaR \equiv (p - Q)y \geq e) \leq \alpha$ , where  $\alpha$  is the probability of losing the entire equity. Under this modified VaR constraint with limited liability, the expected payoffs of the active investors become:  $E(W) = (1 - \alpha)[(q - p)y + e]$ . However, the active investors can purchase CDS to insure against the tail risks associated with losses beyond the VaR and so avoid bankruptcy. Let the cost of CDS used to insure against  $Q$  falling below  $q - z$  be  $\beta$ ; then the VaR constraint in the text is restored, as the expected payoffs of active investors become:  $E(W) = (q - p)y + e - \beta$ . So in the presence of CDS, the formulation used in the text can also apply to the case even if the support of  $Q$  is unbounded.]

Since  $E(W)$  is linear in  $y$ , then for  $q > p$ , so long as the VaR constraint is binding, the demand for risky asset by investment banks becomes:

$$y_A = \begin{cases} \frac{e}{z - (q - p)} & \text{if } q > p \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

#### Market-clearing

For  $q > p$  and assuming that aggregate supply of the riskless bond is potentially unlimited and aggregate supply of risky assets is fixed and equal to 1, the market clearing condition  $y_P + y_A = 1$  gives the equilibrium price:

$$p = q - \frac{z}{2} \left[ \frac{z}{3\tau} + 1 - \sqrt{\left(\frac{z}{3\tau} - 1\right)^2 + \frac{4e}{3\tau}} \right] \quad (3)$$

For a given supply of risk assets (normalised to one) on the horizontal axis, various market equilibria are illustrated in Fig.2, calibrated broadly using figures gleaned from Shin (1010), as shown in Table 1, using the formulae provided in Annex A. The construction is that the demand by passive investors, measured from the right-hand axis, lies below the mean, with a slope that reflects their degree of risk aversion; while the demand curve for active investors is measured from the left hand axis. The kink reflects their initial equity  $e$  and the downward slope indicates, not risk aversion, but the effect of the VaR rule: a fall in price allows more assets to be held as there is less risk per asset, measured as  $p - (q - z)$ , to be covered by their equity. Equilibrium is where total demand matches supply. The outcome shown in the middle of the diagram is labelled L to indicate the Low quality risk assets available; that on the right, labelled H to indicate a much higher quality, shows the considerable expansion of holdings by investment banks triggered thereby; the outcome on the left, where Investment Banks go out of business, is labelled I for insolvency.

The low quality of assets available at L refers to a downside risk of 0.13 relative to an expected payoff of 1.06 which gives the minimum payoff of  $q - z = 0.93$  indicated by the dashed line near the foot of the figure. The demand schedule from Investment banks, subject to VaR with equity of 0.024, has a kink at  $\frac{e}{z} = 0.024/0.13 = 0.18$  and descends as a rectangular hyperbola towards 0.93 as its lower asymptote. It intersects the demand from passive investors at a price just above unity, giving investment banks a market share of about 30%.

What if (for reasons to be discussed below) there is an unanticipated increase in the quality of risk assets, known to all participants? Specifically, let the downside risk fall substantially to only 0.06, lifting the minimum payoff to  $q - z = 1.0$ , as indicated by the dashed line near the middle of the Fig.2. The reduction of perceived risk will of course increase the demand by mean/variance investors, as indicated by the clockwise rotation of their demand schedule. The demand from investment banks will increase for two reasons. First because, with lower downside risk per unit, the initial equity can cover the risk on a larger quantity of assets; and second because, with “mark to market” accounting, capital gains from the price rise for risky assets on their balance sheets will raise their equity value. The combined effect is a marked shift to the right in demand curve for Investment Banks operating under VaR rules, as shown by the upper rectangular hyperbola in the figure.

Given the parameter values indicated, market-clearing equilibrium is at H, with the price lying very close to the top of the narrow ‘band’ of 6% between  $q$  and  $q - z$ , and with the lower downside risk fully covered by the higher equity. In this case, meant to represent pre-crisis boom, demand by the risk-neutral Investment banks, holding about two thirds of the risky assets with a leverage ratio of almost 20, has virtually eliminated the risk-premium  $q - p$  on these assets. <sup>8</sup>

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<sup>8</sup> In line with Crockett’s dictum, that ‘risk exposure is built up in the boom but is only manifest in the bust’.

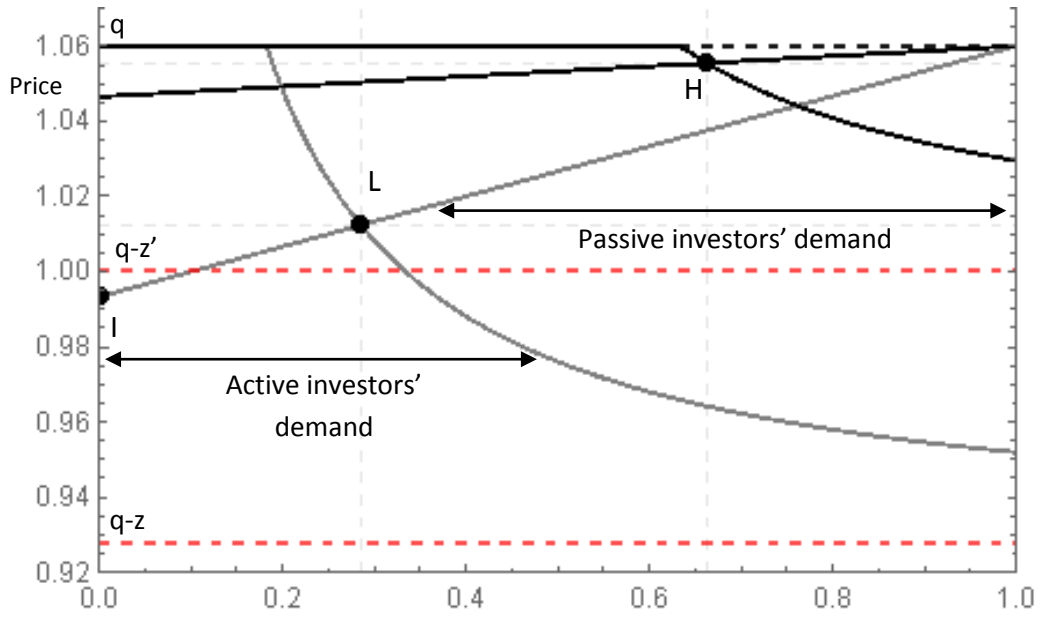


Figure 2. Market-clearing price of risky assets: three cases

Table 1a Parameters used in calibration

q	1.06
z	0.13
e	0.02
$\tau$	0.09
Shocks	
dq	0.
dz	-0.07
Improvement in Asset Quality (dq-dz)	0.07

Table 1b Simulation results

	<i>Initial Equilibrium</i>	<i>Positive Shock</i>	<i>Shock Reversal</i>
<b><i>Equilibrium</i></b>			
Price	1.012	1.055	0.993
ya	0.285	0.663	0.
<b><i>IBs Balance Sheet</i></b>			
Asset	0.289	0.7	0.
Debt	0.265	0.663	0.
Equity	0.024	0.036	-0.005
Percent Change in Equity		51	-113.181
Leverage	11.978	19.212	0.

Notwithstanding the virtual absence of a risk premium, this boom equilibrium is distinctly fragile. Consider, for example, another possible common shock to the quality of risk assets, namely a write-down of the expected payoff,  $q$ . Since, with the level of equity taken as given, this will shift both schedules vertically downwards, it might seem that a write-down of almost 6% could be handled by the equity provisions made under VaR. But this is without taking account of the ‘pecuniary externality’ – namely that the equity base of the banks is endogenous, and will fall as the price falls given ‘mark to market’ accounting. Allowing for the financial accelerator that this implies, which forces the highly-levered banks to contract their holdings as they sell risky assets into the market, it turns out that their initial equity can only stand a write-down of 4%.

Factors mentioned by Shin that might cause such parametric shocks to the mean return include – on the upside – a macroeconomic improvement lowering the probability that the borrowers would default on their loans; and – on the downside – a decline in the quality of mortgage borrowers as the market expands. Miller and Zhang (2015) discuss the possibility that an initial probability upgrade may turn out to be mistaken; and Carlin and Soskice (2015) point explicitly to CRAs as a possible source of such mis-rating, with positive upgradings later reversed. Danielsson et al. (2011), had earlier argued that “heavy reliance on CRAs is misguided as they have been shown to provide conflicting and inconsistent forecasts of individual clients’ creditworthiness. They are unregulated and the quality of their risk estimates is largely unobservable.” The conflict of interest that gave CRAs the incentive to issue erroneous ratings are considered further in the next section; meantime, as a test of robustness, consider a ratings upgrade that gets reversed.

#### *A test of robustness: a reduction in downside risk, later reversed*

To check the robustness of shadow banking in the Shin model, we first introduce a significant reduction in perceived risk; and then, when the equity base has expanded, a reversal of this ‘good news’. The *unexpected increase in asset quality* that results in perceived risk reduction<sup>9</sup> could correspond to the highly favourable pre-crisis ratings given by rating agencies: while the *reversal of this good news* could reflect the subsequent sharp rise in the cost of insurance signalled by the ABX-HE indices, discussed below. The time-line of events is outlined below.

In the first stage, with the downside risk parameter  $z$  and investment bank equity  $e$ , the equilibrium price  $p$  is determined along with  $y$ , the share of the risky asset held by active investors. This corresponds to point L in the figure. After markets have cleared on the assumption of an unchanging future distribution of asset returns, however, ‘good news’ on asset quality arrives: downside risk has fallen to  $z' < z$ . This unanticipated but welcome development leads to an increase in the price of risky assets; and the holdings of active investors also increase, as indicated by point H in Fig. 2.

