The blind monks and the elephant: contrasting narratives of financial crisis[1]

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Abstract

Three persuasive narratives of the US subprime crisis are explored with reference both to theory and to emergency acts of public policy undertaken. First the role of *pecuniary externalities* that amplify any shocks to the quality of risk-assets held by Investment Banks and others. Second is *adverse selection* in marketing these assets; and third the role of *financial panic* in making investment-banking disaster-prone. How relevant these differing perspectives proved is attested by the nature of state support and by subsequent findings in courts of law.

As Chair of the US Federal Reserve, Janet Yellen argued that vulnerabilities within the US financial system in the mid-2000s were "numerous and familiar from past financial panics". That the varied threats to stability featuring in these narratives should be complements and not substitutes is of more than technical interest: it helps to explain 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

Introduction

If financial markets are efficient, how to explain the near-collapse of the global financial system in 2007-2009? The answer given by Andrew Lo is that 'the Efficient Markets Hypothesis isn't wrong, it's incomplete. ... Academia, industry and public policy have assumed rational economic behaviour for so long that we've forgotten about the other aspects of human behavior, aspects that don't fit as neatly into a mathematically precise framework.' *Adaptive Markets* (2017, pp.3,9).

Economists such as George Akerlof and Robert Shiller had already adopted such a wider perspective, as in their 2009 monograph on *Animal Spirits.* With special reference to financial markets, Andrew Lo advocates an evolutionary approach which allows for the sophisticated procedures which promote market efficiency in normal times to be over-ruled by instinctive behaviour in face of the unexpected. To motivate such a multi-faceted view of financial markets, where neatly calculated rationality can be combined with elemental fear and greed, he appeals to an analogy - the ancient Hindu parable of the five blind monks who encounter an elephant for the first time.

> Being blind from birth, they have no idea what this strange creature is, but when one monk feels the elephant's leg, he concludes "an elephant is just like a tree," and when another monk feels the trunk, he disagrees, saying "an elephant is just like a snake", and so on. Each monk's impression is technically correct but they all miss the bigger picture. Lo (2017, p.3)

It is in this spirit that we consider three narratives that have been proposed to explain the global financial crisis - each seemingly sufficient, but each drawing on different aspects of market performance and human behaviour.

The first of these focuses on the presence of *externalities* as the primary explanation of why markets failed – with the added twist that in financial markets these show up as 'pecuniary' externalities[2] that distort asset prices. The second narrative is based on the challenge that *asymmetric information* can pose for market efficiency. The

[2] As defined in the review of the literature that follows.

insights that George Akerlof (1970) illustrated with respect to markets for second hand cars can, it seems, also be applied to markets in financial assets - though equilibrium may not have the 'rational expectations' property which he imposed. The third narrative examined, *financial panic*, relies most explicitly on instinctive patterns of human behaviour. Panic evidently did play a role in the crisis, though the view of Gary Gorton that investor 'Panic of 2007' was the essential trigger of the global financial crisis is open to dispute.

As a guide to judging the relevance of these narratives, we look first and foremost at how the monetary and fiscal authorities chose to act as they strove to avoid a repeat of the Great Depression. How did those in charge of lender of last resort facilities or credit guarantees, for example - or tax-payer funded capital injections - react when faced with evolving crisis? Reference is also made to judgements made in the courts of law; for it is here, we believe, that the allegations of market manipulation by those with superior information were most clearly tested. What does the evidence collected by prosecutors - and the judgements that followed - reveal?

While these narratives throw light on different aspects of the crisis, the evidence suggests the crisis was so severe because all had a part to play.

A selective overview of relevant literature

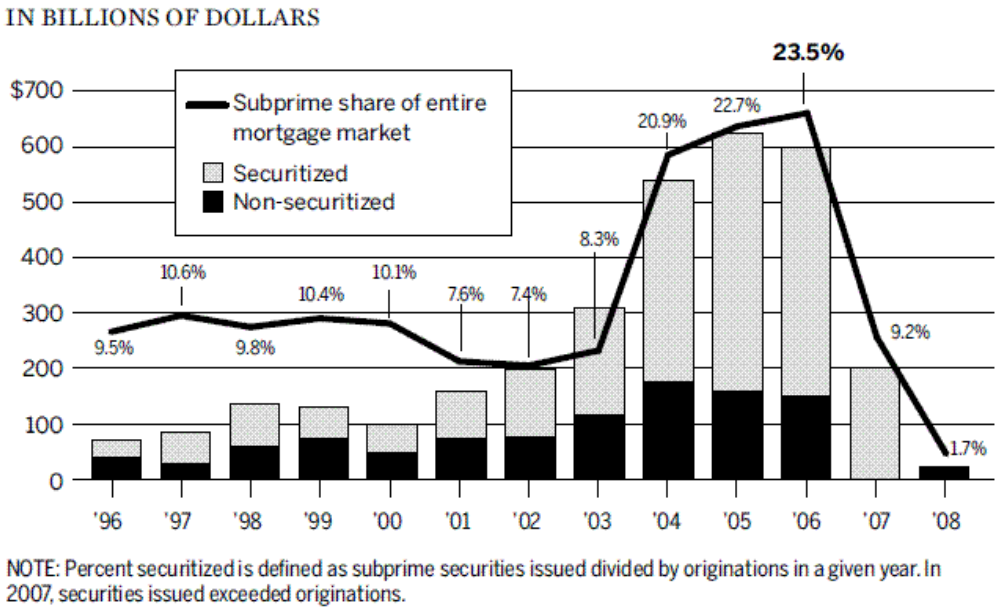

Figure 1 U.S. Subprime mortgage originations. Source: Financial Crisis Inquiry Commission Report, p.70.

To set the scene with institutional and policy background, a key reading is the *Report of the Financial Crisis Inquiry Commission* (2011). In Figure 1 taken from this report, one sees for example the dramatic increase in the share of subprime mortgages in all mortgage originations - almost tripling from 2003 to 2006 – only to fall precipitously when the house-price bubble burst, with virtually none being securitized in 2008. For reasons of space, however, we restrict ourselves here to discussing academic contributions bearing directly on the chosen narratives[3].

First is the paper presented at Jackson Hole by Raghuram Rajan (2005) which famously asked whether financial development has made the world riskier. The focus of his concern was how the combination of *leverage* and *asymmetric information* in financial intermediation could lead to excessive risk-taking. Though his critique met with general scepticism, 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* that can arise when agents are subject to financial constraints which depend on aggregate state variables such as the market value of capital assets[4]. In an iconic metaphor, Shin (2005) used the internal dynamics of London's Millenium Bridge to illustrate how shocks can be greatly amplified by externalities 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 lack of transparency in financial innovation could trigger *financial panic.* It was, he argued, the 'loss of information' involved in securitisation and the consequent 'opacity' of MBS securities in terms of their asset backing that was the root of the crisis - though this view did not pass unchallenged.

