Casting light on shadow banking: externalities in the financial crisis [1]

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Abstract

After the boom in US subprime lending came the bust -- with a run on US shadow banks. The magnitude of boom and bust were, it seems, amplified by two significant externalities triggered by 'news' shocks: the effect on bank *equity* from mark-to-market accounting and on bank *liquidity* from 'fire-sales' of securitised assets. We show how adding a systemic *bank run* to a canonical model of shadow banking allows for a tractable analytical treatment -- including the counterfactual of complete collapse that forces the Treasury and the Fed to intervene.

Writing after the event, Raguharam Rajan describes how sharp financial practice converted the political objective of helping low-income families to acquire housing into financial crisis: such 'agency' problems suggest the 'news' shocks were not exogenous.

Key words: pecuniary externalities, bank runs, illiquidity, Lender of Last Resort, cross-border banking

JEL Classifications: G01, G11, G24

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Financial markets are rife with externalities. Joseph Stiglitz

1. Introduction

Financial stability being a public good, it is unlikely that the private sector will, unaided, deliver what is socially optimal - particularly if international competition encourages a 'race to the bottom' between national regulators. The Basel Accord of 1988, designed by the Basel Committee of Banking Supervision (BCBS), was intended to ensure financial stability and provide a level playing field; and the adoption of a common Capital Adequacy Requirement marked a significant step in coordinating bank regulation among independent sovereign states. In the light of the financial crisis of 2007/8, however, Charles Goodhart (2011, p. 581) concludes his history of the BCBS with the question: "why did the apparatus of financial regulation fail to prevent systemic failure."

The answer he and others proffered, in a critique submitted to the Basel Committee well before the subprime crisis[2], was that the focus on micro-prudential regulation suffered from a fallacy: the belief that ensuring each institution behaves well is sufficient to ensure that the system as a whole is safe and sound. A neat demonstration that the micro-prudential regulatory mantra of the BCBS[3] ignored systemic risk was provided later by Shin (2010) and Adrian and Shin (2011). In their canonical model of investment banking[4], pursuing financial stability by imposing a Value at Risk (VaR) rule on equity for individual banks ignores the fact that, with marking-to-market in the face of aggregate shocks, shadow bank equity becomes endogenous – rising with good news on asset-backed securities and falling on bad. So a system subject to tight VaR regulation is unstable insofaras - with equity powering lending - it amplifies the effect of aggregate shocks to the quality of assets held by these banks. Regulators, it seems, had ignored an important 'collateral externality' – how asset price changes can interact with micro-prudential balance sheet rules.

Could such an externality, alone, lead to financial collapse? In the context of South East Asia financial crisis in 1998, Krugman (1999) argued that excessive foreign currency borrowing following capital account liberalization had so magnified the exchange rate impact on corporate balance sheets as to generate multiple equilibrium. So a loss of confidence could trigger a prompt shift from boom to bust. The

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[2] see Danielsson et al (2001).

[3] a perspective that remained in place as Basel I was upgraded to Basel II.

[4] which, for brevity, we refer to simply as the Shin model in what follows.

amplification in the Shin model does not generate multiple equilibrium. However, if as Stiglitz (2010, p. 150) suggests 'financial markets are rife with externalities', there may be other factors in play.

For it is not only regulators who may ignore systemic risk: so may private agents who fail to hold liquid reserves[5]. Bankers who reckoned that holding 'marketable' assets offered a good - and more profitable – substitute also suffered from a fallacy of composition. For, in the face of aggregate shocks, the vaunted marketability of securitised assets can vanish in collective 'fire sales'. From first-hand experience, Bernanke (2018a) describes how financial panic can lead to a drying up of funding and asset fire sales:

> Before the crisis, investors (mostly institutional) were happy to provide wholesale funding, even though it was not government insured, because such assets were liquid and perceived to be quite safe. Banks and other intermediaries liked the low cost of wholesale funding and the fact that it appealed to a wide class of investors. Panics emerge when bad news leads investors to believe that the "safe" short-term assets they have been holding may not, in fact, be entirely safe. If the news is bad enough, investors will pull back from funding banks and other intermediaries, refusing to roll over their short-term funds as they mature. As intermediaries lose funding, they may be forced to sell existing loans and to stop making new ones.

That many of those involved were not American banks added to the problem of illiquidity, for, according to Tooze (2018, p. 206):

> If the Fed did not act, what threatened was a transatlantic balance sheet avalanche, with the Europeans running down their lending in the United States and selling off their dollar portfolios in a dangerous fire sale. It was to hold those portfolios of dollar-denominated assets in place that from the end of 2007 the Fed began to provide dollar liquidity in unprecedented abundance not only to the American but to the entire global financial system, and above all to Europe.

Such intervention can be viewed as offsetting a negative 'pecuniary externality'; for as Davila and Korinek (2017) 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."

There is a considerable literature examining the role of Network Externalities in propagating disturbances in financial systems, Allen and Gale (2000) and Gai *et*

[5] Allen and Gale (2007, Chapter 5) indicate how individual agents undervalue the value of holding liquid assets in circumstances where markets are incomplete; and Korinek (2009) discusses the private under-provision of liquidity where there is systemic risk.

al.(2011), for example. These are not the subject of this paper, however, which is much closer in spirit to Gertler and Kiyotaki (2015) who focus on Strategic Complementarity and Fire Sales.[6] Their explicit aim, 'to develop a simple macroeconomic model of banking instability that features both financial accelerator effects and bank runs', is executed in elegant fashion with calibrated examples[7]. A distinctive feature of their approach, however, is that, while 'banks in the model are completely unregulated' (Gertler and Kiyotaki, 2015 p.2016), market forces impose a form of *self-regulation*[8]. Assuming that 'rational depositors will not lend funds to the banker if he has an incentive to cheat', an equity buffer ('skin in the game'), which acts as a '*financial market friction'* and limits the size of the banking sector, is determined by the need to check this incentive[9].

By contrast, we follow the approach taken by Adrian and Shin (2011) where the moral hazard problem being checked is not stealing but excessive risk taking; so risk-neutral bankers are subject to *regulation* designed to ensure that their own equity covers the Value at Risk. In this setting, we provide a tractable method for analysing Strategic Complementarity in the response of Investment Banks[10] to positive news on the quality of risk assets - and the impact of Fire Sales when creditors withdraw funds in response to bad news. This allows one to consider the counter-factual of what might have happened in the recent crisis without US Fed and Treasury intervention.

The paper proceeds as follows. In section 2, after recapitulating key features of the shadow banking model to be used, the focus is on what the regulators ignored, namely the pecuniary externality[11] that amplifies the impact of aggregate shocks – like 'good news' about the riskiness of assets being traded.

In section 3 the focus is on what the bankers had not anticipated – the evaporation of liquidity when funding withdrawals lead to asset sales by highly-leveraged actors. Marketability in normal times, they discovered, is no guarantee of liquidity in such circumstances. Absent a Lender of Last Resort, these 'fire-sales'

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[6] In the terminology of De Nicolo et al. (2012) in their overview of externalities and macro-prudential policy.

[7] It is developed further in subsequent papers – distinguishing explicitly between commercial and shadow banks in Gertler *et al*. (2016) and making the stock of capital endogenous with the aid of a New Keynesian model in Gertler *et al*. (2017).

[8] As bankers who steal will effectively lose their franchise one period later, any financial arrangement between the bank and its depositors has to satisfy the incentive constraint that the value the manager can amass by stealing must be less than the franchise value of running the bank without stealing.

[9] Put at 10% of the balance sheet in the numerical example of Gertler and Kiyotaki (2015); but reduced to 5% in Gertler, Kiyotaki and Prestipino (2016).