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<sup>9</sup> Narrowing the ‘downside’,  $z$ , of risky asset’s payoff, leaving the expected payoff unchanged at  $q$  as in Fig. 2.

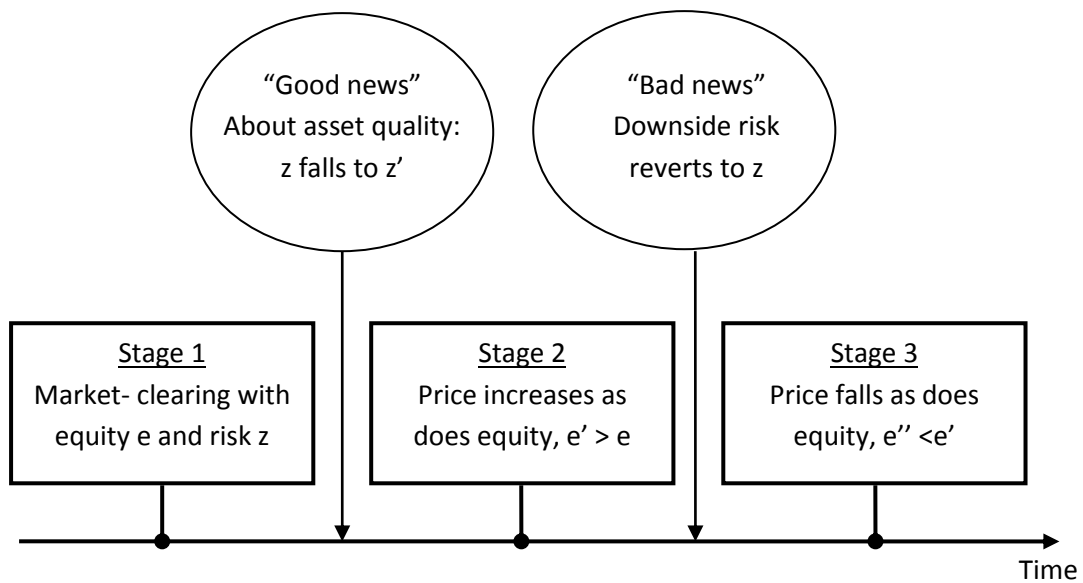


Figure 3 Timeline of events

By marking assets to market at these higher prices, investors are effectively assuming no change in the future distribution of asset returns. They will, however, be disappointed, if 'bad news' arrives that downside risk  $z$  has reverted back to what it was in the first stage, namely  $z$ .<sup>10</sup>

Given the original payoff distribution, but starting now from the higher equity base ( $e'$ ) achieved at stage 2 – with larger holdings financed by higher borrowing ( $p'y'-e'$ ) – the question arises: how much will asset prices have to fall as active investors contract their balance sheets to meet the now-tighter VaR requirements; and will their equity be sufficient to take the hit?

### *Insolvency*

Though news shocks that are reversed need not lead to insolvency, they can do so. The most obvious case is when *the good news 'narrows the band' of downside risk enough to exclude the initial equilibrium price  $p_0$  (i.e.  $q - z' > p_0$ )*. If, for example, from an initial equilibrium at  $L$  in Figure 2 (with  $z = 0.13$ ) the 'good news' was that the downside risk had fallen to  $z = 0.06$  then a reversal will, of course, take equilibrium 'outside the band' involving losses larger than the maximum sustainable; so the entire equity of the banks will be wiped out by the 'bad news'.

<sup>10</sup> If the distribution of  $Q$  has unbounded support, we assume that the cost of CDS for insuring against the tail risks beyond  $q-z$  and  $q-z'$  are the same.

In the context of a model with uniformly-distributed, bounded risk, this would be classified as a 'zero probability event', an outcome that takes prices lower than the worst the banks expect given the downside risk as perceived at H. Should it therefore be discounted? No, for two reasons. First because the design of the VaR regime was flawed in that externalities that could drive the system outside the bounds expected by individual banks were not checked by Pigouvian regulation; so the exaggerated impact of common shocks will be unexpected. Second because Shin's model may be expanded to allow for unbounded downside risk together with the availability of insurance to cover tail risk, as discussed above. In which case, moral hazard would play a role – and the insuring agency take a hit.

The example portrayed in Fig. 2, however, is rather more subtle. It demonstrates that, even where a return to the initial equilibrium *price* would be sustainable (i.e. where  $p_0 > q - z'$ ), a reversal of good news may trigger insolvency nonetheless. In the figure, reducing perceived down-side risk from 0.13 to 0.06 shifts equilibrium from L to H; and, as L remains within the 'narrow band' it might appear that a reversal is sustainable. But the asymmetry of capital gains (applied to initial holdings at L) and the capital losses (applied to expanded holdings at H) is sufficient to wipe out the equity of the active investors, leading to the equilibrium at point I where all risk assets are in the hands of mean-variance investors.

That such widespread insolvency was a possible outcome is supported by David Stockman's (2013, p.543) account of the financial crisis, where he asserts bluntly that, in the absence of Fed intervention: " Every single investment bank, including Goldman, Morgan Stanley, and the embedded hedge funds at J P Morgan, Citibank and Bank of America would have been rendered instantly insolvent and dismembered under court and FDIC protection."<sup>11</sup>

#### *'Catastrophic' behaviour*

The tendency of the system to 'overshoot' its initial equilibrium (on the way down) when a quality upgrade is reversed depends on asset prices being 'marked to market'. This accounting practice makes endogenous the level of risk-taking by firms which keep their balance sheets at the limits set by VaR: but it operates asymmetrically. While the good news has a positive amplification effect applied to the *initial* level of equity at A, the rescinding of this good news has a negative amplification effect applied to the equity level at B, *boosted by the earlier good news*.<sup>12</sup>

Clearly accounting rules can have a marked effect on the dynamic response of the system to exogenous shocks; and, for large enough shocks, it appears that the price of risky assets can exhibit what Zeeman (1974) and Arnold (1984) refer to as 'catastrophic' behaviour – highly asymmetric responses to symmetric movements in exogenous forces. In the paper referenced, Christopher Zeeman sought to explain the gradual rise in equity prices in a boom followed by the sharp fall in the subsequent crash by the difference in behaviour

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<sup>11</sup> Something that he advocated, as he believed that the outcome would not have affected Main Street.

<sup>12</sup> If assets were not marked to market, however, the effects would be symmetric.

between 'bulls and bears' – a psychological explanation that Arnold (1984) criticized as rather ad hoc. In the case we are discussing, however, the dynamics are derived explicitly from the 'rules of the game' – VaR rules sanctioned by Basel II to check moral hazard on the one hand; and market accounting regulations (FAS 157 in particular) designed to ensure fair asset pricing on the other.

The Shin model as analysed here appears to sustain the three charges made against BASEL II in Danielsson et al. (2011), namely that:

- (i) VaR can destabilise and induce crashes when they would not otherwise occur
- (ii) Heavy reliance on CRAs is misguided
- (iii) Financial regulation is procyclical

The obvious weakness in the account so far provided is that it is driven by a sequence of unanticipated, exogenous quality shocks. Altering the common knowledge assumption, as in the next section, helps to make the sequence of shocks endogenous, however.

A different approach to making the shocks endogenous has been explored by Aymanns et al. (2016), in a Minsky-like extension of Shin's model. For them asset quality is judged, not by ratings, but from time-series estimates of downside risk made in a stochastic setting. As time moves on and the last crisis moves into the distant past, these assessments become progressively more rosy, and the system more risk prone – leading to another crisis. In fact, they derive an ever-repeated cycle of boom and bust which, they claim, is consistent with the operation of the BASEL II rules on prudential regulation.

## **1.2 Sourcing the shocks: asymmetric information with adverse selection**

In *Phishing for Phools*, George Akerlof and Robert Shiller (2015) discuss how, with asymmetric information, markets may misallocate risk and resources; and claim they that structural flaws in US Investment Banking industry, and in the agencies that provided ratings for the products it dealt in, are a case in point. The switch from partnerships to limited liability, prior to the subprime crisis, gave the banks much greater willingness to take risks: but the degree of risk involved was grossly understated, as rating agencies – skilled in assessing repayment prospects for the debt of corporations and sovereigns – were paid by the banks to give favourable ratings to complex financial products whose properties defied conventional analysis.

Shin's Investment Banking model assumes common knowledge as to the quality of risk assets on the market; but the possibility of Investment Banks getting favourable ratings for assets known to be high-risk challenges this assumption. The reversal of 'good news' comes about when the mis-rating comes to light. As Akerlof and Shiller (2015, p.36) put it: 'The

mortgage-backed securities may have been rated very highly; but they were largely backed by subprime loans with a high chance of default. When it was discovered that these loans were worth a lot less than previously thought, the investment banks were bankrupt.'

Financial developments over the course of 2008 seem to support this perspective. For, as summarized succinctly in Sorkin (2009, p.529) and indicated in Table 2 below: 'Each of the former Big Five investment banks failed, was sold, or was converted into a bank holding company. Two mortgage giants and the world's largest insurer were placed under government control. And in early October, with the stroke of the president's pen, the Treasury – and by extension, American taxpayers – became part-owners in what were once the nation's proudest financial institutions.'

### *Adverse selection and the securitisation of subprime assets*

As well as holding asset backed securities on their balance sheets, Investment Banks played a key role in the growth of securitization that is portrayed above in Fig. 1. The dual involvement of the banks contradicts the 'hot potato' – originate and distribute – version of events, as Shin (2010) argues. So what if the securitisation process made it difficult for investors to assess the quality of their investments?