[3] A summary background guide to official housing policy is, however, provided in Miller et al. (2016, 2017).

[4] As Davila and Korinek (2015) observe: "Intuitively, when agents are subject to a binding constraint that depends on aggregate variables, a planner internalizes that she can modify allocations to relax financial constraints. For example, the planner may reduce fire sales to raise the value of capital assets that serve as collateral, which raises the borrowing capacity of constrained agents." Further discussion of pecuniary externalities is provided in Miller and Zhang (2015).

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[5]. They stress the role of *heterogeneous beliefs* as the driver of 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. Lying between detailed partial equilibrium models of banking and 'institution free' general equilibrium, another fast-growing branch of the literature focuses on adding 'financial frictions' to DSGE models cast in the Gali/Woodford tradition of modern macroeconomics. Though we make no attempt to discuss these contributions here, a good illustration of the DSGE approach, with a helpful summary of the literature in this burgeoning field, is available in Coimbra and Rey (2017).

The majority of papers on the financial crisis take a partial equilibrium perspective – with a focus on 'shadow banking' in particular. As usual, there is a split between those, like Gary Gorton, who emphasize the role of *shocks to confidence* in a setting where fundamentals are essentially well-founded, and those who focus on *structural flaws* in incentives and/or the regulatory structure which can precipitate insolvency due to excess risk-taking.

Prudential regulation to check excess risk-taking by highly-leveraged institutions was widely discussed well before the subprime crisis as Goodhart (2011) testifies. A key issue in debate was whether the VaR[6] rules - to be adopted in Basel II to check risk-taking by individual banks - would be sufficient to guarantee systemic stability; or whether they could be flawed for ignoring externalities. A masterly survey of the literature on the problems posed by such externalities is provided by Brunnermeier et al. (2012).

An issue that they leave on one side, however, is that of distorted incentives due to *asymmetric information,* an issue analysed earlier by Holmstrom and Tirole (1997) and Hellman et al. (2000), for example. How financial innovation could exacerbate this problem – as high-lighted by Rajan (2005) - was emphasized by Foster and Young (2010) by showing how fund-managers of average ability could use financial derivatives to 'mimic' the

[5] A concise summary of Fostel and Geanakoplos (2012) is available in Miller et al. (2016).
[6] A Glossary of technical terms and abbreviations is to be found after Annex A.

performance of star traders, taking on 'tail risk' to do so[7]. In the context of US housing policy, 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 by manipulation involves taking on significant risk.

Structure of the paper

These issues – externalities, distorted incentives and financial panic – are analysed separately in Sections 1 to 3, considering in particular whether each could itself have been sufficient to cause severe banking crisis.

In Section 1 we focus specifically on the Investment Banking model of Shin (2010) which emphasises how '*pecuniary externalities'* can amplify unexpected shocks regarding the quality of investments they hold. As a check on the robustness of US-style shadow banking in the face of shocks to perceived asset quality, 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 narrative involves 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, Chapter 2). Here we apply the adverse selection approach of Akerlof (1970) to the marketing of subprime assets where there is *asymmetric information* between buyers and sellers. 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 - leading eventually to financial collapse, when it is discovered that these loans were worth a lot less than advertised. Note that the twin threats to bank solvency posed in these narrative are, in fact, complementary: if pecuniary externalities greatly amplify 'news shocks' on asset quality,

[7] This strategy offers the prospect of high returns for some time, followed by substantial losses as tail risks finally materialise.

collusion between investment banks and the rating agencies can provide the shocks – with inflated ratings on the upside, and true revelation on the downside.

The third narrative to be explored is the *'confidence crisis'* view and we ask: was the rise in the cost of insuring subprime assets a matter of mindless panic? Or was it not due to a realisation of faulty fundamentals?

What if these various perspectives are high-lighting different aspects of a complex reality, as in the parable of the blind monks and the elephant? The conclusion in the Rigveda as regards the parable of the elephant - 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 to the evidence of law courts and the actions of policy-makers in the Fed and Treasury.

To weigh these perspectives in the balance – and to see whether in practice they proved complementary – Section 4 summarizes key official policy actions taken in response to the crisis; and subsequent findings in the law courts in respect of CRAs and Investment Banks. In some versions of the parable a sighted observer appears to reconcile the various conflicting perspectives. In this spirit, the retrospective view of the then-chair of the Federal Reserve, as expressed at Jackson Hole 2017, is also cited. Section 5 concludes.

Section 1 The first narrative: 'pecuniary externalities' *or* levitation by leverage

Rajan (2005) may have warned that HLIs would take on too much risk; but the rules adopted by the Basel Committee on Banking Supervision seemed to offer an appropriate regulatory counter-balance: that the equity of the institution involved should cover (almost) all the risk exposure as measured by Value-at-Risk (VaR). Because these rules took no account of the effect of bank behaviour on asset prices - and so, via mark-to-market accounting, on banks' own equity - such VaR-based regulation had been roundly criticised as no guarantee of systemic stability in the 'LSE critique' of Danielsson et al. (2001)[8]. In this section, we use the Investment Banking model subsequently developed by Hyun Shin, one of the authors, to examine the amplification effects that come through this channel; and whether they could trigger systemic collapse. We find that the effect of externalities is

[8] As discussed further in Miller(2018)

potentially 'catastrophic', in that the representative Investment Bank could become insolvent when a significant upgrade in risky asset quality is followed by its subsequent reversal.

In what, for convenience, will be referred to simply as the Shin model, there are two groups of investors; risk averse agents with mean-variance preferences who do not use leverage to finance investments, such as pension funds and mutual funds; and 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, though in reality such active leveraged investors include hedge funds and foreign banks, as well as U.S. investment banks.

The Shin model

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: $E[Q] = q$ and $Var(Q) = \frac{z^2}{3}$. 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 τ 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: $\max_y \left(qy + (e - py) - \frac{y^2 z^2}{6\tau}\right)$; so the demand function of passive investors is: $y_P = \begin{cases} \frac{3\tau}{z^2}(q-p) & if \quad q > p \\ 0 & if \quad otherwise \end{cases}$ (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.

Active investors: Investment Banks

Risk-neutral investors are 'active' as they use leverage – issuing debt - to finance their investments, subject to a VaR constraint. Specifically, investment banks' optimization is described as: $\max_{y} E(W) \quad s.t. \quad VaR = (p - q + z)y \leq e$ where $E(W) = (q - p)y + e$ and the VaR constraint implies that borrowing is no greater than can be financed with the worst realized payoff on the risky asset, $py - e \leq (q - z)y$.