[10] Which we refer to interchangeably as Shadow Banks in what follows.

[11] Such 'pecuniary externalities', were first analysed by Kiyotaki and Moore (1997) to provide a variant of the 'financial accelerator' of Bernanke and Gertler (1989).

threaten insolvency – much like the early recall of illiquid bank loans in the bank run model of Diamond and Dybvig (1983).

Finally, the onset of systemic crisis is explored by calibration in Section 4, with 'bad news' on bank assets triggering a withdrawal of funding - and prompt insolvency. Though undeniably sparse and simplified, the tractability of the model allows one to see how externalities can precipitate financial collapse[12], with the qualification that - given forthright intervention by Treasury and the Fed - this is a counter-factual exercise.

Before concluding, however, there is an important caveat. We refer to evidence that *financial regulation was circumvented* – by manipulation of capital ratios and mis-representation of asset quality in particular. This suggests the need to complement the role of externalities by what Akerlof and Shiller (2015) call 'the economics of manipulation and deception'.

2. Pecuniary externalities and amplification

2.1. The canonical 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 $Var(Q) = z^2/3$. Both types of investors are endowed with initial equity denoted e. Investors' portfolio payoff (end of period wealth) is $W \equiv Qy + (e - py)$, where y represents the quantity of the risky asset holdings and p is the price of the risky asset.

Unleveraged '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 $U(W) \equiv E(W) - \sigma_W^2/(2\tau)$, where τ represents their risk tolerance and, since their portfolios comprise of riskless bonds and holdings of the risky asset, denoted x, the portfolio variance is $\sigma_W^2 = x^2z^2/3$. The risk averse investors' optimization thus becomes: $\max_y[qx + (e - px) - x^2z^2/(6\tau)]$; so for $q > p$ the demand function of passive investors is:

Risk-averse demand $\qquad x = \eta(q - p) \qquad (1)$

[12] We do not, however, go further to look at the linkage between credit disruption and the real sector, a topic analysed numerically using a DSGE model by Gertler *et al*. (2017) and in considerably greater detail by Bernanke (2018b).

where $\eta = 3\tau/z^2$.

Note that, because of the assumption on mean-variance preferences, the demand for the risky asset by passive investors is independent of their wealth and depends solely on the risk premium.

Leveraged, 'active' investors: referred to as Investment Banks

Risk-neutral 'active' investors use leverage – issuing debt to finance their investments in risky assets, denoted y, subject to a VaR constraint. For convenience, we refer to them collectively as Investment Banks (IBs) although commercial banks, Government Sponsored Enterprises and hedge funds are also included, Shin (2010, p.153, Table 9.1). Specifically, the optimization of these active investors is described as:

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

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 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 and there is no funding constraint, the demand for risky assets by investment banks becomes:

(Risk-neutral demand subject to VaR) $$y = \frac{e}{z-(q-p)} \tag{2}$$

For $q > p$ and fixed aggregate supply of risky assets, normalised at 1, the market clearing condition is:

(Market clearing) $$y + x = 1 \tag{3}$$

Note that leverage is defined as $\lambda = py/e$.

2.2 Baseline: initial equilibrium

Equilibrium may be found by substituting the demand functions into the equation for market clearing and, for convenience, using the notation $\pi = q - p$ (which we refer to for convenience as the risk premium[13]) to yield:

$$\eta\pi^2 - (1 + \eta z)\pi + z = (\eta\pi - 1)(\pi - z) \equiv g(\pi; z) = g(q - p; z) = e_0 \tag{4}$$

[13] Though this is not strictly correct, as the risk premium properly defined is $(q - p)/p$. Note that Shin (2010) uses the same symbol to denote $(q - p)/q$.

a quadratic polynomial with roots $\pi = z$ and $\pi = \eta^{-1}$.

This quadratic is plotted in Figure 1, with price, p, on the vertical axis and Investment Bank equity e on the horizontal, and the risk premium π measured as the shortfall of p below q in the figure. As the function $g(q-p;z)$ indicates, higher levels of initial IB equity will be associated with higher market clearing prices of risk assets to an upper limit of q. At the point labelled H, where the equity base of investment banking is sufficient to cover the downside on all risk assets, i.e. $e = z$, risk averse investors play no part; so $p = q$ and there is no risk premium.

At prices below the expected payoff, q, however, positive risk premia tempt risk averse investors to enter the market. For convenience (and broadly in line with the parameter restriction suggested by Shin, 2010, p.36), we start with the special case where both roots of the quadratic coincide, so $g(q-p;z)$ is tangent to the vertical axis where $q-p = \pi = z = \eta^{-1}$. Hence, at the point labelled L, risk averse investors would be willing to take all risk assets onto their (portfolio?) balance sheets.[14]

For a given level of initial IB equity $z > e_0 > 0$,the price of risk assets will lie between q and $q-z$, as shown at point A in the Figure. It is assumed that IBs can borrow as much necessary to maximise their asset holdings subject to the VaR constraint, implying that $e_0 = y_0\,(z-q-p_0)$ at A. How Good News on asset quality affects asset valuation and IB equity is considered next.

[14] In the calibration below, however, the simplifying restriction that $z = \eta^{-1}$ is relaxed.

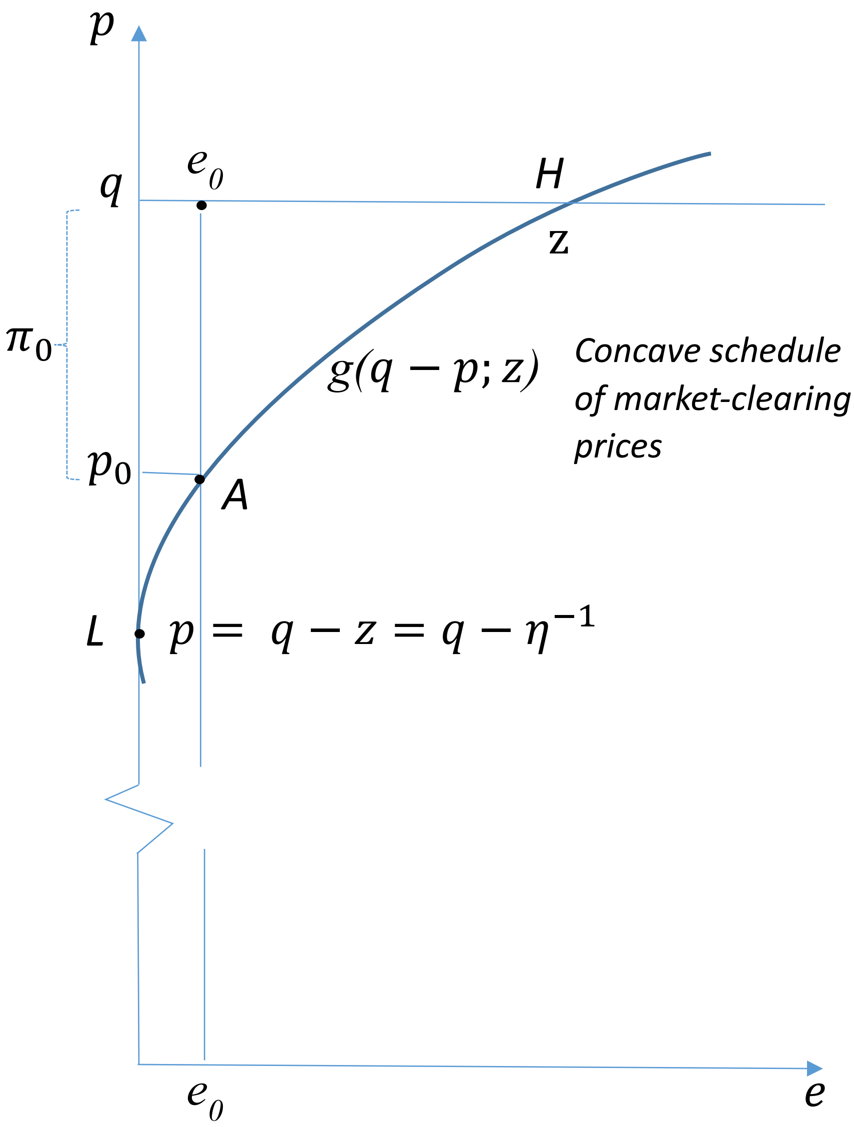

Fig. 1. The market clearing price of risk assets, given initial IB equity

2.3 How the effect of Good News gets amplified

The Good News we refer to is a widely-perceived improvement in the quality of risk assets, as for example when credit rating agencies (CRAs) give high ratings to subprime assets, Akerlof and Shiller (2015, Chapter 2), Financial Crisis Inquiry Commission (2011, Chapter 10). This could be a rise in the mean return, q; or a reduction in the maximum risk to $\underline{z}$. Here we focus on the reduction of risk.