To help analyse the role of investment banks and the rating agencies in packaging and marketing MBS, we apply the adverse selection model of Akerlof (1970) under various assumptions about information as to quality. First we describe the inefficient low-trade equilibrium that Akerlof's analysis predicts given asymmetry of knowledge of quality as between buyers and sellers (but common knowledge as to the parameters of the quality distribution). This being so inefficient relative to the outcome with symmetric knowledge, the question posed is whether the credit rating agencies (CRAs) succeeded in restoring informational symmetry by delivering true quality ratings; or whether, as argued by Akerlof and Shiller, there was 'mining of reputation' by the CRAs who inflate the ratings so as to please the Investment Banks. In the latter case, we show how 'rating inflation' allows sellers to collect more than the assets are worth in a cheating equilibrium. However, if ratings lose all credibility when buyers discover evidence of mis-rating – and if buyers also lower their belief as to the lower bound of asset quality - the result could be market collapse, as indicated in Fig. 1 above.

### *Asymmetric information*

Let there be a pool of risky assets, each indexed by  $\theta$ , a measure of 'quality'.<sup>13</sup> Assume that the price of risky assets is determined by risk-averse investors in a competitive market. With full information, we normalize the price of asset  $\theta$  to be  $\theta$ .

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<sup>13</sup> Thus if all risky assets have the same expected returns but differ in their standard deviations, the parameter  $\theta$  would represent the inverse of the standard deviation.



In what follows, we characterise pricing in competitive equilibrium under asymmetric information. The information structure is that the support and the distribution of  $\theta$  is common knowledge to both the banks and the investors, but only the banks know the quality of any given risky asset. The risky assets are "packaged" and held or sold on by Investment Banks who assign reservation values to these assets denoted  $r(\theta)$  where  $r(\theta) < \theta$ .

The pool of the risky assets available constitutes a set  $[\underline{\theta}; \bar{\theta}]$ , with the measure of quality below  $\theta$  represented by a cumulative distribution function  $F(\theta)$ . Given the asymmetry of information as to quality, there will be a single price reflecting the *average riskiness* of assets made available at that price. Let this price be  $p$ .

As banks will only supply these assets if the market price covers their reservation value,  $\theta(p)$ , the amount of risky assets supplied at any given price, is defined as:

$$\theta(p) = \{\theta: r(\theta) \leq p\}$$

A competitive equilibrium is a price  $p^*$  and a set  $\theta^*$  of risky assets such that

$$\theta^*(p) = \{\theta: r(\theta) \leq p^*\}$$

and

$$p^* = E[\theta \mid \theta \in \theta^*]$$

which together imply that the competitive price must satisfy

$$p^* = E[\theta \mid r(\theta) \leq p^*]$$

i.e. that it matches the expected value of the assets which have reservation values less than the equilibrium price. (Those with higher value are withdrawn.)

#### *An illustration*

Let the pool of the risky assets be uniformly distributed in  $[\underline{\theta}; \bar{\theta}]$ , with reservation values of  $r(\theta) = \alpha\theta < \theta$ . The equilibrium price may be determined as follows. Assume the equilibrium price to be  $p$ , then the set of risky assets offered by banks is

$$\theta(p) = \{\theta: r(\theta) \leq p\} = \{\theta: \alpha\theta \leq p\}$$

If this is the set of risky assets sold in the market, the conditional expectation of the quality of assets can be determined as:

$$E[\theta \mid \theta \in \theta(p)] = \frac{\left(\frac{p}{\alpha}\right) + \underline{\theta}}{2}$$

The equilibrium is given by the condition requirement that, in a competitive equilibrium,

$$p^* = \frac{\theta}{2-\alpha^{-1}}$$

The equilibrium price is within the lowest and the average quality of asset if  $\alpha \in \{\frac{1}{2}, 1\}$  and  $\alpha \geq \frac{1}{2}(1 + \frac{\theta}{\bar{\theta}})$ .

With  $p^*$  as the equilibrium price, the highest quality asset sold in the market is  $\theta_H = p^*/\alpha$ . So the set of assets in equilibrium is  $\theta(p^*) = \{\theta: \underline{\theta} \leq \theta \leq \theta_H\}$ . In the presence of asymmetric information, only lower quality assets are sold in equilibrium.

Note that when  $\underline{\theta} = 0$  then  $p^* = 0$  so only assets which have no reservation value are available in the market. Note also that the smaller is  $\alpha$ , the higher would be the equilibrium price. So decreasing  $\alpha$  increases the set of assets sold in equilibrium.

The competitive equilibrium in this case is illustrated in Fig. 4. For prices falling between the lowest and highest 'reservation values'  $r(\underline{\theta})$  and  $r(\bar{\theta})$ , the expected quality will lie on the schedule labelled BT running from the lower bound  $\underline{\theta}$  at B to the mean  $\tilde{\theta}$  at T. Equilibrium, where the price matches the expected quality, is at E, where BT crosses the 45 degree line. This is the 'rational expectations' equilibrium of Akerlof (1970) where the price is, *on average*, justified by quality. As only lower quality assets are put on the market, it is clearly inefficient relative to the *symmetric information* case, where price matches quality on each and every asset and all MBS will be on the market, as indicated by the dashed section of the 45 degree line between  $\underline{\theta}$  and  $\bar{\theta}$ .

### *Faking the ratings*

For sellers to bundle loans into 'buckets' of similar quality would seem to offer obvious efficiency gains. In the limit, if the grading is fine enough, Pareto efficient equilibrium might be achieved where all loans are traded and average quality rises to  $\tilde{\theta}$ <sup>14</sup>. Given the asymmetry of information, however, there is an obvious temptation for sellers to indulge in 'grade inflation'. Hence the case for third party authentication, by Credit Rating Agencies (CRAs) in particular.

With collusion between the sellers of MBSs and the CRAs – if the latter are prepared to upgrade quality ratings in order to retain business – then the grade inflation will not be checked. A sequence of events consistent with a rise in price of securitised assets followed by market collapse (as indicated earlier in Fig. 1) is illustrated in what follows.

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<sup>14</sup> as in the symmetric information case just described.

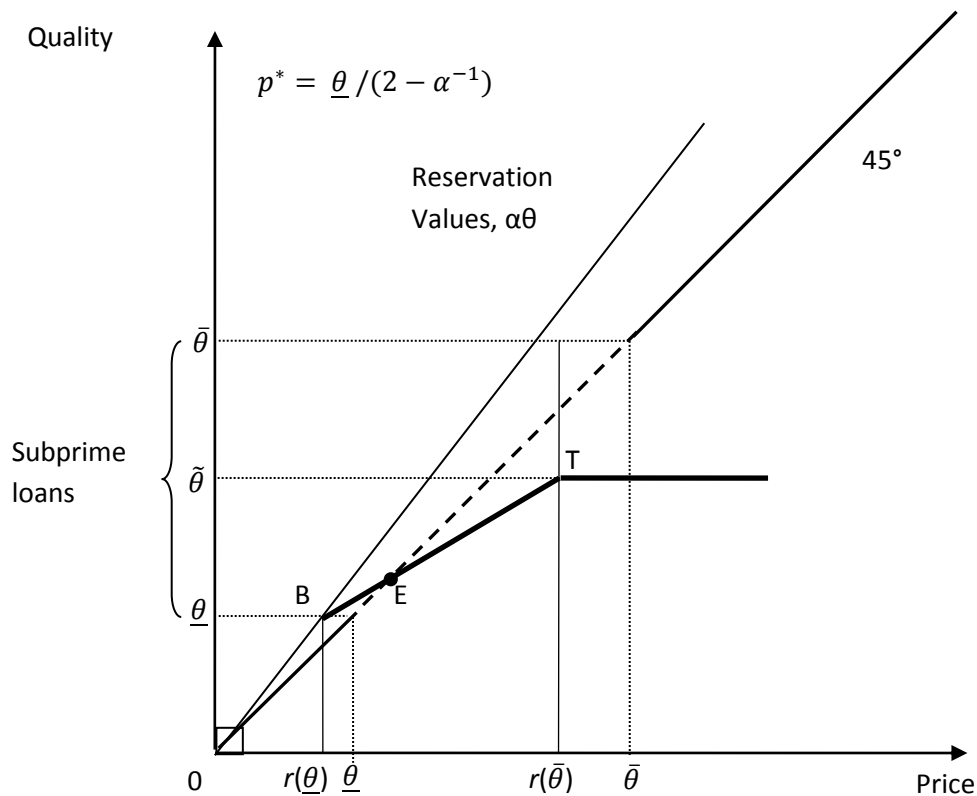


Figure 4. Market equilibria with Asymmetric and Symmetric information

Given that the spread of quality is uniformly distributed in  $[\underline{\theta}; \bar{\theta}]$ , and equilibrium with adverse selection at E, *correct* authentication could add to the average value of MBS traded and, in principle, deliver mean quality of  $\tilde{\theta}$ . But, with collusion between the sellers and the CRAs, buyers can be misled as to the quality. Assume for example that with ‘grade inflation’ the lower bound remains unchanged, but the upper bound *apparently* increases to  $\bar{\theta}'$ , where  $\bar{\theta}' - \underline{\theta} = 2(\bar{\theta} - \underline{\theta})$  i.e. the spread has doubled, so the apparent quality range of authenticated assets on the market now has a mean value at  $\bar{\theta}$ , the high end of the actual distribution. The dashed line labelled MM in Fig. 5 shows graphically how buyers are being misled, with the slope of less than 45 degrees indicating how the price/quality relationship is being distorted (as the overstating of product quality increasing as actual quality rises). If these distorted ratings are taken at face value, all assets will be traded but prices will systematically exceed actual quality (except at the very bottom). The average price paid will be  $\tilde{p}$ , as indicated on the horizontal axis, which will exceed the average quality shown as  $\tilde{\theta}$  on the vertical axis, with ‘overpayment’ averaging  $\tilde{p} - \tilde{\theta}$ , as indicated by the bracket in the figure.