Since $E(W)$ is linear in *y*, then for *q* > *p*, so long as the VaR constraint is binding, the demand for risky assets by investment banks becomes: $y_A = \begin{cases} \frac{e}{z-(q-p)} & if \quad q > p \\ 0 & otherwise \end{cases}$ (2)

Market-clearing; and how shocks to quality get amplified

For $q > p$ and fixed aggregate supply of risky assets, normalised at 1, the market clearing condition $y_P + y_A = 1$ determines the equilibrium price: $p = q - \frac{z}{2}\left[\frac{z}{3\tau} + 1 - \sqrt{\left(\frac{z}{3\tau} - 1\right)^2 + \frac{4e}{3\tau}}\right]$ (3)

For the given supply of risk assets on the horizontal axis, various market equilibria are illustrated in Figure 2. The construction in the Figure is that the demand by passive investors, measured from the right-hand axis, lies below the mean, *q*, with a slope that reflects their degree of risk-tolerance, τ. Demand for active investors is measured from the left hand axis, with the kink reflecting their initial equity *e* and the downward slope indicating, not risk aversion, but the effect of the VaR rule (whereby 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; and, when risk assets are reckoned to be of Low-quality, this is where the demand curves shown in bold intersect at L. If this assessment were to be revised, however, so that they are judged to be of High-quality, equilibrium shifts to the right to H, with a considerable expansion of holdings by investment banks triggered thereby, as described formally in the Annex. (The outcome on the left, where Investment Banks go out of business, is labelled I for insolvency.)

The quality of assets available at L is calibrated to have an expected payoff q of 1.06 and a maximum downside risk z of 0.26, giving the minimum payoff of $q - z = 0.8$ indicated by the red dashed line near the foot of the figure. The demand schedule for such assets from Investment banks, subject to VaR with equity of 0.03, has a kink at $\frac{e}{z} = 0.12$; then descends towards 0.8 as its lower asymptote. It intersects the demand from passive investors, with risk tolerance τ = 0.8, at a price of 0.88, giving investment banks a one third share of the market, see Table 1.

What if there is an unanticipated increase in the perceived quality of risk assets? Specifically, let the expected payoff rise by five points, $dq \equiv q' - q = 0.05$, lifting the minimum payoff to $q' - z = 0.86$ as indicated by the upper red dashed line. The higher payoff will, of course, appeal to both types of investors, with their demand schedules shifting up by *dq* for initial equity values – which would raise equilibrium vertically to N in the Figure. But this ignores the pecuniary externality induced by "mark-to-market" accounting by VaR investors which will amplify their fully-leveraged demand, as indicated in Annex A. This amplification will take market-clearing equilibrium from N to H, where VaR investors now hold almost half of the risk assets (on which the risk-premium $q' - p'$ has fallen substantially).

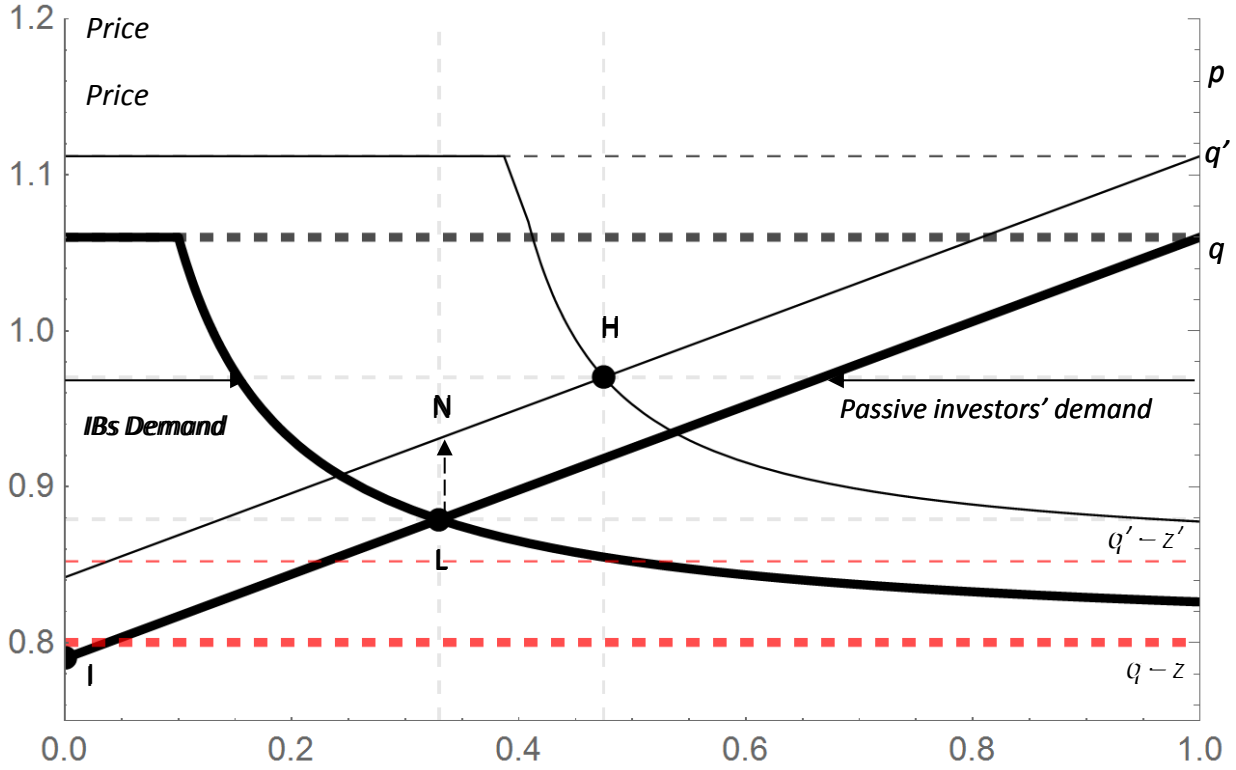

Figure 2. Market-clearing price of risky assets: three equilibria (q=1.06, z=0.26, e=0.03, τ=0.08)

	Initial Equilibrium	***Positive Shock***	***Shock reversal***
Equilibrium			
Price	0.88	0.97	0.79
ya	0.33	0.47	0.
IBs Balance Sheet			
Asset	0.29	0.461	0.
Debt	0.264	0.405	0.
Equity	0.026	0.056	−0.03
Percent Change in Equity		116	−152.67
Leverage	11.153	8.221	0.