Before solving for the impact and equilibrium effects of such 'news' in terms of the market-clearing schedule $g(q-p;z)$, it may be helpful to indicate these effects as in Figure 2, where the initial demands of each sector taken separately are plotted as a function of asset price and IB equity of e_0. Given a fixed supply, the demand of passive investors, measured from the RHS and given by $\eta\pi = \eta(q-p)$, increases as the price falls below q; while the demand for active investors, measured from the LHS, is given by $y = e_0/(z - \pi)$ and shown as a segment of the rectangular hyperbola passing through e_0/z (when the risk premium is zero) and tending asymptotically to $q - z$. Initial equilibrium is at A.

On *impact*, the reduction of perceived risk increases demand by both sectors. For passive investors, the fall in downside risk (from z to $\underline{z}$) makes risk assets more attractive, as indicated by the increase in Passive Demand shown in the figure. The demand schedule for active investors subject to a binding VaR constraint shifts to the right (from e_0/z to $e_0/\underline{z}$ at the top of the figure) as the unit risk falls; and it flattens out as the lower asymptote moves up to $q - \underline{z}$. With no marking of this price increase to market, equilibrium will move from A to B as shown, with a substantial change in the price and the risk premium but not much trading of assets.

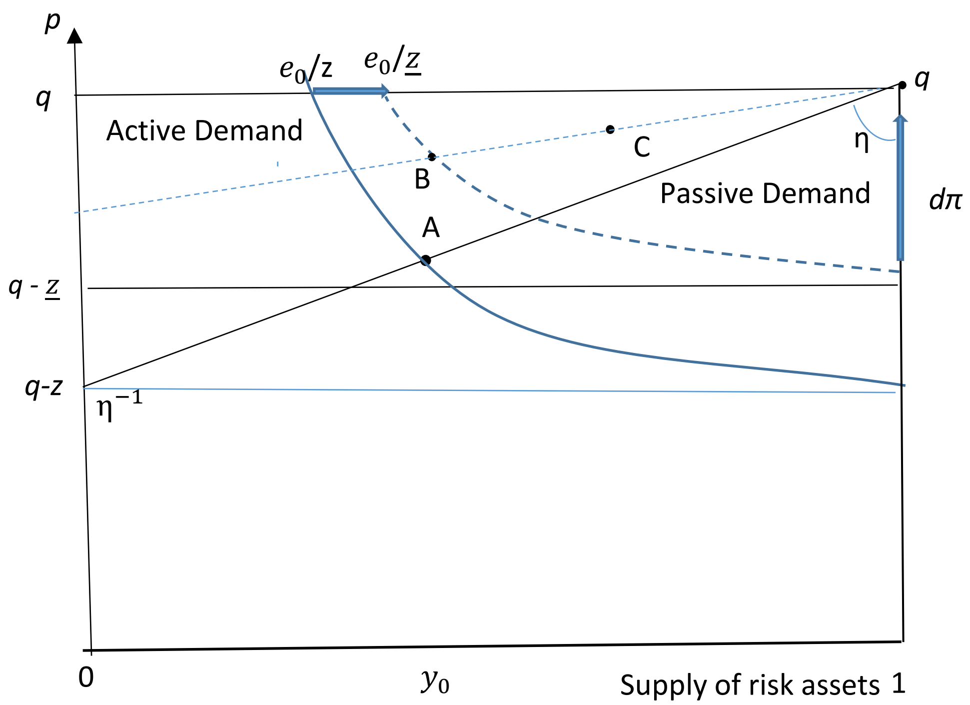

Fig. 2. Demand, Supply and Market-clearing

When their assets are marked-to-market at these higher prices, however, the increase in IB equity will – consistent with the VaR constraint -- allow for increased asset holding. These endogenous adjustments of bank equity will *amplify* the effect of Good News, with Investment Banks expanding their market share so equilibrium shifts along the demand curve for passive investors to a point like C. (Whether or not the leverage of the banks rises or falls depends on how the balance sheet expansion compares with the equity increase.)

Turning to aggregate market clearing, the *impact* effect of reducing the measure of downside risk on the risk premium and on market prices is found by replacing z in (4) by $\underline{z}$ to give:

$$\eta_1\pi^2 - \left(1+\eta_1\underline{z}\right)\pi + \underline{z} \ = (\eta_1\pi - 1)\left(\pi - \underline{z}\right) = \ g\left(\pi;\underline{z}\right) = g\left(q-p;\underline{z}\right) = \ \ e_0 \qquad \text{(4a)}$$

where $\eta_1 = 3\tau/\underline{z}^2$ as the demand by passive agents is also affected since the news is common knowledge.

How this affects the price of risk assets is illustrated in Figure 3, which focuses on asset prices close to q, with the value of equity measured along the horizontal as before. As shown, the reduction of downside risk **raises the schedule indicating market-clearing prices** from $g(q-p;z)$ to the solid line labelled $g(q-p;\underline{z})$. So the *impact effect* on market price **without marking to market** is indicated by the upward shift from A to B as measured at the initial level of equity e_0. (Note that, with the fall in downside risk, $\eta_1^{-1} < \underline{z}$, i.e. the root associated with nonbanks holding all risk assets is now smaller than the measure of downside risk.)

The 'amplification' effect that arises when assets are 'marked to market' is indicated by the movement from B to point C, where the polynomial intersects the schedule labelled MM measuring the impact of rising prices on IB equity. Here we follow the methodology of Shin (2010) who uses initial IB holdings as the benchmark to which price adjustments are applied. Solving for equilibrium with endogenous equity involves

$$g\left(q-p;\underline{z}\right) = e = \ y_0\left(p-(q-z)\right) \qquad \text{(5)}$$

gives equilibrium at C, where the increase in the equity value as balance sheets are marked to market is measured as $y_0\left(p_1 - p_0\right)$. (One could think of this equilibrium as the limit of a series of equity adjustments, with the first step shown in the figure.)