With buyers being systematically misled as to quality, this is no ‘rational expectations’ equilibrium. Differential information is actively being exploited to the advantage those who

know the true quality of the MBS that they are mis-selling. In this in this respect it differs from models such as that of Di Tella (2017), where intermediaries have known incentives to ‘steal’ but markets adjust so that, in equilibrium, there is no stealing. In choosing between such different perspectives, subsequent legal findings can play a crucial role, as discussed below.

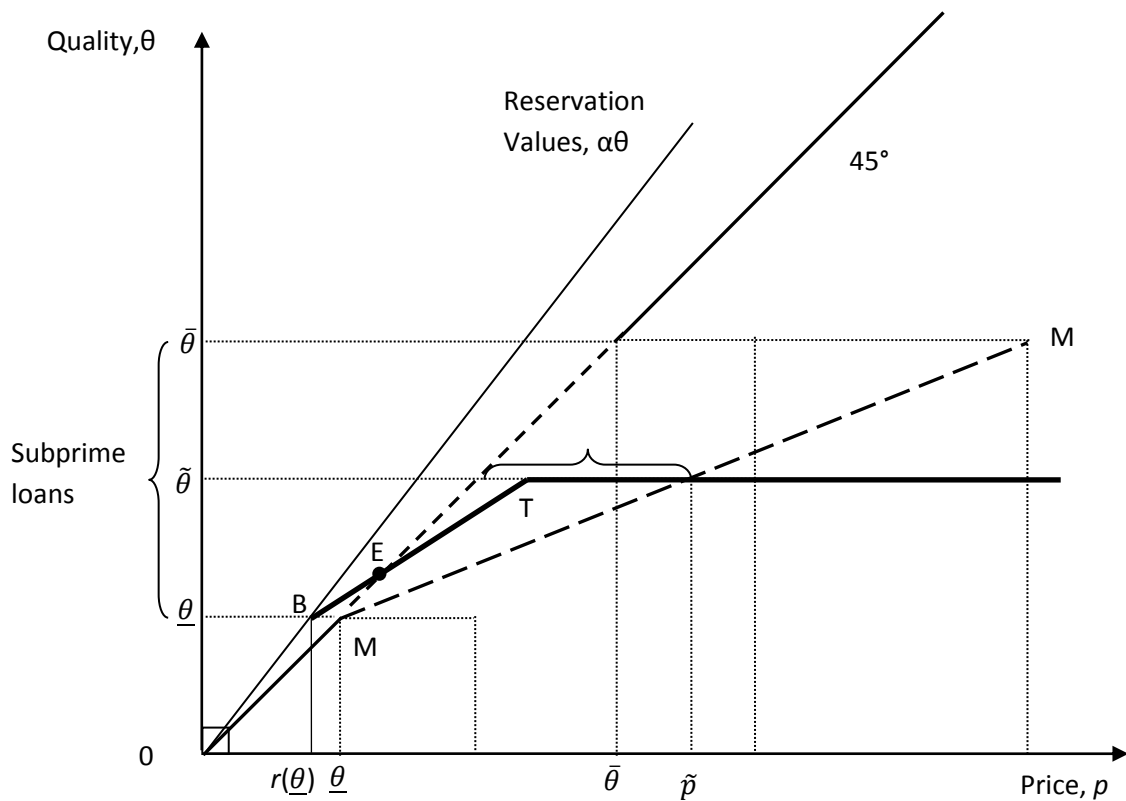


Figure 5. Cheating: market equilibrium with inflated ratings

What happens when the music stops and buyers discover that many of the loans are not, in fact, worth what they were led to expect? It seems self-evident that the ratings will lose credibility and buyers become more wary of subprime than before. Let us assume, specifically, that the ratings are totally disregarded, with prices determined as for equilibrium with adverse selection. Assume also that buyers also shift their beliefs to the detriment of MBS: while willing to credit that the upper support is  $\bar{\theta}$ , they now believe the lower support is zero. With sellers and buyers differing in respect of the parameters of the quality distribution, the equilibrium will not have the ‘rational expectations’ feature of Akerlof (1970).

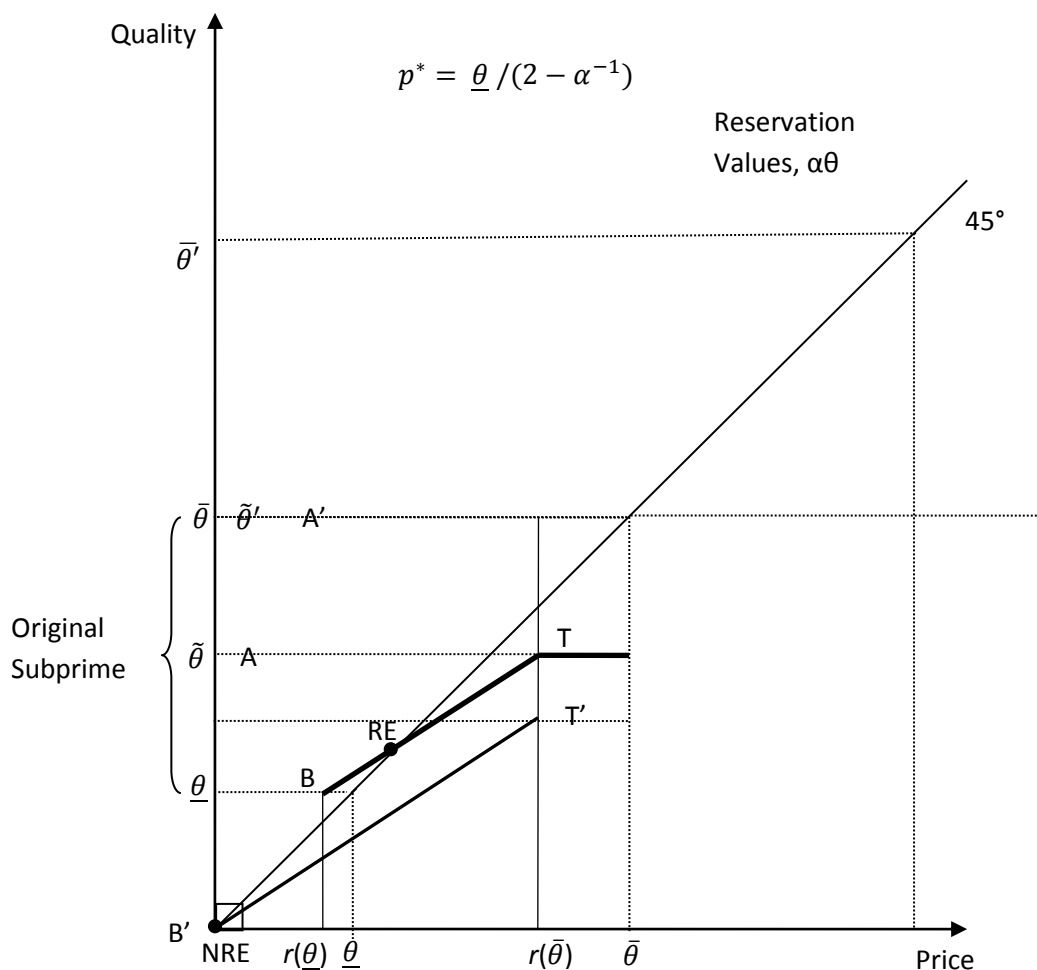


Figure 6. Despair: downside revision of sellers' distribution, leading to collapse.

What will the equilibrium be? Despite the quality being as originally specified, with bounds  $\bar{\theta} > \underline{\theta} > 0$ , the jaundiced beliefs of the buyers, with bounds  $\bar{\theta} > \underline{\theta}' = 0$ , now implies the schedule of expected quality (from the viewpoint of the buyers) is as shown as B'T' in Fig. 6. As this lies below the 45 degree line showing actual quality except at the origin, sellers will find their asset quality systematically undervalued. So the market will collapse with no trade in assets of any quality in what is the no-trade equilibrium of Akerlof (1970), arrived at here by excessively pessimistic beliefs.

The behavioural phenomenon which Gennaioli et al. (2012) have dubbed 'neglected risk' – the tendency of investors to ignore certain possible outcomes – also supports the 'phishing' perspective.

The key insight is that bankers will create securities that are vulnerable only to those neglected risks. ... For, example, if investors convince themselves that house prices throughout the country cannot fall by 10 percent or more, then bankers will create

securities that retain their value in every scenario except when house prices throughout the country fall by 10 percent or more. Because these securities look riskless to investors, they will be produced in abundance. This large expansion in the supply of securities that look riskless will fuel an asset bubble by allowing optimists to buy even more expensive homes. When house prices do in fact fall by more than 10 per cent, the result is catastrophic. Mian and Sufi (2014, p.113, 4)

In addition, Foote et al. (2012) uses empirical evidence to argue that the decline in house price during the crisis might have been entirely neglected scenario rather than being considered with low probability ex-ante.

The account derived from the presence of asymmetric information – and its exploitation by banks working in collusion with the rating agencies to whom prudential regulation had effectively been delegated – generates a boom/bust sequence much like that in the previous section. But the ‘shocks’ on asset quality becomes *endogenous*. This does not imply that the financial accelerator that Shin emphasizes is irrelevant: the impact of developments, both positive and negative, on the equity base of the banks involved will amplify their effects on industry equilibrium, rendering implosion more likely.