Passive investors' demand

L

I

Table 1 Calibration of initial equilibrium and effects of dq= 0.05, subsequently reversed

A test of robustness: what if the quality improvement is reversed?

As a 'stress test' of the robustness of equilibrium, let the *unexpected increase in asset quality* (corresponding to the highly favourable pre-crisis ratings given by the CRAs) *be later reversed*[9], with the state-contingent sequence of events outlined below. Note that, for convenience, this stylised test considers successive equilibria at their distribution means (without reference to other stochastic outcomes).

[9] As, for example, when there is a sharp rise in the cost of insurance, see Figure 7 below.

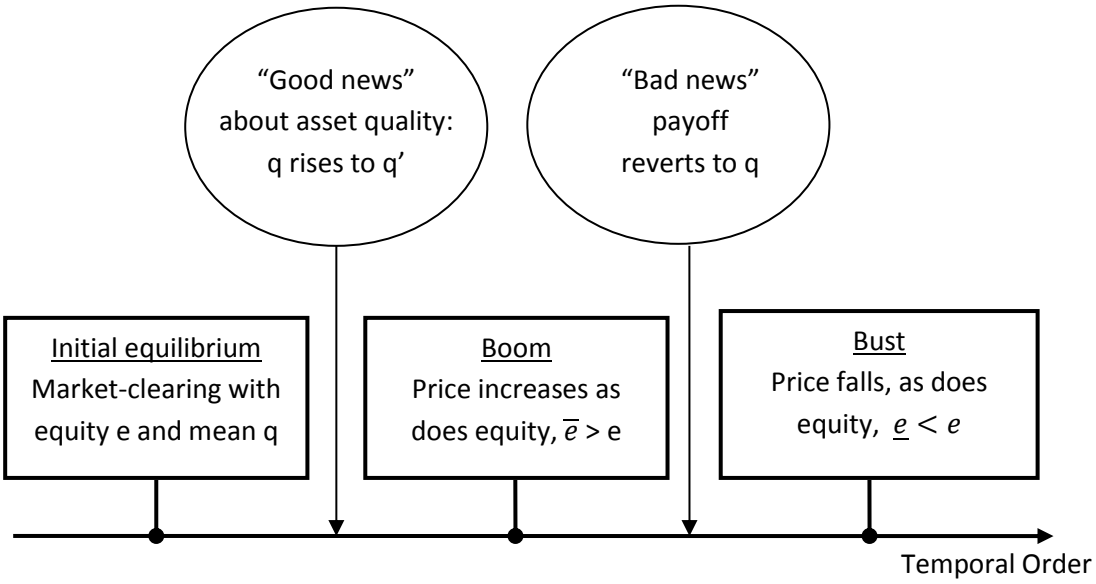

Figure 3 Sequence of events

The initial equilibrium corresponds to point L in Figure 2. After markets have cleared on the assumption of an unchanging future distribution of asset returns, however, 'good news' on asset quality arrives: the payoff to be expected has changed $q' > q$. This unanticipated but welcome development leads to a 'boom', with pecuniary externalities leading to equilibrium at point H in Figure 2, with details in Table 1. 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, when 'bad news' arrives that asset quality has reverted back to what it was in the first stage.[10] Returning to the original expected return of q , but starting from the higher equity base ($\overline{e}$) achieved in the boom – with larger holdings financed by higher borrowing ($p'y'-\overline{e}$) – raises two issues: first, how much will asset prices have to fall as active investors contract their balance sheets to meet the now-tighter VaR requirements? Second, will their own equity be sufficient to take the hit?

Insolvency

Though news shocks that get reversed need not lead to insolvency, they can do so. The most obvious case is when *the good news lifts the 'band of downside risk' high enough to exclude the initial equilibrium price* p_0 (i.e.

[10] If the distribution of Q had unbounded support, we assume that the cost of CDS for insuring against the tail risks below q-z and q'-z are the same.

$q' - z > p_0$); in which case a return to the initial price would take equilibrium below the 'band' of sustainable outcomes and wipe out the entire equity of VaR investors.

Such a large shock, though sufficient for insolvency, is not necessary. The example in Table 1 and Figure 2 demonstrates that, even where the initial equilibrium price lies inside the higher band of downside risk (i.e. where $p_0 > q' - z$), a reversal of good news can nevertheless lead to insolvency. In the figure, increasing the expected payoff from *q* to *q'* shifts equilibrium from L to H as discussed; and, as L remains within the 'band of sustainability' associated with *q'*, it might appear that a reversal is sustainable. This is not so, however, as 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 a 'bust' with equilibrium at point I where Investment Banks are insolvent leaving all risk assets in the hands of mean-variance investors[11].

Clearly accounting rules can have a marked effect on the dynamic response of the system to exogenous shocks; for large shocks that get reversed, indeed, VaR investors may become insolvent, leaving it to others to stabilise prices. 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 realistically worst case outcome foreseen by the banks at H. We do not believe it should be discounted, however, for two reasons. First because the design of the VaR regime was flawed in that it left unchecked the pecuniary externalities which can drive the system outside the bounds expected by individual banks; so the exaggerated impact of common shocks would indeed come as an unanticipated surprise. Second, because Shin's model may be expanded to allow for unbounded downside risk so long as there is insurance to cover tail risk: but the possibility of financial crisis will persist if the insurers, in turn, fail to internalise these pecuniary externalities.

'Catastrophic' behaviour?

[11] This need not be the case for smaller shocks, where the asymmetry of gains and losses will lead to a contraction of market share for VaR investors, but not insolvency. In terms of Figure 2, the outcome of reversing 'good news' of only *dq*=0.2, for example, is that equilibrium will shift to the left of L as Investment Banks reduce their holdings to about 20% of the market.

The Shin model 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; and (iii) financial regulation is pro-cyclical. The obvious weakness in this narrative of crisis is that it is driven by a sequence of unanticipated, exogenous quality shocks attributable to the activities of CRAs[12].

For large enough shocks, indeed, it seems 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 between 'bulls and bears' – a psychological explanation that Arnold (1984) criticized as rather ad hoc. In the case we are discussing, the key psychological assumption is of relentless profit-maximising behaviour on the part of investment banks; with the resulting dynamics 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.

A complementary, time-series approach to explaining this boom/bust behaviour has been explored by Aymanns et al. (2016). In their Minsky-like extension of Shin's model, asset quality is assessed, not by ratings, but from time-series estimates of downside risk made in a stochastic setting where there are shocks in demand from patient investors. As time moves on and the last crisis moves into the distant past, these assessments become progressively rosier, and the system more risk-prone – leading to another crisis. In fact, they derive an ever-repeated cycle of a slowly building price bubble followed by a crash which, they claim, is consistent with the operation of the Basel II rules on prudential regulation.