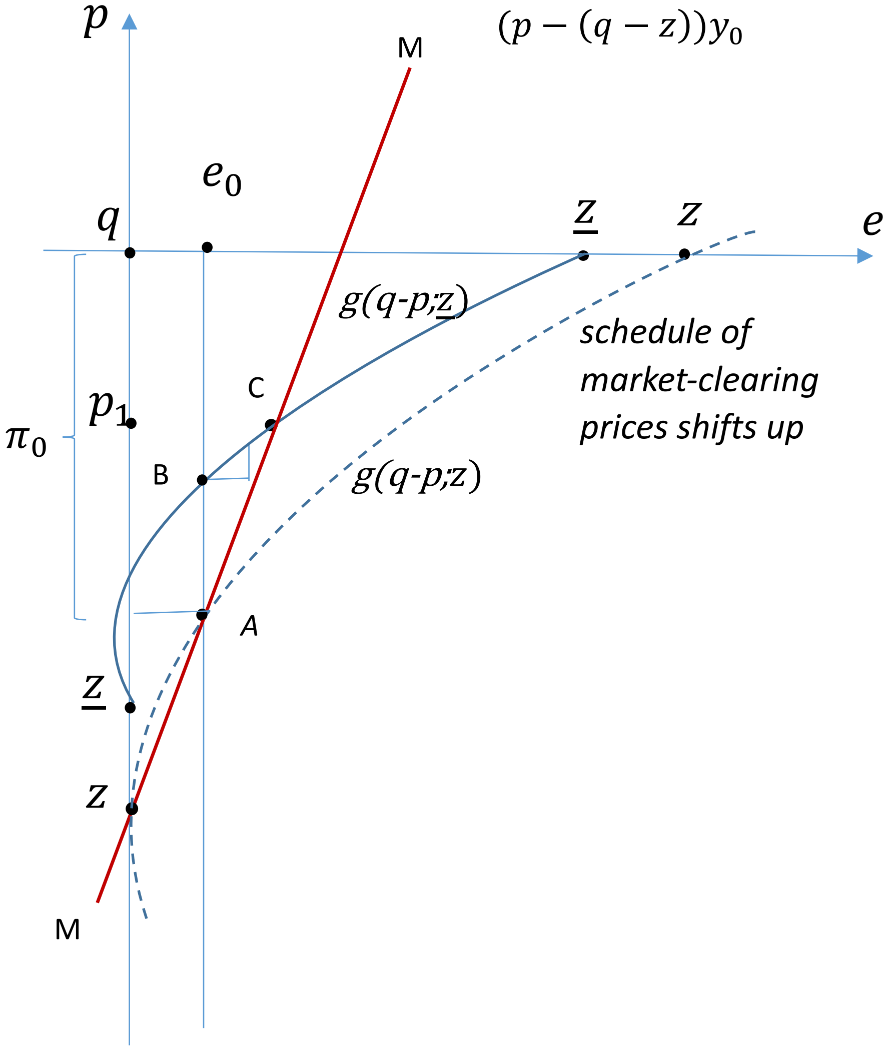

Fig. 3 Good News on asset quality increases market valuation; and bank equity

In the calibration reported below, a reduction of perceived risk has a substantial effect on bank equity, which almost doubles in the market-clearing equilibrium. Thus, despite the strict application of VaR rules, there is a substantial rise in the market-clearing price and the share of the leveraged sector as the effect of rising asset prices on their equity allows Investment Banks to expand their balance sheets – a pecuniary externality seemingly ignored by the Basel regulators.

3. How Bad News can threaten Insolvency - especially if funds are withdrawn

Thus far we have assumed that, in order to expand their balance sheets as far as VaR rules permit, Investment Banks can always obtain -- at low cost -- the funding needed, typically in the form of repos[15]. But what if such funding is withdrawn in a 'silent' run[16]?

Absent liquidity reserves, assets will need to be sold to meet the withdrawal of funding. By seeking to reduce assets and liabilities in tandem, investment banks will be acting 'as if' they are targeting a higher capital ratio - albeit involuntarily. *If many banks do this at the same time, however, asset prices will fall in the 'fire-sale' of involuntary deleveraging and bank equity will be reduced both by trading losses on sales and the marking down of assets retained.*

In Annex A it is shown that a system-wide 'bank run' (involving a loss of funding by the fraction ω) can be analysed by banks adjusting their portfolios 'as if' they are planning to hold capital for increased downside risk – as if their portfolios are determined not by equation (2) above but by

$$y = \frac{e_0}{(z^{\omega} - \pi)} \qquad (6)$$

where $z^{\omega} = (1 - \omega)z + \omega q$.

How to model the onset of financial crisis where, as Bernanke describes it, there is Bad News about the assets in bank portfolios and this triggers a withdrawal of funding? As indicated in Figure 4, we do this in two stages. First, on the assumption that the news is of an increase in asset risk, there is the impact effect of a rise in the downside risk parameter which -- given the steep rise in volatility seen during the crisis[17] -- we assume will return to its starting value, z. Jon Danielsson (2019, p.263) supports the idea there was strong reaction:

> Before 2008, everybody believed that the banks knew what they were doing, that they could value assets correctly and had accurate risk assessments. When things started going wrong, everybody's opinion changed by 180 degrees, and everybody thought that all evaluations and all risk assessments were wrong. Typical in crises.

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[15] where the 'borrower' sells securities to the 'lender' with a commitment to repurchase at a future date at a specified price.

[16] so-called because – rather than depositors running to withdraw their funds - repos are simply not rolled over.

[17] See Adrian and Shin (2014), p.381.

This will of course lead to an immediate reduction of aggregate demand for risk assets and a fall in their price.

Second we add a systemic Bank Run. So, as the news leads to a funding withdrawal from IBs, there will be asset fire-sales, leading to added downward pressure on prices. The fall in equity, when trading losses on such sales are added to the write-down as remaining assets are marked to market, may indeed pose a threat of immediate insolvency, as is indicated in the calibration below.

To compute these shifts numerically we first replace $\underline{z}$ by $\overline{z}$ in (4a) to give

$$\eta_2\pi^2 - (1+\eta_2\overline{z})\pi + \overline{z} = (\eta_2\pi - 1)(\pi - \overline{z}) = g(\pi;\overline{z}) = g(q-p;\overline{z}) = e_1 \quad \text{(4b)}$$

where $\eta_2 = 3\tau/\overline{z}^2$ as the news is common knowledge; and e_1 denotes equity as measured at the peak of the preceding boom.

This will **lower the schedule giving market-clearing prices**, from $g(q-p;\underline{z})$ to $g(q-p;\overline{z})$, shown as a solid line in Figure 4. For given equity e_1 this downward shift will lead to fall in prices from C to D. Thus the *impact* of Bad News on the market clearing price -- without marking to market – is found by solving for $g(q-p;\ \overline{z}) = e_1$.

How to incorporate the effect of a run? As discussed in Annex A, this will involve replacing $\overline{z}$ by z^w for the banks, while leaving η_2 unchanged for passive investors, i.e. solving for $\eta_2(q-p)^2 - (1+\ \eta_2 z^w)(q-p) +\ z^w\ =\ e_1$, where $\eta_2 = \frac{3\tau}{\overline{z}^2}$. The effect of this on asset prices as the size of the run ω increases is indicated graphically by the arrow running downward from D to R in Figure 4.

When the impact of these falling prices is taken on the balance sheet this may well imply prompt insolvency, as indicated by negative values on the endogenous equity schedule $e = \left(p - \left(q - \underline{z}\right)\right) y_1$ labelled MM in Figure 4. This will be true if the run R takes the price of assets below q- $\underline{z}$, the lowest level that the IB equity base can cover. For in that case trading losses and marking to market using the endogenous equity schedule shown as $\left(p - \left(q - \underline{z}\right)\right) y_1$, i.e. moving horizontally from R to the equity valuation schedule in the Figure, will lead to a negative value for equity, as illustrated in the calibration below.

Even without a bank run, the longer run effect of Bad News may be sufficient to trigger insolvency. As indicated in the Figure, the dashed schedule of market clearing prices that incorporates Bad News fails to intersect the line MM showing the value of bank equity after with mark to market and trading losses. So prices fall to the point where nonbanks are willing to hold all risk assets.