If ‘reality is one, though wise men speak of it variously’, one may be tempted to ask whether – and how – these seemingly conflicting accounts might be combined. An ingenious exercise along these lines, Zhang (2017), involves applying the Shin model to determine Demand for risk assets by active and passive investors (based on common but less-than-complete knowledge as to quality), and Akerlof’s approach to determine Supply. The latter will depend on the level of participation by those securitising risk assets, who have full information about quality – where a *distribution* of downside risk provides the basis for distinguishing risk assets on the basis of quality. Adding the assumption of a given *quantity* distribution of risk assets (e.g. a quantity  $\sigma$  of each quality), generates the Supply curve. Aggregate demand by active and passive investors for bundles of MBS securities – who estimate quality by the unconditional mean of the distribution – gives the Demand for risky assets. So market clearing, where Demand matches Supply, provides one way of combining the two approaches.

Such an equilibrium – where the quality assumed on the demand side will exceed the mean quality on offer – has the virtue of showing that the rationality of equilibrium in Akerlof (1970) is not a necessary feature of a model with asymmetric information; and comparative statics will involve both amplification and endogenous supply. But evidence from subsequent legal prosecutions and fines indicates that simply conflating these two approaches omits a key aspect stressed by Akerlof and Shiller (2015), namely the incentive for those with superior information to turn it to their advantage. In practice, it seems, Suppliers turned to ‘manipulation and deception’, as discussed above.

If the subprime crisis merits the description of a perfect storm, it is because it involves so many contributory factors. The two models examined above highlight particular features – the challenges to financial market efficiency and stability coming from asymmetric information and from pecuniary externalities. How these may best be combined is left as unfinished business. For, like the elephant in the parable, reality is undeniably complicated. In the next section, we turn to another aspect – the idea of creditor panic, a bank run.

## **Section 2 Illiquidity: mindless panic or realistic reassessment?**

The ‘insolvency’ views discussed in Sections 1.1 and 1.2 focus on the poor quality of bank assets and the excessive leverage and risk-taking involved. The ‘liquidity crisis’ view by contrast emphasizes

excessive reliance on short-term borrowing and the resulting maturity mismatch, the weakness of ‘mark to market’ accounting rules...and the panic withdrawal of short-term funding that created wide-spread market illiquidity, resulting in undervaluation of assets and the dislocation of money markets where banks normally borrow short term. Alistair Milne (2009, pp.18,19).

Indeed Gary Gorton (2009, 2014), one of the leading proponents of this view, titled the paper on the subprime crisis presented to central bankers and academics at Jackson Hole, as ‘The Panic of 2007’.<sup>15</sup>

The principal piece of evidence Gorton refers to is the cost of insuring against losses on subprime mortgages, as measured by the ABX-HE indices. From January 2006 onwards these indices were constructed to price traded insurance contracts, each contract providing cover on repayments of a bundle of Mortgage Backed Securities for a period of five years.<sup>16</sup> Fig. 7 shows the movements in the BBB and AA versions of this ABX index, reflecting the cost of purchasing investment-grade tranches of twenty major MBS products.

While both indices initially stood at par, the relatively riskier ABX-BBB index began to fall at the beginning of 2007; and both indices began to fall sharply after August 2007 - the date the Panic began, according to Gorton. Continued precipitous decline took the BBB down to about 5c in late 2008; by which time even the less risky ABX-AA index was down to 20c, implying up-front insurance costs of 80c in the dollar.

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<sup>15</sup> This paper was later incorporated in his monograph on the subprime market, Gorton (2014).

<sup>16</sup> Thus a price of 80 for a particular AAA contract on a given date means that the protection buyer must pay 20% of the par value of the AAA index to get protection for the next five years.

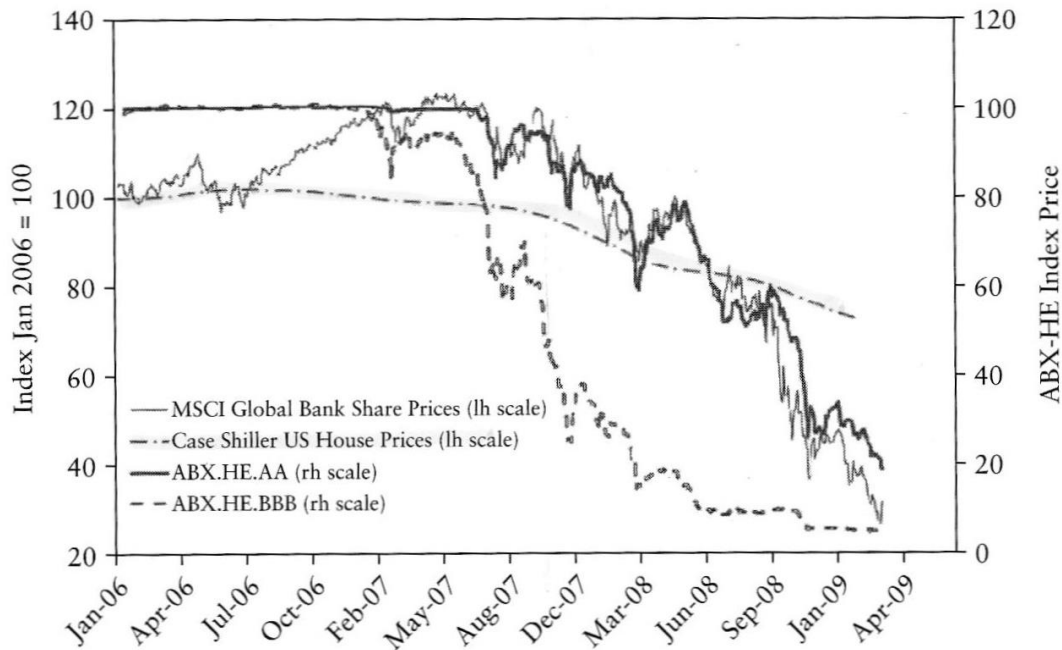


Figure 7 US House prices, ABX indices, and share prices of Global Banks. Source: A. Milne (2009, p. 201)

*Reasons for panic: opacity or product design?*

For Gorton (2009, p.199) the main reason for panic was the ‘loss of information’ involved in securitisation and the consequent ‘opacity’ of MBS securities in terms of their asset backing. He states specifically that ‘House price declines and foreclosures do not explain the Panic’. But, in commenting on Gorton’s paper, Bengt Holmstrom (2009, p. 267) argued to the contrary:

The problem with sub-prime related securities was not the lack of transparency as such... the real problem was the sensitivity of the MBSs to a fall in the average house price. ... *The dynamic credit enhancement model only worked as long as house prices were rising, a point that seems obvious in retrospect.* (Italics added)

For there was a catch to the ‘dynamic credit enhancement’ on offer: the finance provided when house prices were rising would cease when house prices stopped rising, or began to fall. When those who had been lent the funds found no refinancing was available, they would be unable to avoid the scheduled step-up in rates (possibly doubling); and, if house prices were falling, they would need to post more collateral or pay down the loan: otherwise, they could become homeless as their homes were repossessed.

That the banks involved were aware of this emerged from subsequent legal investigation. An email from Angelo Mozilo, co-founder of Countrywide to other Countrywide bank executives, dated August 1, 2005, warned explicitly that:



when the loan resets in five years there will be enormous payment shock and the borrower is not sufficiently sophisticated to truly understand the consequences, then the bank will be dealing with foreclosure in potentially a deflated real-estate market. This would be both a financial and reputational catastrophe.

In circumstances when house prices were already high by historical standards<sup>17</sup>, aggressive marketing of such loans looks to have two undesirable consequences (a) to push house prices yet higher; (b) to leave as homeless those who were unaware of how and when the finance would effectively be withdrawn when the bubble burst. In the process, homeowners may well have been deceived by the mortgage lenders. Mian and Sufi (2014, p. 149) note that: 'Home owners mistakenly believed that house prices would rise forever. Perhaps this was a silly belief, but the image of a sophisticated home owner gaming lenders and the government is wrong. If anything, sophisticated lenders may have taken advantage of naïve home owners by convincing them that house prices would continue to rise.'<sup>18</sup>

As the Case-Shiller index of House Prices plotted in Fig. 7 above indicates, property prices in main US cities peaked in the third quarter of 2006, and went on to decline by about 30% over the next two and a half years. This – the timing of house price declines – supports Holmstrom's analysis.

The evolution of house prices in the US over the long run also supports the idea that house prices had been experiencing a 'bubble' in the years when subprime lending had widened access to house purchase (with Private Label Securitisation lowering credit standards). Fig. 8 shows the index constructed by Robert Shiller giving U.S. house prices in real terms since 1880, where the spike that developed in the early years of this century is clearly visible; and the other series shown suggest that it was not related to underlying fundamentals.

### *Contagion*

Holdings of the 'liquidity crisis' view argue that, by retaining only super-senior tranches on their books, investment banks were immune from insolvency risks. But, as Shin (2010, Chapter 8) points out, the prevalence of interbank lending and borrowing provides a channel for contagion: the liquidity shock suffered by a bank with good assets may be the consequence of withdrawals by another bank suffering equity losses from poor asset quality (causing it to reduce its balance sheet). In other words, one bank's liquidity shock could reflect another's solvency shock.

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<sup>17</sup> As Gorton (2009, p. 202) himself notes: 'it was widely understood that house prices were likely a 'bubble''.

<sup>18</sup> In fact, as indicated below when discussing the fines on investment banks, 'part of the settlement requires Bank of America to pay down mortgages for certain home owners; reduce tax payments for others'.