Section 2 The second narrative: MBS as 'lemons'

[12] Altering the 'common knowledge' assumption, as in the next section, helps to remedy this.

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. Could it be that, in reality, the 'good news' shocks discussed above were due to 'inflated ratings' secured by the banks; and the 'bad news' was when the mis-rating came to light? For, as Akerlof and Shiller (2015, p.36) argue, 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.

Adverse selection and the securitisation of subprime assets

It turns out that, as well as holding asset backed securities on their balance sheets, Investment Banks played a key role in the growth of securitization, as graphically described by Gillian Tett in *Fool's Gold*. To analyse the role of Investment Banks and the credit rating agencies (CRAs) in packaging and marketing MBS, we turn to 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 between buyers and sellers. As this is so inefficient relative to the outcome with symmetric knowledge, the question is whether 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 providing rosy ratings designed 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 an equilibrium with 'cheating'. But when buyers discover evidence of mis-rating the result could be market collapse.

As*ymmetric information*

Let there be a pool of risky assets, each indexed by θ, a measure of 'quality'.[13] Assume that the price of risky assets is determined by risk-averse investors in a competitive market. With full information, the price of asset θ can be normalized to be θ. In what follows, we characterise pricing in competitive equilibrium under asymmetric

[13] Thus if all risky assets have the same expected returns but differ in their standard deviations, the parameter θ would represent the inverse of the standard deviation.

information. The information structure is that *the support and the distribution of θ 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 $\mathrm{r}(\theta)$ where $\mathrm{r}(\theta) < \theta$.

The pool of the risky assets available constitutes a set $[\underline{\theta}; \overline{\theta}]$, with the measure of quality below θ represented by a cumulative distribution function F(θ). Given the asymmetry of information as to quality, let there be a single price *p* reflecting the *average riskiness* of assets made available at that price. As banks will only supply these assets if the market price covers their reservation value, $r(\theta)$, the amount of risky assets supplied at any given price, is defined as: $\Theta(p) = \{\theta: \mathrm{r}(\theta) \leq \mathrm{p}\}$ and a competitive equilibrium may be defined as a price p^* and a set Θ^* of risky assets such that $\Theta^*(p) = \{\theta: \mathrm{r}(\theta) \leq p^*\}$ and $p^* = E[\theta \mid \theta \; \varepsilon \; \Theta^*]$. Together these imply that the competitive price must satisfy $p^* = E[\theta \mid \mathrm{r}(\theta) \leq p^*]$ i.e. that it matches the expected value of the assets on the market, which have reservation values less than the equilibrium price. (Those with higher reservation value are withdrawn.)

Uniform distribution of quality

For convenience, let the pool of the risky assets be uniformly distributed in $[\underline{\theta}; \overline{\theta}]$, with 'reservation values' of $\mathrm{r}(\theta) = \alpha\theta < \theta$. Note that, If the equilibrium price is *p*, the set of risky assets offered by banks is $(p) = \{\theta: \mathrm{r}(\theta) \leq \mathrm{p}\} = \{\theta: \alpha\theta \leq \mathrm{p}\}$, so the conditional expectation of the quality of assets can be determined as: $E[\theta \mid \theta \; \varepsilon \; \Theta(p)] = \frac{\left(\frac{p}{\alpha}\right)+\underline{\theta}}{2}$; and competitive equilibrium, given by the condition that price matches the expected quality, is $p^* = \frac{\underline{\theta}}{2-\alpha^{-1}}$. Figure 4 illustrates.

For prices falling between the lowest and highest 'reservation values' $r(\underline{\theta})$ and $r(\overline{\theta})$, 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. Competitive equilibrium is at E, where BT crosses the 45 degree line: this is the 'rational expectations' equilibrium of Akerlof (1970), where the market price is, *on average*, justified by quality. Since only lower quality assets are put on the market, however, it is clearly inefficient relative to the *symmetric information* case, where price matches quality on each and all the MBS will be on the market, as indicated by the dashed section of the 45 degree line between $\underline{\theta}$ and $\overline{\theta}$.

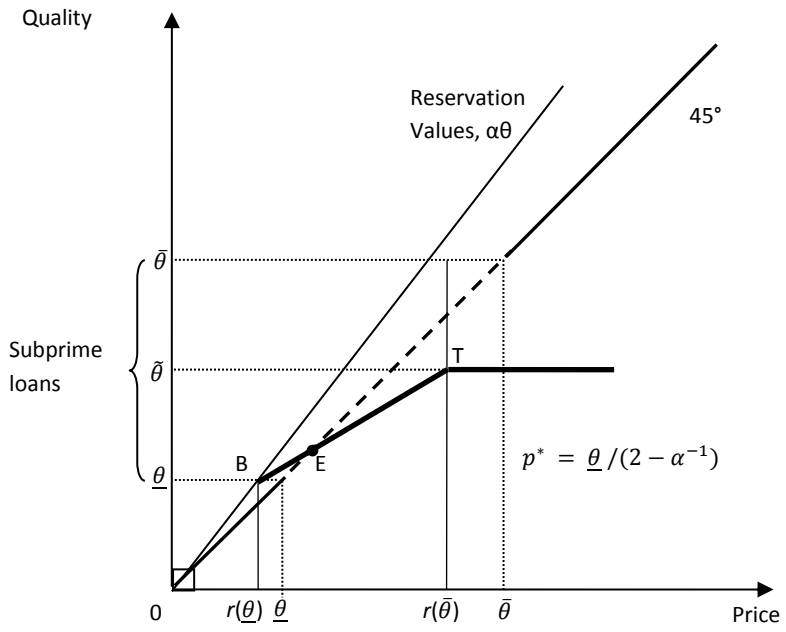

Figure 4. Market equilibria with Asymmetric and Symmetric information

Faking the ratings

For sellers to bundle loans into 'tranches' of similar quality would seem to offer obvious efficiency gains: In the limit, if the grading is fine enough, Pareto efficiency might be achieved where all loans are traded and average quality rises to $\tilde{\theta}$ [14]. With asymmetry of information, the temptation for sellers to indulge in 'grade inflation' calls for third party authentication, e.g. by CRAs. But with collusion between the sellers of MBS and the CRAs – where the latter are prepared to raise quality ratings in order to retain business – grade inflation will not be checked.