Is this not overly dramatic? After all only one US investment bank was actually liquidated in the crisis! Our illustration is, however, an avowedly counter-factual exercise where no account is taken of the spectacular rescue operations mounted by the Fed and the Treasury to avoid wholesale liquidations, see Bernanke *et al*. (2019). The US Financial Crisis Inquiry Commission (2011, p. 386) put it bluntly:

> The Commission concludes that, as massive losses spread throughout the financial system in the fall of 2008, many institutions failed, or would have failed but for government bailouts. … the country [was left] with stark and painful alternatives – either risk the total collapse of our financial system, or spend trillions of taxpayer dollars to stabilize the system and prevent catastrophic damage to the economy.

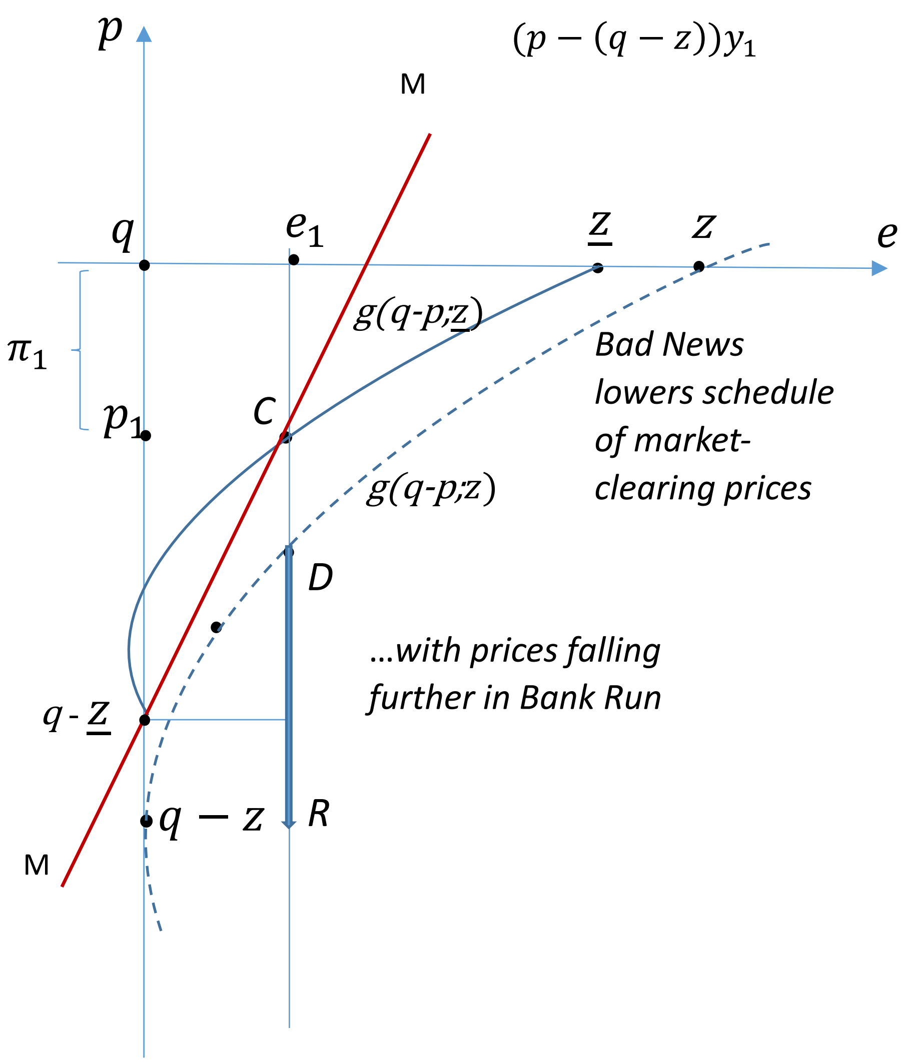

Fig. 4. Bad News and a 'Bank Run' leading to prompt insolvency

Capital injections by the Treasury, using TARP funds of $70b for the four investment banks remaining in business after Lehman went into liquidation[18], constituted more than half the equity they reported for end-2007, for example (Miller *et al*., 2018, p.103). In terms of liquidity support, those same banks, with balance sheet value of about $3.5tr at the end of 2007 (and leverage averaging 30), are on record as having utilised the Fed's primary dealer overnight facility to the tune of over $4tr in the ensuing crisis (Tooze, 2018, p.216). As Blinder (2013, p.124) indicates, two of them (Goldman Sachs and Morgan Stanley) registered as Bank Holding Companies for the purpose, after the other two had been taken over by commercial banks.

In the opinion of the historian Adam Tooze (2018, p.9):

> Never before, not even in the 1930s, had such a large and interconnected system come so close to total implosion. But once the scale of the risk became evident, the US authorities scrambled. … not only did the Europeans and Americans bail out their ailing banks at a national level. The US Federal Reserve … established itself as liquidity provider of last resort to the global banking system.

4. A calibrated illustration

To illustrate, we present a calibration to show first how 'pecuniary externalities' amplify a boom triggered by Good News; and then how banks could – absent intervention - suffer from prompt insolvency in the face of Bad News combined with a Bank Run.

Table 1: Parameters values used in calibration

Variable	Name	Description	Value
z	Initial downside risk		0.08
τ	Risk tolerance of patient investors	= z/3	0.08/3
η	Coefficient of demand	Derived as $3\tau/z^2$, or $3\tau/\underline{z}^2$ or $3\tau/\overline{z}^2$	
q	Expected annual payoff on risk assets	Net of payment to creditors	1.02
e_0	Initial IB equity	Chosen to give leveraged banks	0.01

[18] Namely Goldman Sachs, Merrill Lynch, Morgan Stanley and Bear Sterns.

		approx. 65 % of assets at peak	
$\underline{z}$	Good News	z – 0.03	0.05
$\overline{z}$	Bad News	z	0.08
λ	leverage	Derived value of assets/equity	
ω	Bank run	Fractional loss of funding that causes insolvency when losses are marked to market.	

The expected payoff, q, measured net of the cost of borrowing, is set to be 1.02 on an annual basis, broadly in line with Gertler and Kiyotaki (2015). Relative to this modest expected payoff[19], the maximum downside risk, z, is set initially at 0.08. With Good News, however, this is reduced to 0.05; returning to 0.08 with Bad News. The parameter for risk tolerance is chosen so that the two roots z and η^{-1} coincide in the initial equilibrium, as in Figures 1 and 3. The Initial value of IB equity is chosen to give shadow banks, after the boom triggered by Good News, approximately the two third share of the market reported for leveraged institutions in Shin (2010, p.153). Using the parameter values indicated in Table 1 in the relevant quadratic equations produces the results in Table 2 below.

Table 2 Calibration results

		1	2	3	4	5
		Initial Equilibrium (with high downside risk)	Impact effect of 'Good News' (of lower risk)	Equilibrium effect of 'Good News' with marking to market	Impact effect of 'Bad News' (of return to higher risk)	Impact effect of Bad News plus Bank Run
1	Max downside risk	0.08	0.05	0.05	0.08	0.08
2	Risk premium	0.05172	0.02061	0.01158	0.03601	0.08
3	IB Holdings	0.3536	0.3403	0.6296	0.5499	0
4	Market Price	(0. 9683)	(0.9994)	(1.0084)	(0.9840)	0.94
	Aggregated IB balance sheet					
5	Asset value	(0.3423)	(0.3401)	(0.6349)	(0.5411)	0
6	Debt	(0.3323)	(0.3301)	(0.6107)	(0.5169)	0
7	Equity	0.01	0.01	0.02419	0.02519	Insolvency

[19] A substantial reduction on the gross expected payoff used Miller and Zhang (2018).