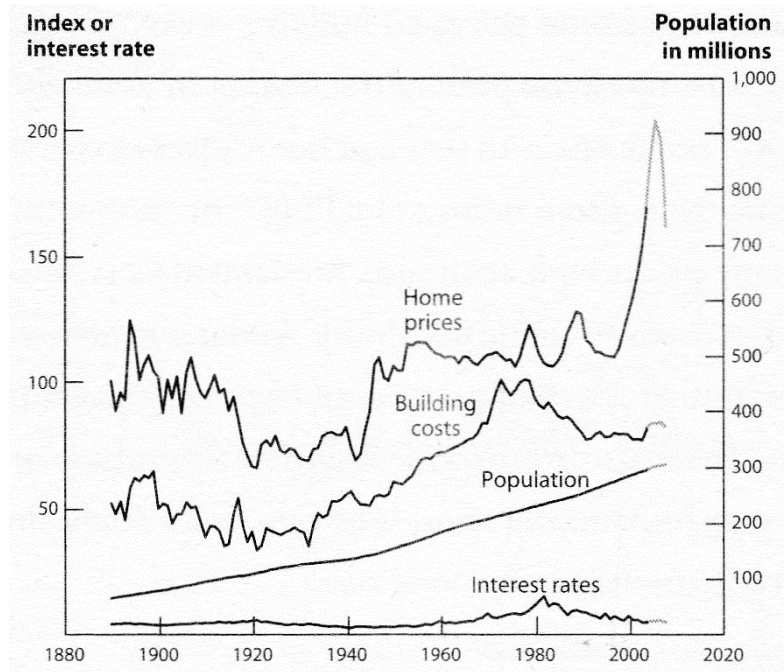


Figure 8 U.S. Real home prices in the long run. Source: R. Shiller (2008, p. 33)

### Section 3 Policy Actions and Legal Evidence

#### *Liquidity provision by the Fed*

For Gorton, the opacity of the products created to securitise loans to subprime households leading to creditor panic in 2007 was a key factor in the financial crisis. There is, of course, no question that the banks were exposed to liquidity risk: ‘the use of overnight repos became so prevalent that, at its peak, Wall Street investment banks were rolling over a quarter of their balance sheets every night’, Shin (2010, p.156).

Action was, moreover, taken by the Fed to help provide liquidity. Thus in March 2008 the Fed created a Primary Dealer Credit Facility making it easier to lend to security firms by widening the range of eligible collateral. Further, when Morgan Stanley and Goldman Sachs – both “enthusiastic practitioners of the new Wall Street model that combined sky-high leverage with heavy reliance on short-term borrowing” – faced a debilitating loss of credit in September 2008, they were granted the status of Bank Holding Companies” thereby pulling the two beleaguered companies inside the Fed’s safety net. That stopped the runs.” Blinder (2013, pp. 153, 4).

But this action to extend the safety net was taken in what Blinder calls ‘The Panic of 2008’, when the *structural* problems of subprime lending described by Holmstrom were already apparent; in other words, it was a liquidity crisis driven by bad fundamentals. This confirms that the mercurial nature of investment bank liabilities left them prone to creditor panic –

so called 'silent bank runs' where creditors fail to rollover their investments; but it hardly supports Gorton's thesis - that a pure liquidity crisis based on opacity, 'The Panic of 2007', was the primary driver of the financial crisis. In the words of Janet Yellen (2017), "the deterioration from early 2007 until early September 2008 was a slow trickle compared to the tidal wave that nearly wiped out the financial sector that September".

#### *Capital injections by the US Treasury: official purchase of preference shares*

For Shin, the wholesale take-up of low-quality subprime assets by highly-leveraged banks at a time when measured risks seemed low was the key factor, leaving them exposed to insolvency as and when 'bad news' arrived.

As balance sheets expand, new borrowers must be found. *Someone* has to be on the receiving end of the new loans. When all prime borrowers have a mortgage, but balance sheets still need to expand, then banks have to lower their lending standards in order to lend to subprime borrowers. When the downturn arrives, the bad loans are either sitting on the balance sheets of the large financial intermediaries or they are on special purpose vehicles that are sponsored by them. This is so, since the bad loans were taken on precisely in order to utilize the slack in their balance sheets caused by the apparent lull in measured risks. Although final investors such as pension funds and insurance companies will suffer losses, too, the large financial intermediaries are more exposed in the sense that they face the danger of seeing their capital wiped out.

Shin (2010, p.156, 7)

This perspective, that the 'fair weather' expansion strategy posed the risk of insolvency when storm clouds appeared, finds support in the action taken by the US Treasury in October 2008. As Blinder notes: 'most banks were presumably undercapitalized on a mark-to-market basis at the time. They needed capital desperately, and most of them could not raise it on the dire circumstances of October 2008. ... Equity injections would improve banks' capital positions directly'.

Alongside losses and write-downs totalling \$344b incurred in 2007/8, the table provides details of the principal capital injections<sup>19</sup> made by the US Treasury using TARP funds, running to a total of almost \$100b for the banks in the table. For a pure liquidity crisis, where the investments of the banks are not in question, such capital support is not necessary. But in this case, when house prices were already falling, subprime insurance had become prohibitively expensive, the MBS market had essentially closed down and losses amounted to a third of a trillion dollars, such solvency support was considered essential.

#### *Phishing for Phools?*

As noted above, the asymmetric information account of Akerlof and Shiller stands in sharp contrast to the 'common knowledge' perspective of Shin, where active banks compete with patient lenders to supply funds to risky borrowers, maximising profits in a regulatory regime

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<sup>19</sup> Enforced purchases of preference shares.

facing exogenous ‘news shocks’ amplified by VaR-based financial accelerators. What is offered, instead, is an analysis based explicitly on ‘the economics of manipulation and deception’. Investment banks can make high returns by taking on ‘tail risk’, concealing this by getting the investments rated as first class; they can further increase their profits by selling the magic elixir to others, while hedging their own exposure by purchasing CDS. On this account, the risks to which the shadow banking system is exposed are the consequence of exploiting information asymmetry for profit.

**Table 2 Big Five Investment banks and survivors of the Big Eight: losses, capital injection, fines**

The ‘Big Five’ US Investment Banks (as of early 2008)	Assets, Leverage, and equity end 2007	Fate after crisis	‘Big Eight’ Banks (Current Survivors)	Credit losses and write downs 2007-8	Capital injections October 2008	Subsequent fines for Mis-selling of MBS
Goldman Sachs	\$1,120b (26; \$43b)*	Became a Bank H Co in Sep 2008	Goldman Sachs	\$10b (0.7)**	\$10b	\$5b
Morgan Stanley	\$1,045b (33; \$32b)	Became a Bank H Co in Sep 2008	Morgan Stanley	\$19b (2.1)	\$10b	\$3b
Merrill Lynch	\$1,020 (32; \$32b)	T/O by Bank of America, Sep, 2008	Bank of America	ML: \$73b (7.5) BoA: \$57b (1.8)	\$25b	\$17b (+\$37b set aside)
Lehman Bros	\$691b (31; \$22b)	Liquidation, Sep 2008	–	\$30b (5.0)	–	–
Bear Sterns	\$396b (33; \$12b)	T/O by J P Morgan, Mar 2008	J P Morgan	\$41b (2.8)	\$25b	\$13b
			Citigroup	\$114b (4.0)	\$25b	\$7b
<b>Totals</b>	\$4,272b IBs only			<b>\$344b</b>	<b>\$95b</b>	<b>\$45b</b>

Notes: \*Figures in brackets are leverage, Assets / Equity, followed by Equity. \*\* Figure in brackets shows ratio of losses and write downs to 2006 pre-tax earnings.

Sources: Losses: Milne (2009, p.249); Injections: Sorkin (2009, p.524 ); Fines: (DoJ web reports)

Although Akerlof and Shiller make only passing reference to legal measures, substantial support for their perspective comes from legal decisions subsequent to the crisis, as indicated in Table 2.

### *Mis-selling of MBS*

First there are ‘fines’ on the Investment Banks themselves - settlements agreed to with Federal and/or State prosecutors for having misled other investors as to the quality of the MBS they sold. The sums paid by investment banks and the big commercial banks such as Bank of America, J P Morgan and Citigroup amount to \$45b, as shown in the Table (of which \$8b were levied on the two surviving investment banks, and \$20b on the big banks that had taken over Bear Sterns and Merrill Lynch).

The largest fines – and some of the most chilling evidence – comes from the case against Bank of America which, in addition to acquiring Merrill Lynch, had earlier taken over Countrywide Financial, the largest lender of subprime mortgages in the US. At a press conference where the settlement against Bank of America was announced, Eric Holder, the U.S. attorney general, is on record as saying:

These financial institutions knowingly, routinely, falsely, and fraudulently marked and sold these loans as sound and reliable investments. Worse still, on multiple occasions – when confronted with concerns about their reckless practices – bankers at these institutions continued to mislead investors about their own standards and to securitize loans with fundamental credit, compliance, and legal defects.

The fines were for misleading investors as to the quality of the mortgages that had been securitised and sold on. But what about the homeowners who had been persuaded to take out loans which might well fail? In the case of Bank of America ‘part of the settlement requires Bank of America to pay down mortgages for certain home owners; reduce tax payments for others; and pay to demolish abandoned homes in certain neighborhoods to reduce urban blight’. In addition, it appears, ‘the bank has also set aside \$37.3 billion to buy back bad mortgages from investors’. (Guardian newspaper report).<sup>20</sup>

### *Collusion with CRAs?*

The allegation of collusion between Credit Rating Agencies and investment banks has also been the subject of court proceedings; with fines imposed on the two major agencies as follows. In February, 2015 S&P settled for a fine of \$1.5b – and it was reported that ‘S&P executives admitted that they made decisions about testing and rating CDOs based at least

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<sup>20</sup> It would be interesting to see how these redress procedures compare with those set by the Financial Conduct Authority for UK banks who had mis-sold interest rate swaps to small and medium enterprises, as described on [www.the-fca.org.uk/consumers/interest-rate-hedging-products](http://www.the-fca.org.uk/consumers/interest-rate-hedging-products).

partly on the effect they might have on relationships with the banks issuing them'. In January of 2017, Moody's settled for a sum of \$0.9b. Both credit rating agencies have thus agreed to pay substantial settlements for mis-rating; with S&P admitting what Akerlof and Shiller allege, namely that the ratings were influenced by the incentives to retain the business.