With the spread of quality uniformly distributed in $[\underline{\theta}; \overline{\theta}]$ 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 $\tilde{\theta}$, as indicated in Figure 4 above. With collusion between the sellers and the CRAs, however, buyers can be misled as to asset quality. Assume for example that with 'grade inflation' the lower bound remains unchanged, but the upper bound *apparently* increases to $\overline{\theta}'$, where $\overline{\theta}' - \underline{\theta} = 2(\overline{\theta} - \underline{\theta})$ i.e. the spread has doubled, so the apparent

[14] as in the symmetric information case described earlier.

quality range of authenticated assets on the market now has a mean value at $\overline{\theta}$, the high end of the actual distribution.

The dashed line labelled MM in Figure 5 illustrates graphically how buyers are being misled, with the slope of less than 45 degrees indicating how the price/quality relationship is being distorted (with the overstating of product quality increasing as 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 parenthesis in the figure. With buyers being systematically mi-led as to quality, this is no 'rational expectations' equilibrium: differential information is actively being exploited to the advantage of those who know the true quality of the MBS that they are mis-selling[15].

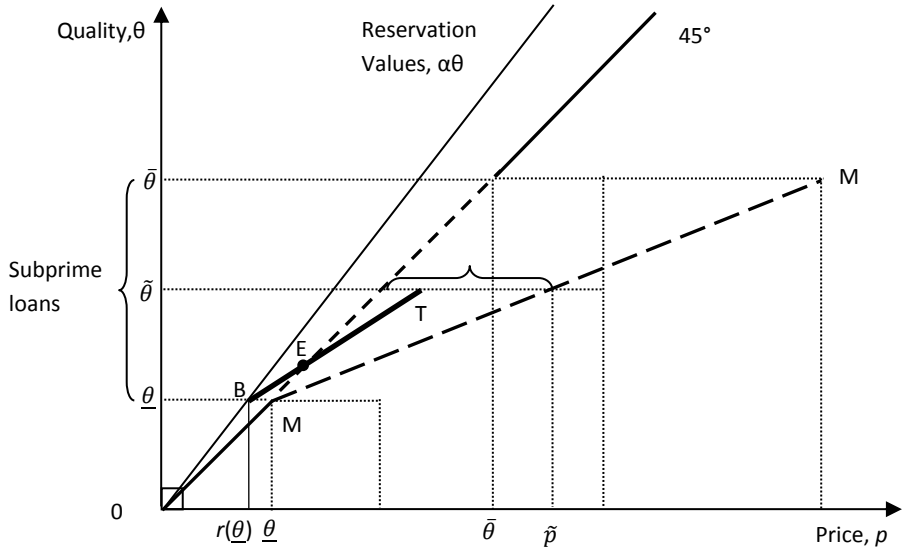

Figure 5. Deception: market equilibrium with inflated ratings

What happens when the music stops and buyers discover that most of the loans are not, in fact, worth what they were led to expect? What if the ratings are totally disregarded, with prices determined as for equilibrium with

[15] 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, legal findings can play an important role.

adverse selection, for example - and, for good measure, buyers also shift their beliefs to the detriment of MBS - by reducing the lower bound on quality to zero?

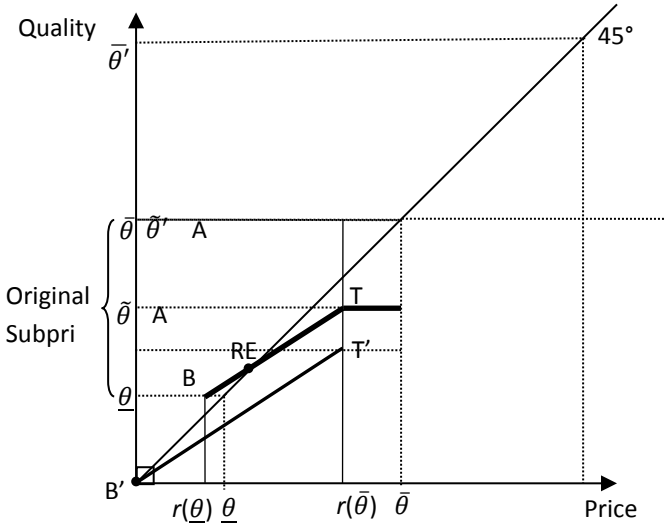

Figure 6. Disillusion: downside revision of sellers' distribution, leading to collapse.

In that case, despite the quality being as originally specified, with bounds $\overline{\theta} > \underline{\theta} > 0$, the jaundiced beliefs of the buyers, with bounds $\overline{\theta} > \underline{\theta'} = 0$, will now imply the schedule of expected quality (from the viewpoint of the buyers) shown as B'T' in Figure 6. As this lies everywhere 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 to the origin, the no-trade equilibrium of Akerlof (1970), arrived at here by excessively pessimistic beliefs.

Thus it seems that asymmetric information – and its exploitation by banks working in collusion with the rating agencies (to whom prudential regulation had effectively been delegated) - can generate a boom/bust sequence like that discussed in the previous section. But here the 'shocks' to asset quality are essentially *endogenous*. This does not make the financial accelerator that Shin emphasizes irrelevant: far from it. The impact of these developments, both positive and negative, on the equity base of the banks involved will have amplified effects on industry equilibrium, rendering implosion more likely.

If the subprime crisis merits the description of a perfect storm, it is because it involves so many contributory factors. The two narratives discussed so far feature the challenges to financial market efficiency and stability

coming from pecuniary externalities and asymmetric information. How these may best be combined is left as unfinished business, for, like the elephant in the parable, reality is undeniably complicated[16]. In the next section, we turn to another feature - creditor panic.

Section 3 The third narrative: baseless panic

There is a third perspective, with special appeal to those familiar with the Asian financial crisis of 1997-99 - like Paul Krugman (2018, p.158), who writes: 'when the crisis struck, I'm sure I wasn't the only economist whose reaction was not 'How can this be happening?' but rather to yell at oneself, 'Diamond–Dybvig, you idiot!' He refers to the classic 1983 paper where banks can face insolvency when depositors panic and they are forced, in emergency, to recall good but illiquid loans. But is this still relevant when the miracle of securitisation can - by packaging loans into saleable securities - apparently banish illiquidity? Were sub-prime mortgages not successfully pooled and sliced into securities – many rated AAA - with widespread investor appeal, see Table 1?