8	Bank Run, ω					0.037
9	Leverage, λ	34.24	34.01	26.24	22.37	n.a.

In the **initial equilibrium** shown in the first column, the IBs hold about 35% of risk assets, see row 3, where the total supply of risky asset is normalised to 1. With a market-clearing price of 0.97, this implies assets worth 0.34 on the aggregate balance sheet, funded by borrowing and by 0.1 of own equity, implying leverage of about 34, see rows 4,5, 7 and 8. The risk premium needed to clear the market, about 0.05 (row 2), is over half maximum downside risk of 0.08.

The **impact effect of Good News** (which narrows the maximum downside risk by more than a third) leads to a rise in the market price, and a corresponding fall in the risk premium. But with equity kept at its original value, there is little asset trading and IB leverage remains unchanged, see last entry in column 2.

Marking capital gains to market, however, leads to a boom in shadow banking with a **Good News equilibrium** in column 3 where the equity of the banks has more than doubled and their share of assets has risen to 63%. That their equity has risen faster than the value of assets implies that leverage has fallen somewhat, to about 26.

On impact, Bad News (that raises the maximum downside back to its initial level) triggers substantial unloading of assets by banks, whose leverage falls to 22; and a substantial rise in the risk premium is required so as to get non-leveraged investors to take up these assets, see Column 4.

Since the initial risk premium is practically the same as the downside range of 0.05 for which they are provisioning after the Good News, the banks may feel that such a shock can be accommodated. But as prices fall back towards their initial level, trading losses on these sales, together with mark to market adjustments on remaining holdings, pose a severe threat of insolvency. So great, indeed, that it takes a **systemic bank run** of only 4 percent to trigger the immediate insolvency of the leveraged sector[20], see Column 5. With all assets in the hands of risk-averse agents, the risk premium increases to 0.08, far above its initial level.[21]

In this counterfactual exercise, no attempt is made to calibrate the rescue operations made to save the banks from collapse. Del Negro *et al*. (2018), however,

[20] 'Brunnermeier (2009) has noted that the use of overnight repos became so prevalent that, at its peak, the Wall Street investment banks were rolling over a quarter of their balance sheets every night' (Shin, 2010, p. 156)

[21] Even without a bank run, Bad News leads to insolvency in this calibration, with prices falling to the point where nonbanks are willing to hold all risk assets as in Column 5.

offers a 'quantitative evaluation of the Fed's liquidity policies'; and Bernanke *et al*. (2019) gives an overview of the unprecedented policy response by those directing policy at the time.

5. Conclusion – and a caveat

The effect that externalities can have on financial stability has been studied by highlighting two specific channels. The first is via balance sheet rules designed for micro-prudential purposes which turn out to amplify shocks common to all agents through the price of assets on their balance sheets. The second channel operates when creditor panic impinges on the equity base of financial intermediaries. Diamond and Dybvig (1983) showed that reserve holdings based on the law of large numbers would be unable to cope in such circumstances. Shadow banks can face similar problems even when they invest in fully marketable securities, as the 'liquidity insurance' seemingly offered by holding saleable assets can disappear in the face of common shocks.

Together these externalities can lead to prompt insolvency of highly-leveraged Investment Banks in the face of Bad News as to quality of assets on their balance sheets, even if nonbank demand were highly elastic (as in the calibration summarized in Annex B[22]). For not only will the news lead to a fall in market demand for the assets in question and in their market price, it can lead to the equivalent of a Bank Run.

Checking systemic risk

That externalities can play a key role in the financial system has major implications for theory and policy. Theoretically, it challenges unthinking reliance on competitive markets. With private incentives failing to deliver socially efficient levels of public goods, the first welfare theorem of competitive equilibrium will not apply. Public policy, not market forces, will be necessary to protect financial stability. So, in conclusion, we broaden the discussion to look albeit briefly at regulatory, institutional and legal steps taken.

One way of checking externalities is by explicit *Pigovian taxes*. An idea discussed in Brunnermeier et al. (2009) is, for example, that

> bank equity can lowered in a boom by an explicit centralized tax …which has the potential to enhance the efficiency of the overall financial system in the same way as a congestion charge would improve traffic in a city. [Moreover] if the

[22] This differs a little from Figure 4, for here $\eta^{-1} < z$ so as capture the highly elastic nonbank demand of the calibration, which seems to promise protection.

revenue raised through the Pigovian tax could be put into a separate bank resolution fund, then the scheme would not imply a net transfer away from the banking sector. Shin (2010, p. 163).

In practice, however, *macro-prudential policy* has been the approach favoured by Central Banks to reduce systemic risk in banking [23]. Thus, under the provisions of Basel III, capital requirements have been increased and a cyclical buffer added, together with a leverage cap[24]. With regard to liquidity risk, 'Basel III proposals to impose liquidity and stable funding requirements can be thought of as tools to limit the risk of fire sales stemming from bank reliance on short-term debt', De Nicolo *et al.* (2012, p.13).

There has been some *structural change* in banking - with the Volcker Rule to limit proprietary trading by banks in the US and the 'ring-fencing' of banks' of retail banking operations in the UK. New institutions have been created to manage risk. In the U.S. under the provisions of Dodd-Frank Act, a Financial Stability Oversight Council (FSOC) was established as the systemic risk regulator for the United States, with the secretary of the Treasury in the chair and the head of the Fed as a key adviser. In the UK – to complement the Monetary Policy Committee, whose task was, broadly, to protect the public good of price stability - the Bank of England now has a Financial Policy Committee designed 'to remove or reduce systemic risk with a view to protecting and enhancing the resilience of the UK financial system'.

Are these varied responses to the recent crisis sufficient to stabilise shadow banking – or its likely successor; or are further steps needed? In considering this question, we return to the caveat flagged in the Introduction, namely the evidence of incentive problems.

Unresolved agency problems

[23] See, for example, De Nicolo et al (2012) for a 'taxonomy of macro-prudential policies in terms of the specific negative externalities in the financial system that these policies are meant to address'. Walther (2016) considers how capital and liquidity regulations are best combined. Cerutti et al. (2017) provide a review of evidence on the use and effectiveness of macro-prudential policies.

[24] With Systemically Important Financial Institutions (SIFIs) required to hold more and higher-quality capital.

In the Shin model all risk is covered by equity; so the analysis above takes it as given that the regulatory structure restrains excess risk taking. As Stiglitz (2019, p.164) notes, however:

> Many of the problems observed in the financial market may, in part, be a result of … control/corporate governance problems. They help explain perverse incentives, lack of transparency, and even the excesses of risk taking.

There is, indeed, considerable and convincing evidence of such agency problems. After discussing this evidence, we indicate how it may lead to a reinterpretation of the model used above, so what have been called exogenous shocks may arise from distorted incentives within the system.

Raghuram Rajan (2005) famously warned ahead of time that financial development was making the world riskier. Writing after the event, he describes how sharp financial practice converted the political objective of helping low-income families to acquire housing into financial crisis:

> The sophisticated U.S. financial sector responded to the government's desire to promote low-income housing, as well as foreign demand for highly rated debt securities. The edge the financial sector exploited was the unthinking, almost bureaucratic way the mortgage agencies and foreign investors evaluated the issued securities. Market discipline broke down as mortgage brokers found they could peddle all sorts of junk, especially because the deterioration in credit quality was masked by the immense amount of money pouring into the sector. Rajan (2010, p.122,3)

Collusion between the banks and the rating agencies in the marketing of mortgage backed securities is indeed cited by Akerlof and Shiller (2015, Chapter 2) as an egregious example of those with superior information colluding to fool those with less.