For Gorton the main reason for panic was the 'opacity' of MBS securities in terms of their asset backing leading to a collective 'loss of confidence' hitting the investment banks when the housing bubble burst. But the legal proceedings and fines imposed indicate that the investments did not deserve confidence that they had enjoyed. According to evidence from the courts, mortgage originators had sold financial products to low-income households without explaining the downside risk; and investment banks had mis-sold bundles of the resulting mortgages to other financial institutions, keeping super-senior tranches on their balance sheets. So creditor panic could be understood as a reaction to discovering the business model of subprime lending was seriously flawed.

#### *Summary overview*

In previous sections we have presented various insights offered by seasoned observers on reasons for crisis – be it the powerful momentum effects of VaR-based banking, the irresistible temptation to conceal risks faced by many financial operatives, or the quick-silver nature of the liabilities financing much of the risky lending. Each of these factors, it seems, could alone lead to financial disaster. But the actions taken by those holding the levers of monetary and fiscal policy at the time, together with the legal determinations made subsequently by prosecutors in US courts of law, show that, in reality, the crisis had multiple contributory causes.

How evidence from policy action and the law courts supports such a multi-faceted perspective is indicated in Fig. 9.

That the investment banks were hit with *liquidity shocks* is clear enough. For Gorton (2010), who endorses the soundness of their business model, there was a pointless panic in 2007, stemming- from a 'lack of transparency', see the area labelled (1). His view was challenged by Holmstrom, who pointed the finger at fundamentals; and it was in 2008, after Lehman's went bankrupt, that the Fed gave banking status to Goldman Sachs and Morgan Stanley – the only remaining independent Investment Banks – and supplied them with plentiful liquidity, pending subsequent support from the Treasury. So there was a liquidity shock, but not without good reason.

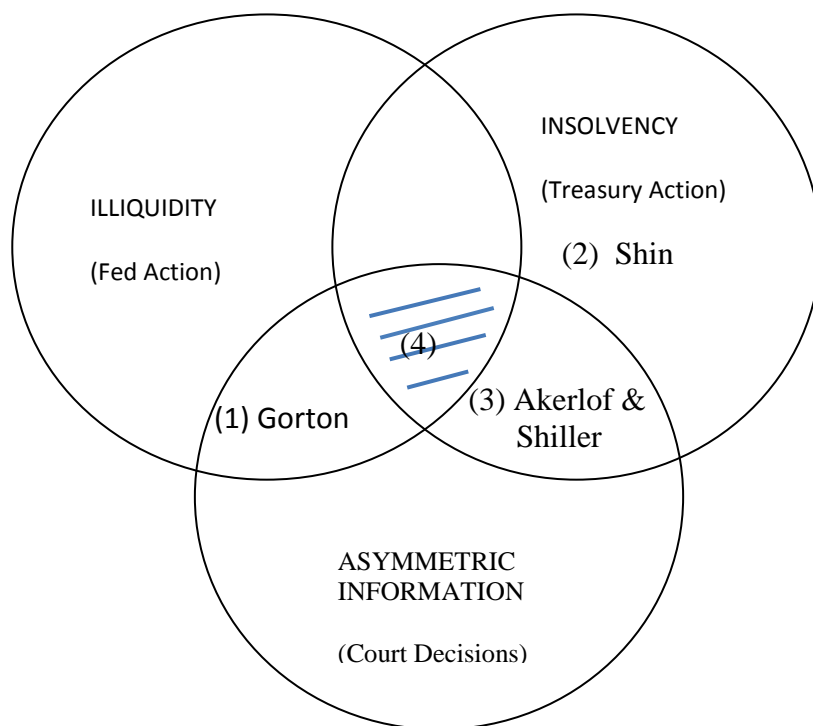


Figure 9 Illiquidity, Insolvency and Asymmetric Information, as indicated by policy action and legal proceedings

For banks, of course, risk of insolvency is a key driver of creditor sentiment: and for investment banks who had invested in subprime, solvency was surely at risk: why else did the US Treasury have to step in to provide equity for them with TARP funds? Shin’s iconic analogy of the Millenium Bridge suggests that the threat of insolvency could be attributed to some unanticipated, exogenous ‘bad news’ greatly amplified by ‘pecunuiary externality’. In this case, no illiquidity nor asymmetric information need be involved, as for the area labelled (2) in the Figure.

The evidence of legal decisions, however, confirms that world-leading investment banks and rating agencies *exploited asymmetric information* to market subprime assets as high-quality investments for private profit, as alleged by Akerlof and Shilller. Insolvency involving asymmetric information could lie in the areas labelled (3) and (4), depending on the impact of liquidity shocks.

From policy actions to support the institutions involved – and the fines subsequently imposed upon them – one is led to conclude that the shaded area (4) in the Figure – ‘triangulated’ by the three views just discussed – gives the best impression of the nature of the crisis. Its heart of the crisis lay in the betrayal of trust by institutions that were the very pillars of the financial system. That revelations of this could trigger price effects that could have wiped out their equity base is hardly surprising. For these were hardly exogenous ‘bad

news' shocks; more like evidence - to be borne out subsequently in courts of law - that key players had their hands in the till!

In her speech a decade after the crisis began, the current chair of the Federal Reserve endorsed a multi-faceted approach, noting that: "the vulnerabilities within the financial system in the mid-2000s were numerous and, in hindsight, familiar from past financial panics". As she went on to observe:

In response, policymakers around the world have put in place measures to limit a future build up of similar vulnerabilities, ...Preeminent among these domestic and global efforts have been steps to *increase the loss-absorbing capacity of banks*, regulations to *limit both maturity transformation* in short-term funding markets *and liquidity mismatches* within banks, and new authorities to facilitate the *resolution* of large financial institutions and to subject systemically important firms to more stringent *prudential regulation*. Yellen (2017) (italics added)

#### *Legal evidence – why “deferred prosecution agreements”?*

To help establish asymmetry of information, we have appealed to the 'fines' imposed on banks and rating agencies for mis-selling and mis-rating. But the courts have been criticised on the grounds that, in contrast to what happened in previous crises – that of savings-and-loan associations in the 1980s and the accounting frauds of the 1990s, for example – 'not a single high-level executive has been successfully prosecuted in connection with the recent financial crisis', Rakoff (2014). In the article cited, retired Judge Rakoff notes that there has, in fact, been a shift from prosecuting high-level individuals to prosecuting companies. In order to change 'corporate culture', the policy pursued is to secure "deferred prosecution agreements" (DPAs) in which the company, under threat of criminal prosecution, agrees to pay a fine and to take remedial measures to prevent future wrong-doing.

As the Department of Justice has argued, it is indeed difficult to prove fraudulent intent on the part of high-level management of the banks and companies in cases that involve the mis-selling of innovative financial products.<sup>21</sup> While the product itself may provide welfare improvement from better risk-sharing, its complexity not only gives room for sellers to manipulate the quality being offered to investors, but also proves to be a 'grey area' for court cases. The very complexity allows bank executives to argue that they have the same beliefs about the quality of MBS as they describe to investors, for example.<sup>22</sup> As John Kay (2017) notes, however, 'the very prevalence of such [DPA] settlements is an indication that their deterrent effect is small. Senior executives appear not to mind paying out large

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<sup>21</sup> Making successful criminal prosecution is a great deal more costly than securing a DPA, an important factor if, as some allege, the relevant Federal agencies were being starved of funds.

<sup>22</sup> In the circumstances, rather than individual banks 'phishing for phools' it might be more appropriate to talk of 'market phishing', to borrow the terminology of Akerlof and Shiller (2015).



amounts of shareholders' money to escape any personal liability for their actions, or the actions of those whom they ostensibly supervise'.

Improving the prospects for prosecution may involve reducing the 'grey areas' arising from the complexity of innovative financial products. This will not only assist in pursuit of fraud, but, by reducing product opacity, should restore confidence in the market. It will also require more funding for the purpose.

Interestingly enough, a recent proposal by Mian and Sufi (2014, Chapter 12) is that *appropriate* financial innovation may be the key to preventing a recurrence. They argue that standard mortgage contract, which 'forces the borrower to bear the full burden of a decline in house prices until his equity is completely wiped out, be replaced by Shared-Responsibility Mortgages (SRM). An SRM has two important differences: (1) the lender offers downside protection to the borrower; and (2) the borrower gives up 5 percent capital gain to the lender on the upside'. The risk-sharing involved in such contracts keeps the loan-to-value ratio stable even when house prices fall: it should also make lenders more cautious about lending into the boom – and so limit house price volatility.<sup>23</sup>

Insofar as the subprime experiment was designed to give marginal borrowers access to housing, it must be judged a spectacular failure. Far better to provide explicit subsidies; e.g. government matching of down-payments by new homebuyers as Calomiris (2009, p. 29) suggests; or to promote the introduction of SRM contracts as Mian and Sufi and David Miles recommend.

#### **Section 4 Conclusion**

Given mark-to-market accounting and the usual VaR conventions, highly-leveraged investment banks could, it seems, face insolvency due solely to exogenous common shocks to fundamentals: a simple reversal of 'good news' on the perceived quality of risky assets could be sufficient. We have argued, however, that the shocks were in practice *endogenous* – due to the mis-selling of subprime assets by investment banks, assisted by excessively favourable assessments on the part of rating agencies. Rather than some 'rational expectations' equilibrium with common knowledge, the legal evidence is of temporary cheating equilibrium leading to crisis when the truth emerges.