A widely-cited paper presented to central bankers and academics at Jackson Hole with the title 'The Panic of 2007' provided cold comfort for the view that securitisation guaranteed saleability: for what Gary Gorton (2009) claimed to show was that *the market for securities was itself prone to fits of baseless panic*. The principal piece of evidence (provided by one who had worked as a consultant for the insurance company AIG Financial Products[17]) was the alarming increase in the cost of buying insurance against losses on subprime mortgages, as measured by the ABX-HE indices. Fig. 7 shows the movements in the BBB and AA versions of this index, constructed from January 2006, each reflecting the cost of purchasing insurance for investment-grade tranches of twenty major MBS products[18] . While both indices initially stood at par, the relatively riskier ABX-HE-BBB index began to fall at the beginning of 2007; and both fell sharply after August 2007 - the date that, according to Gorton, the Panic began. Continued precipitous decline took the BBB down to about 5c in late 2008; by which

[16] Yifan Zhang (2017) provides an elegant, if stylised, combination of these two narratives in one analytical framework.
[17] see Lewis (2011, p.88).
[18] Thus a price of 80 for a particular AA contract on a given date means that the buyer must pay 20% of the par value of the AAA index to get protection for the next five years.

time even the less risky ABX-HE-AA index was down to 20c, implying up-front insurance costs of 80c in the dollar!

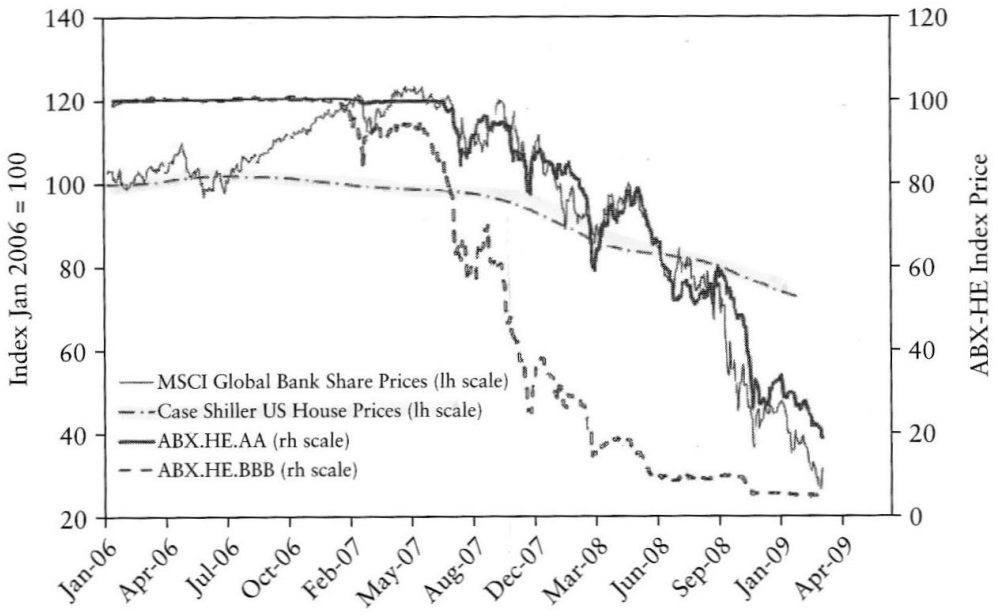

Figure 7 US House prices, ABX indices, and share prices of Global Banks. Source: A. Milne (2009, p. 201)

Why the panic: opacity or fundamentals?

According to Gorton (2009, p.199), the reason behind this enormous increase in the cost of insuring MBS lay not in any failure of securitisation as such, but in the 'loss of information' involved it involved - and the consequent 'opacity' of MBS securities in terms of their asset backing. This view was robustly challenged by Bengt Holmstrom (2009, p. 267), who , in his commentary, argued that the fault lay with the business model of subprime finance:

> 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.

For the finance provided when house prices were rising would cease when house prices stopped rising, or began to fall; and, with no refinancing, borrowers would be unable to avoid the scheduled step-up in 'teaser' rates (possibly doubling). If house prices were falling, moreover, they would need to post more collateral or pay down

the loan. As borrowers in default, they could become homeless as their homes were repossessed and resold into a falling market[19].

For Akerlof and Shiller, the deliberate misuse of securitisation was how the better informed could exploit asymmetries of information for profit - a prime example of 'phishing for phools'. If securitisation is misused in this way, of course, the challenge it poses to the Diamond/ Dybvig perspective – by making bank assets as liquid as their liabilities – is only too likely to fail. More than that, when misuse is revealed, there will be evidence of unsound investment for all to see – just what is needed to trigger creditor panic, driven by chicanery not sunspots !

That investment banks were seriously exposed to liquidity risk there is no question: '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, italics added). Some have argued that, by retaining mainly super-senior tranches on their books - with insurance to cover residual risk - and by assigning riskier tranches to special purpose vehicles (SPVs), investment banks were immune from insolvency risk. But for banks intimately involved in the business of subprime securitisation to protest that their hands were spotlessly clean was like Lady Macbeth rubbing her hands to wash off any trace of the death of Duncan. It was a strategy that failed: for, in the event, investment banks had to take responsibility for their SPVs; and the prevalence of interbank lending and borrowing provided abundant channels for contagion[20].

Section 4 Policy Actions and Legal Proceedings

Liquidity provision by the Fed

[19] As the Case-Shiller index of House Prices plotted in Figure 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 rises and declines – supports Holmstrom's analysis.

[20] The liquidity shock suffered by a bank with good assets could be the consequence of withdrawals by another bank suffering equity losses from poor asset quality, leading it to reduce its balance sheet.

Decisive action was taken by the Fed to help provide liquidity in the crisis. 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. Furthermore, 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 fully entitled to support by the central bank "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 had become apparent. This hardly supports Gorton's thesis - that the primary driver of the financial crisis was 'the Panic of 2007' due to the opacity of the products created to securitise loans to subprime households. 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". Creditors panicked, it seems, when they realised that lending on sub-prime mortgages was a bad investment.

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

For Shin, the widespread take-up of low-quality subprime assets by HLIs at a time when measured risks seemed low was the key factor, leaving them exposed to insolvency as and when 'bad news' arrived. 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. Alongside losses and write-downs totalling $344b incurred in 2007/8, Table 2 provides details of the principal capital injections[21] made by the US Treasury using TARP funds, running to a total of almost $100b for the banks in the table.

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

The 'Big Five' US Investment	**Assets, Leverage,**	**Fate after crisis**	**'Big Eight'**	**Credit losses and write downs 2007-8**	**Capital injections**	**Subsequent fines for**

[21] Enforced purchases of preference shares.

Banks (as of early 2008)	**and equity end 2007**		**Banks (Current Survivors)**		**October 2008**	**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
Totals	$4,272b IBs only			**$344b**	**$95b**	**$45b**

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)

For a pure liquidity crisis, where the investments of the banks are not in question, capital support should not be needed. But in this case - with house prices already falling, subprime insurance prohibitively expensive, the MBS market essentially closed down and losses on the books of investment banks amounting to a third of a trillion dollars - such solvency support was considered essential. 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'.

Mis-selling of MBS: Phishing for Phools?