The threat that this 'breakdown of market discipline' posed for banking stability was reaffirmed recently by Robert McCauley (2019, p.73) of the BIS. He pointed out that 'the application of the international rules known as Basel II allowed big banks to evaluate the riskiness of their assets and permitted US securities firms and European Banks to pile 50 or more dollars or euros for every dollar or euro of equity'. Likewise, Danielsson (2019, p. 262) warned that: 'Any bank wanting to be seen as having a high capital [ratio] while actually holding little capital can use clever financial engineering tricks to make bank capital appear to be almost anything the bank wanted, at least until 2008.' It appears that banks took advantage of this to 'game' the weights intended to measure the risk on assets in their portfolios -- allowing them to take on higher-than-justified leverage [25].

There is, in addition, a raft of legal evidence showing that the riskiness of the assets that investment banks were holding and assembling for sale was substantially understated. American investment banks and affiliates of European banks have been fined in US courts for mis-selling securitised mortgages, Kane(2016), Miller *et al*. (2018). Likewise, the unregulated, but highly regarded, Credit Rating Agencies have been fined for mis-rating as they competed for business[26].

The evidence of successful cheating is a challenge for models of externalities like that developed here (where shadow banks are assumed to play by VaR rules) and that of Gertler and Kiyotaki (where self-regulation is deemed sufficient to deal with stealing). The evidence could mean that the shocks driving boom and bust were not exogenous, but generated by distorted incentives within the financial system. With respect to Good News, for example,it appears that the agencies who issued the inflated ratings were aiding and abetting shadow banks in what Rajan calls the 'peddling of junk' – assembling MBS both to sell to others and to keep on their own balance sheets[27]. As Holmstrom (2015, p.267) has pointed out, moreover, the 'dynamic credit enhancement' that underpinned subprime lending could only work if house prices - already buoyed by a bubble - continued to rise: so the resulting boom was not sustainable. Consequently, the Bad News would also be endogenous - when the mis-rating came to light.

Metaphorically, significant externalities mean the financial system is far from fireproof: agency problems may supply the spark that lights the fire. The challenge of how, formally, to combine the two is beyond the scope of this short paper.[28]

Restoring confidence in banking

After the Wall Street crash and banking collapse, major public policy intervention - the wide-ranging Glass-Steagall Act of 1933 in particular - restored stability and trust in US banking, Brands (2008). Will policies of Macroprudential

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[25] As Haldane et al. (2010, p.89) note: 'Those banks with the highest leverage are also the ones which have subsequently reported the largest write-downs. That suggests banks may also have invested in riskier assets, which regulatory risk weights failed to capture.'

[26] As discussed in Stiglitz (2010, p.92)

[27]That shadow banks held on to such risky assets is one of the paradoxes of the crisis: it may be that use of 'tranching' and of off-balance-sheet SPVs - like installing bulkheads on S.S. Titanic – offered seeming protection from disaster.

[28] The effect of asymmetric information on equilibria of the Shin model is, however, examined in Y. Zhang (2017), however; and the application of Akerlof's lemons model discussed by Miller *et al*. (2018).

regulation do the same after the crisis of 2008/9? The caveat discussed above suggests that, though necessary, this will not be enough without complementary measures to deal with agency problems in investment banking.

There are broadly two approaches to checking misgovernment of financial institutions that may need to be considered further – criminalising reckless behaviour, as the UK Senior Persons regime seeks to do, Kane (2016); or removing limited liability for selected high level executives, as advocated by Goodhart and Lastra (2019).

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Annex A. Involuntary deleveraging (in a systemic bank run) and the threat of insolvency

To analyse how aggregate funding losses reduce investment bank demand for risk assets, we start with the balance sheet of investment banks in aggregate:

$$py = B + e_0$$

where *B* denotes borrowing and *p* is the price of risk assets. Let involuntary deleveraging be introduced as

$$B = (1-\omega)(q-z)y$$

where the term ω represents the fraction of withdrawals**,** relative to the standard assumption of maximum borrowing consistent with VaR.

To see how this impacts on asset demand we substitute for *B* in the balance sheet:

$$py = (1-\omega)(q-z)y + e_0$$

hence

$$\big(p-(1-\omega)(q-z)\big)y = [(p-q+z)+\omega(q-z)]y = e_0$$

giving the revised demand for risk assets as

$$y = \frac{e_0}{z-\pi + \omega\,(q-z)} = \frac{e_0}{z^{\omega}-\pi}$$

where $z^{\omega} = (1-\omega)z + \omega\, q > z$.

By reducing assets in line with borrowing for given equity, e_0, it's 'as if' the investment banks are aiming at a higher capital ratio **-** specifically that which would match greater downside risk of $z^{\omega} > z$. Note, however, that the risk aversion of non-banks, as measured by $\eta = 3\tau/z^2$, remains unchanged.

How this reduces investment bank demand for risk assets is shown by the dashed line labelled D' in Figure A1, a modification of the diagram in Shin (2010, p.33). If as shown $\eta^{-1} > z$, asset prices will fall sharply as banks sell to patient investors.

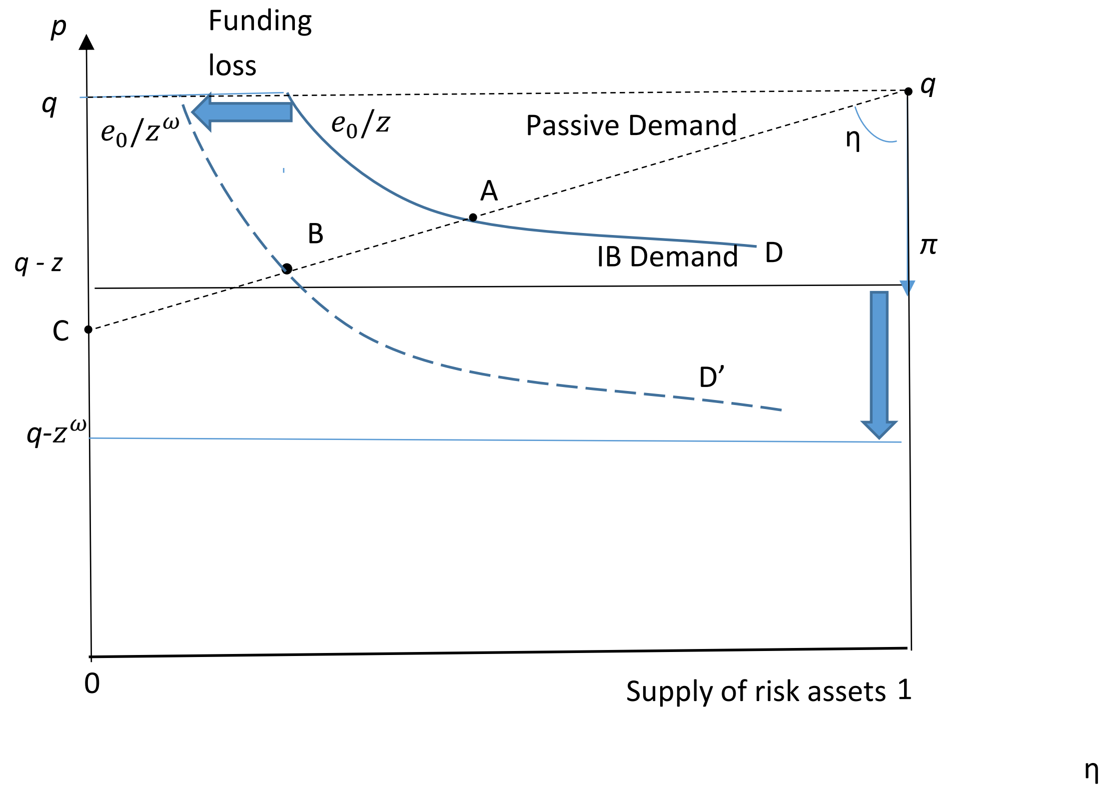

Fig. A1. Impact effect of systemic Involuntary Deleveraging

In the figure, where market equilibrium shifts from A to B, the reduction of deposits shown by the dashed schedule does not indicate immediate insolvency. This may occur, however, if a greater rate of withdrawals pushes the asset price to $-z$; then the risk premium will jump to $1/\eta$ as all assets are transferred to Passive Investors, as at point C.