That financial institutions who nightly need to roll over a quarter of their balance sheets are exposed to creditor panic is uncontroversial. What is controversial is to maintain that the subprime crisis was caused by unreasoning panic based on product opacity rather than fear based on bad news about the business model.

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<sup>23</sup> The UK experiment with a 20% 'shared equity loan' available under the Government's 'Help to buy' programme launched in 2013 is analysed in Miles (2015), who argues that even such limited risk-sharing could have substantially mitigated the Great Recession in the UK.

The three views we have focussed on provide plausible threats to financial stability coming from differing factors – from externalities, cheating, or balance sheet fragility. So one may be tempted to ask: which one is correct? As the parable of the elephant suggests, however, each may provide a partial perspective of a complex reality that involves all of them. The actions of policy-makers and the courts supports this conclusion, as does the ex post assessment of the current chair of the US Federal Reserve.

That these threats to stability should be complements and not substitutes is more than a point of technical interest. What is being described is how radically the US financial system was exposed to failure. The emergency actions of policy-makers was, however, to provide unprecedented liquidity and capital support to world-leading banking institutions soon to be found guilty of serious malfeasance. Rating agencies, upon whom the Basel Committee had seen fit to rely for ensuring the quality of bank risk assets, were likewise found by top prosecutors to be complicit in deception.

Acemoglu and Robinson (2012) have famously argued that a nation's prospects for successful long-run growth depend essentially on the quality of its institutions: and the US is typically cited as an example of best practice. That the US financial system and its key institutional pillars should be so injury-prone must throw some doubt on this assessment, particularly if the law is being hobbled in its pursuit of those responsible.

## **References**

Acemoglu and Robinson (2012) *Why Nations Fail*. London: Profile Books

Adrian, T. and H. S. Shin (2010). "Liquidity and Leverage", Paper presented at BIS Annual Conference, June 2007. *Journal of Financial Intermediation*, 19(3), pp. 418-37.

Adrian, T. and H. S. Shin (2011) *Financial Intermediaries and Monetary Economics*. Handbook of Monetary Economics, Volume 3A.

Akerlof, G. A., (1970) "The market for "lemons": quality uncertainty and the market mechanism", *Quarterly Journal of Economics*, 84(3), 488-500.

Akerlof, G. A. and R. J. Shiller, (2015) *Phishing for Phools: The Economics of Manipulation and Deception*. Princeton, NJ: Princeton University Press.

Allen, F. and E. Carletti (2012) "Systemic Risk and Macroprudential Regulation" chapter 10 in Allen, F., et al. eds. *The Global Macro Economy and Finance*. Basingstoke: Palgrave Macmillan.

Arnold, V. I. (1984) *Catastrophe Theory*. Berlin: Springer-Verlag.

Aymanns, C., F. Caccioli, J.D. Farmer, V.W.L. Tan (2016). "Taming the Basel leverage cycle". *Journal of Financial Stability*, <http://dx.doi.org/10.1016/j.jfs.2016.02.004>.

Blinder, A. S. (2013) *After the Music Stopped: The Financial Crisis, the Response, and the Work Ahead*. NY, NY: Penguin Group.

Brunnermeier, M. K. , T. M. Eisenbach and Y. Sannikov (2012). "*Macroeconomics with Financial Frictions: A Survey*,". NBER Working Papers 18102, National Bureau of Economic Research.

Calomiris, C. W. (2009) "The Subprime Turmoil: What's Old, What's New and What's Next". *Maintaining Stability in a Changing Financial System*. Federal Reserve Bank of Kansas City 2009.

Calomiris, C. W. and S.H. Haber, (2014) *Fragile by Design: the political origins of banking crises and scarce credit*. Princeton, NJ: Princeton University Press.

Carlin, W. and D. Soskice. (2015) *Macroeconomics: Institutions, Instability, and the Financial System*. Oxford: Oxford University Press.

Coimbra, N. and R. Helen, (2017) *Financial Cycles with Heterogenous Intermediaries*. LBS Working Paper. (March 3)

Danielsson, J., P. Embrechts, C. Goodhart, F. Muennich, O. Keating, C.Renault and H. S. Shin, (2001) "An academic response to Basel II" Financial Markets Group, Special Paper 130, LSE.

Di Tella, S. (2017) "Optimal Regulation of Financial Intermediaries" Paper presented at the XX Worksp in International Economics and Finance, Buenos Aires (March)

Foote, C. L., K. S. Gerardi and P. S. Willen (2012) "Why Did So Many People Make So Many Ex Post Bad Decisions? The Causes of the Foreclosure Crisis." Federal Reserve Bank of Boston Public Policy Discussion Paper 12-2.

Fostel, A. and J. Geanakoplos (2012) "Tranching, CDS and asset prices: how financial innovation can cause bubbles and crashes". *American Economic Journal: Macroeconomics*. 4(1) pp. 190-225.

Foster, D. and P. Young (2010) "Gaming performance fees by portfolio managers" *Quarterly Journal of Economics*, pp. 1435-1458.

Gennaioli, N., A. Shleifer and R.Vishny (2012) "Neglected risks, Financial Innovation and Financial Fragility". *Journal of Financial Economics* 104 pp. 452-68.

Goodhart, C. (2011) *The Basel Committee on Banking Supervision: a history of the early years 1974-1997*. Cambridge: Cambridge University Press.

Gorton, G. B. (2009) "The Panic of 2007". *Maintaining Stability in a Changing Financial System*. Federal Reserve Bank of Kansas City. Reprinted in Gorton, G. B. (2014). *Slapped by the Invisible Hand*. Oxford University Press.

Hellman, T.F. K.C. Murdock, and J. E. Stiglitz (2000) "Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough?" *American Economic Review*, vol. 90(1), pp. 147-165.

Holmstrom, B. (2009) Commentary: "The Panic of 2007". *Maintaining Stability in a Changing Financial System*. Federal Reserve Bank of Kansas City.

Holmstrom, B., and J. Tirole (1997): "Financial Intermediation, Loanable Funds, and the Real Sector," *Quarterly Journal of Economics*, 112(3), 663-691.

Kay, J. (2017) "Justice has settled for second best in the Rolls Royce scandal" *Financial Times*, 21 Jan.

Mian, A. and A. Sufi (2014). *House of Debt*. Chicago, IL: University of Chicago Press.

Miller, M. and L. Zhang (2015). "The Hedgehog and the Fox: from DSGE to Macro Pru". *Manchester School*, vol. 483, No. S3, pp. 31-55.

Miller, M, L. Zhang and S. Rastapana (2016) 'A comedy of errors: misguided policy, mis-sold mortgages and more' DP No.11533, London: CEPR.

Miles, D. (2015), "Housing, Leverage, and Stability in the Wider Economy, *Journal of Money, Credit and Banking*, Vol: 47, Pages: 19-36.

Milne, A. (2009) *The Fall of the House of Credit: What Went Wrong in Banking and What Can Be Done to Repair the Damage?* Cambridge: Cambridge University Press.

Rajan, R. G. (2005) "Has Financial Development Made the World Riskier". *The Greenspan Era: Lessons for the Future*. Kansas City, MO: Federal Reserve Bank of Kansas City.

Rajan, R. G. (2010) *Fault Lines*. Princeton, NJ: Princeton University Press.

Rakoff, J. S. (2014) "The Financial Crisis: Why Have No High-Level Executives Been Prosecuted?" *The New York Review of Books* (January 9)

Shin, H. S. (2010) *Risk and Liquidity*. Oxford University Press

Shin, H. (2005) "Commentary: Has financial development made the world riskier?" *The Greenspan Era*, pp. 381-386. Kansas City, MO: Federal Reserve Bank of Kansas City.

Sorkin, A. R. (2009) *Too big to fail*. NY, NY: Viking Penguin

Stockman, D. (2013) *The Great Deformation*. NY, NY: PublicAffairs

Yellen, J. L.(2017) "Financial Stability a Decade after the Onset of the Crisis". *Fostering a Dynamic Global Recovery*. Kansas City, MO: Federal Reserve Bank of Kansas City.

Zeeman, E. C. (1974) "On the Unstable Behaviour of Stock Exchanges". *Journal of Mathematical Economics*, Volume 1, Issue 1, March, pp. 39-49

Zhang, Y. (2017) "Procyclical-leverage, asymmetric information and financial market instabilities". MSc Dissertation, University of Warwick.

## Annex A

### *Effect of exogenous shocks raising asset quality*

How to determine the ultimate effect taking these externalities into account? To derive this formally, note first how, with mark-to-market gains following an improvement in asset quality, the previously binding VaR constraint is relaxed and the new equity level of active investors is given by:

$$e' = p'y - (q - z)y \quad (\text{A1})$$

where  $p'y$  denotes assets revalued at new prices and  $(q - z)y$  is pre-existing level of borrowing. The increased equity value allows active investors to take more risky assets onto their balance sheets. These expand until VaR constraint is again binding, so:

$$e' = p'y' - (q' - z')y' \quad (\text{A2})$$

where  $y'$  denotes the new optimal holdings of risky assets held by active investors, and the improved asset quality is indicated by  $q' > q$ ,  $z' < z$ .

For the holding of risky assets by active portfolio managers, equations (A1) and (A2) imply the expanded level of asset holdings following such favourable shocks is:

$$y_A' = y_A \left( 1 + \frac{(q' - q) - (z' - z)}{p' - q' + z'} \right)$$

or

$$y_A' - y_A = y_A \left( \frac{(q' - q) - (z' - z)}{z' - \frac{z'^2}{3\tau}(1 - y_A')} \right) \quad (\text{A3})$$

given the market clearing condition,  $y_P' + y_A' = 1$ .