The asymmetric information account of Akerlof and Shiller is based explicitly on 'the economics of manipulation and deception'. Support for their challenging perspective comes from legal decisions subsequent to the crisis. The final column of Table 2 indicates the '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[22]. The sums paid by investment banks and the big commercial banks such as Bank of America, J P Morgan and Citigroup amount to $45b (of which $8b was levied on the two surviving investment banks, and $20b on the big banks that had taken over Bear Sterns and Merill Lynch).

The largest fines – and some of the most chilling evidence – comes from the case against Bank of America which, in addition to acquiring Merill 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.

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. 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 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 (2015) allege, namely that the ratings were influenced by the incentives to retain the business.

Summary overview

Various narratives offered by seasoned observers have been presented – each apparently sufficient to cause financial crisis. But the policy actions to support the institutions involved – and the fines subsequently imposed upon them – suggest that all three narratives had a part to play. In a speech a decade after the crisis began, Janet

[22] 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 discussed in Rakoff (2014).

Yellen, as 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". She went on to observe that:

> 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 reg*ulation. Yellen (2017) (italics added)

Whether this will succeed in preventing another crisis one cannot tell: but it is an acknowledgement of the many-sided nature of the problem.

Section 5 Conclusion

Given mark-to-market accounting and the usual VaR conventions, highly-leveraged investment banks could, according to the first narrative, face insolvency due to exogenous common shocks to fundamentals. It appears, 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 supports the allegation of the second narrative – that there was a 'cheating' equilibrium leading to crisis when the truth emerged.

That financial institutions who need to roll over a quarter of their balance sheets on a nightly basis should be exposed to creditor panic –as in the third narrative - is uncontroversial. What is controversial is to maintain that the subprime crisis was caused by unreasoning panic based on product opacity, rather than fear triggered by bad news about the flawed business model.

The three perspectives provide plausible threats to financial stability coming from different directions - tempting one to ask: which is correct? As the parable of the elephant suggests, however, each may provide a partial perspective of a complex reality that involves them all. The actions of policy-makers and the courts support this conclusion - as does the ex-post assessment of the then-chair of the US Federal Reserve.

References

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.

---------- (2009) *Animal Spirits.* Princeton, NJ: Princeton University Press.

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,* Vol. 27(December) pp. 263- 277.

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.

Coimbra, N. and H. Rey, (2017) *Financial Cycles with Heterogenous Intermediaries.* LBS Working Paper (March)

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.

Davila, E. and A.Korinek (2017) "Pecuniary Externalities in Economies with Financial Frictions". *Review of Economic Studies* **0**, 1–44

Diamond, D.W. and P.H.Dybvig, 1983. "Bank Runs, Deposit Insurance, and Liquidity". *Journal of Political Economy,* 91(3), pp. 401–419.

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

Financial Crisis Inquiry Commission (2012) *Final Report*. NY, NY: Public Affairs

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.

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.

Krugman, P. (2018). "Good enough for Government work: Macroeconomics since the crisis". *Oxford Review of Economic Policy,* Vol. 34, Nos. 1–2, pp. 156–168

Lewis, M. (2011) *The Big Short*. NY, NY: W.W. Norton

Lo, A. (2017) *Adaptive Markets.* Princeton, NJ: Princeton University Press.

Miller, M. (2018) "Cross-border banking and monetary independence: difficult partners". In P. Hartmann, H.Huang and D. Schoenmaker (eds.) *The changing fortunes of central banking*. Cambridge: Cambridge University 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 (2017). "Subprime assets and financial crisis: theory, policy and the law." University of Warwick, CAGE WP No.340.

---------- (2016) 'A comedy of errors: misguided policy, mis-sold mortgages and more" DP No.11533, London: CEPR

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.

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

Rastapana, S. (2017) "Three Essays on Financial Crisis". University of Warwick

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.

Tett, G. (2009) *Fool's Gold.* London: Little, Brown Book Group

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 *Amplification effect of pecuniary externality*

How to determine the effect of unchecked pecuniary externality in Shin's model? To derive this formally, as in Rastapana (2017), 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:

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

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. Assume that these expand until the VaR constraint is again binding, so:

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

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

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

Glossary[23]

AAA: triple A – top rating for bonds with exceptional degree of credit-worthiness

ABS: Asset-Backed Security - security that is backed by a portfolio of assets, normally placed in a specially designated vehicle (see SPV).

ABX-HE: a CDS contract that pools lists of exposures to mortgage backed securities.

Bank holding company: broadly defined as any company that has control over a bank. In 2008 traditional investment banks such as Goldman Sachs and Morgan Stanley, converted to bank holding companies in order to gain better access to liquidity and funding.

Basel Accords: regulations drawn up by the Basel Committee of Banking Spervisors that establidshed levels of bank capital judged necessatry for financial stability. Basel I was drawn up in 1988; Basel II in 2004.

CDO of ABS: collateralized debt obligation built out of Asset Backed Securities, usually Mortgage Backed Securities

CDS: Credit Default Swap - insurance style contract where the buyer pays a regular fee for guarantee of compensation by seller in event of default on a stipulated piece ofdebt

CRA: Credit Rating Agency – private company that assigns ratings (AAA and down) of creditworhiness - ability to service debt; the 'Big Three' agencies are Moody's Investors Services, Standard and Poor's and Fitch Ratimgs.

HLI: Highly Leveraged Institution- a company or other institution with a high debt to equity ratio

MBS:Mortgage-Backed Security – bonds issued by SPV holding a portfolio of mortgages

Leverage: ratio of debt to equity

[23] With due acknowledgement to GillianTett (2009).

Repo: transaction where one party ('borrower') sells ecurities to another ('lender') with a commitment to repurchase at a future date at a specified price

Securitisation: issuance of tradable securities, such as bonds, backed by the income generated by loans or other sources of revenue

Shadow banking: a diverse set of institutions and markets that, collectively, carry out traditional banking functions — but do so outside, or in ways only loosely linked to, the traditional system of regulated depository institutions. The shadow banking system includes SPVs, Repo markets, Investment Banks and and Mortgage companies

SPV: Special Purpose Vehicle - shell company created to hold a portfolio of assets and issue securities backed by them. It may be created by a bank, but is a separate legal entity.

Super-senior risk: the most senior part of capital structure of a CDO

TARP : Troubled Assets Relief Program – the Federal program enacted in late 2008 authorizing $700 billion for capital injections and other measures to stabilize the banking system

Tranche: subset of ABS or MBS securities on issue that carry a certain level of risk

VaR : Value at Risk - the realistically worst case outcome in the sense that anything worse only happens with probabiity less than some benchmark level, Shin (2010, p.16)