Algebraically, the effect of the run will be to revise the schedule determining the market clearing asset price $g(q-p; z)$ as follows. Substituting the revised demand for risk assets, along with the demand by 'patient' investors, into the market clearing condition $y + x = 1$ yields

$$e_0/(z^\omega - \pi) + \eta\pi = 1$$

so

$$e_0 - z^\omega + (1+\eta z^\omega)\pi - \eta\pi^2 = 0$$

giving the revised polynomial

$$g1(q-p; z^\omega) = \eta\pi^2 - (1+\eta z^\omega)\pi + z^\omega = (\eta(q-p)-1)(q-p-z^\omega) = e_0$$

with roots $\eta^{-1}$and z^ω.

Relative to $g(q-p;z)$, withdrawals shift the schedule down to the right as in Figure A2, which illustrates the case where insolvency is immediate, with the fall in the asset price from A to B being sufficient to reduce initial equity to zero. In the main text, however, insolvency occurs because -- in addition to 'fire sales' by deleveraging banks --the price of risk assets suffers from the direct impact of bad news on asset quality.

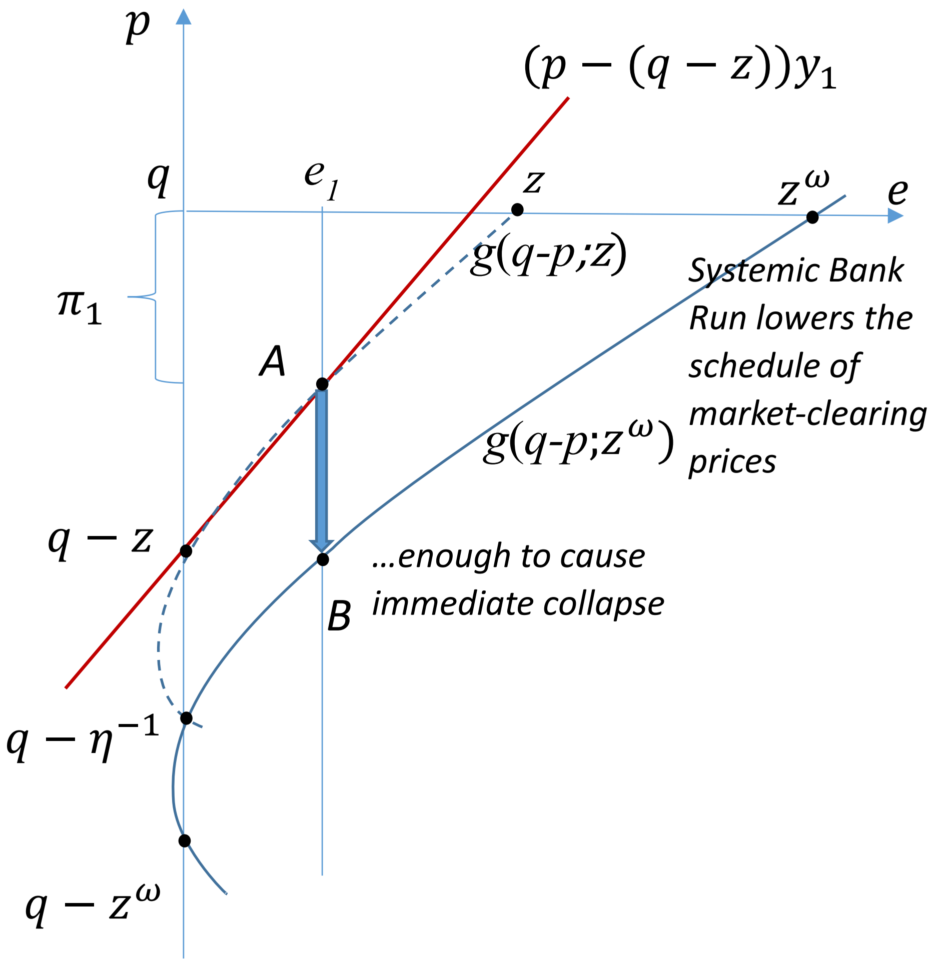

Fig. A2. A systemic bank run leading to prompt insolvency for Investment Banks

Annex B. Calibration with procyclical leverage

The calibration in the text does not display pro-cyclical leverage. The latter may be achieved by reducing the downside risk, and ensuring a very high elasticity of nonbank demand, as is illustrated below.

Table B1: Parameters values used in calibration

Variable	Name	Description	Value
z	Initial downside risk		0.06
τ	Risk tolerance of patient investors	> z/3 to ensure procyclical leverage	0.03
η	Coefficient of demand	Derived as 3 τ/z^2	
q	Expected annual payoff on risk assets	Net of payment to creditors	1.02
e_0	Initial IB equity	Chosen to give leveraged banks approx. 65 % of assets at peak	0.01
$\underline{z}$	Good News	z – 0.03	0.03
$\overline{z}$	Bad News	z + 0.00	0.06
λ	leverage	Derived value of assets/equity	
ω	Bank run	Fractional loss of funding that causes insolvency when losses are marked to market.	

The expected payoff, q, measured net of the cost of borrowing, is set to be 1.02 on an annual basis. Relative to this modest expected payoff, the maximum downside risk, z, is set initially at 0.06. With Good News, however, this is reduced to 0.03; returning to 0.06 with Bad News.

The parameter for risk tolerance is set high enough to ensure pro-cyclical leverage in response to Good News; which requires $\tau > z/3$. Ensuring that, as in Gertler and Kiyotaki (2015), the fall in asset price due to fire-sales after Bad News is sufficiently large to trigger a bank run ex ante requires $\tau < 3\underline{z}/\bar{z}^2$. To satisfy both conditions, given values chosen for Good and Bad News, τ is set at 0.03. [Note that, with these parameters, the two roots z and η^{-1} do not coincide in the initial equilibrium, as was shown for simplicity in Figures 1 and 3: here $\eta^{-1} < z$.]

The Initial value of IB equity is chosen to give shadow banks, after the boom triggered by Good News, the two third share of the market reported for leveraged institutions in Shin (2010, p.153). Using the parameter values indicated in Table B1 produces the results in Table B2 below, which is broadly similar to that in the text, but that leverage rises from 31 to almost 40 in response to good news.

Table **B**2 Calibration results

		1	2	3	4	5
		Initial Equilibrium (with high downside risk)	Impact effect of 'Good News' (of lower risk)	Equilibrium effect of 'Good News' with marking to market	Impact effect of 'Bad News' (of return to higher risk)	Impact effect of Bad News plus Bank Run
1	Max downside risk	0.06	0.03	0.03	0.06	0.06
2	Risk premium	0.02764	0.005858	0.003422	0.02173	0.03
3	IB Holdings	0.3090	0.4142	0.6578	0.4568	0
4	Market Price	(0. 9923)	(1.014)	(1.017)	(0.9982)	0.99
	Aggregated IB balance sheet					
5	Asset value	(0.3067)	(0.4201)	(0.6687)	(0.4560)	0
6	Debt	(0.2967)	(0.4101)	(0.6512)	(0.4385)	0
7	Equity	0.01	0.01	0.01748	0.01748	Insolvency
8	Bank Run, ω					0.042
9	Leverage, λ	30.67	42.01	38.24	26.08	n.a.