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by Ilhyock Shim and Goetz von Peter

Monetary and Economic Department

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Ilhyock Shim
Bank for International Settlements

Goetz von Peter*
Bank for International Settlements

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This paper examines the process of distress selling and asset market feedback. It splits this process into several stages, in order to analyse what triggers distress selling, why asset prices fall, and how falling prices generate additional rounds of selling. This framework enables us to understand and compare models relevant to distress selling from diverse literatures. The paper also considers what policy options are available at each stage to mitigate the adverse economic consequences of distress selling and asset market feedback.

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*Ilhyock Shim and Goetz von Peter are economists at the Research and Policy Analysis Group, Bank for International Settlements. We are grateful to Claudio Borio, Blaise Gadanecz, Herbie Poenisch, Kostas Tsatsaronis and Christian Upper for detailed and helpful comments. We also thank seminar participants at the Bank of England and the Bank for International Settlements. The views in this paper are those of the authors and do not necessarily represent those of the Bank for International Settlements. Email addresses: Ilhyock.Shim@bis.org, Goetz.von.Peter@bis.org. Fax: +41-61-280-9100.

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1 Introduction

Many episodes of financial instability have falling asset prices and widespread financial distress at their heart. One common pattern is that financially distressed institutions sell assets, asset prices fall, losses spread, cash flows and balance sheets deteriorate, and more assets are sold into a falling market. This process of distress selling and asset market feedback can be costly and potentially unstable, and policymakers have shown interest in measures to prevent or remedy adverse economic consequences. In spite of growing interest, there has been little systematic work with a common framework including definitions, mechanisms and outcomes. After Fisher's (1933) early treatment, few models have taken up distress selling explicitly, and fewer still have studied the role of asset prices in producing feedback.

To fill this gap, this paper provides an anatomy of distress selling and asset market feedback. We split the process into several stages (Figure 1). Given the initial state of balance sheets, a shock in combination with cash commitments or financial constraints triggers initial distress selling of assets. Excess supply in the asset market then lowers the asset price. Falling asset prices in turn elicit further rounds of distress selling, which we call asset market feedback. We also identify adverse economic consequences stemming from distress selling and asset market feedback, and consider policy options available at each stage.

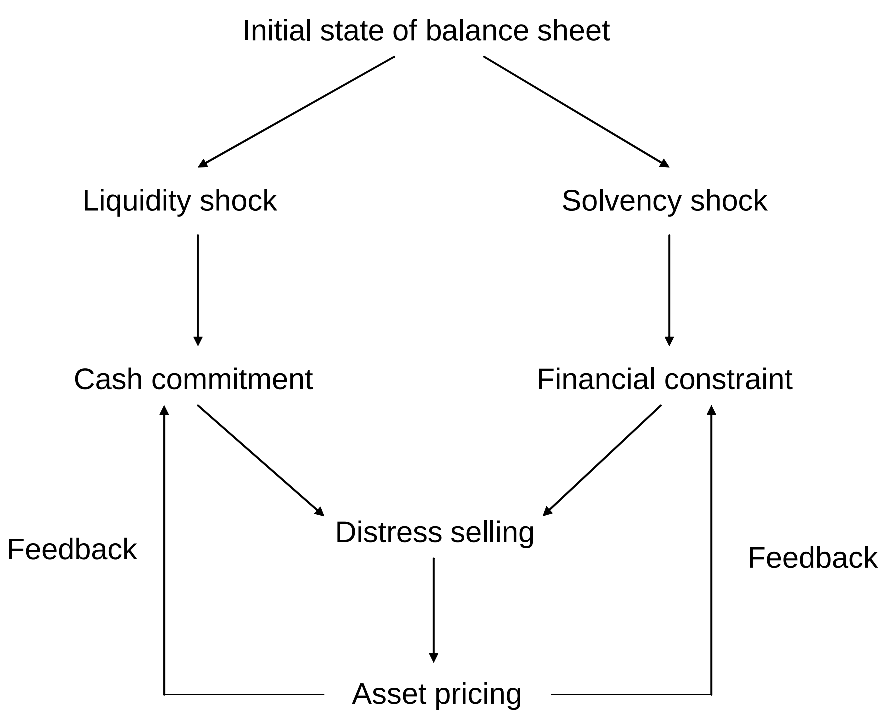

Figure 1: Distress selling and asset market feedback

The paper draws together model elements relevant to distress selling from diverse literatures, ranging from macroeconomics to corporate finance, banking, financial economics, and game theory. By providing a unified framework with a common notation, we show that the leading models can be understood and compared in terms of the stages we identified. Our analysis also provides useful guidance on what policymakers can do at each stage, so that early action can be taken to contain adverse economic consequences.

The paper is structured as follows. Section 2 defines distress selling and asset market feedback, and presents the basic analytical framework that will be used throughout the paper. Section 3 shows how specific models combine the ingredients of this framework to generate distress selling, where we distinguish between liquidity-driven and solvency-driven selling. Section 4 investigates the pricing of assets from the perspective of buyers, where we emphasise the role of liquidity and concavity in the valuation of assets. Section 5 explores how falling asset prices can cause asset market feedback, where we identify four channels: cash flow, financial constraints, propagation, expectations. Section 6 explores economic costs of distress selling and asset market feedback in terms of output and distribution. Section 7 considers policy options that can be taken at each stage in Figure 1. The final section concludes.

2 Concepts and framework

This section first defines financial distress, distress selling and asset market feedback, and then provides a basic notational framework to be used throughout the paper. In particular, it states the period-by-period budget constraints (cash flows) and the balance sheet positions of a generic agent which can be a household, a firm, or a bank. Distinguishing between cash flows and balance sheets will help differentiate between liquidity- and solvency-driven distress selling (Section 3).

2.1 Concepts

We consider a typical agent who purchases long-term assets using his own as well as borrowed resources. It is not necessary at this stage to specify whether the assets are financial or real, nor why the agent purchases them (Section 4 elaborates). The important feature is that the assets can be traded each period.[1] By assumption, the agent does not rent or borrow the assets. The distinction matters in that a purchase requires a sizeable expenditure up-front, often involving the use of debt, and exposes the agent to price risk associated with the resale of the assets.

The agent is committed to make payments in cash (henceforth, cash commitments). Cash commitments could be unrelated to asset holding (such as a firm's wage bill), but we focus on

[1] This notion of assets includes durable consumer goods, and excludes claims maturing within the horizon of analysis.

the repayment of debt using cash available to the agent.[2] He may also face financial constraints on his balance sheet positions (henceforth, financial constraints), such as borrowing constraints or liquidity requirements.

After the assets have been purchased on credit, he is subject to shocks, such as changes in the asset value or the cash in- and out-flows. Given his initial balance sheet position, depending on the size of shocks, he may face difficulty in meeting cash commitments or financial constraints. Now we are ready to provide the definition of financial distress.

Definition 1 *Financial distress refers to the inability to meet cash commitments or respect financial constraints after a shock, unless further action is taken.*

The underlying assumption is that failure to meet cash commitments (default), or the violation of financial constraints and subsequent bankruptcy or regulatory sanctions are costly: the agent may lose control over the assets or the right to future cash flows. In order to deal with financial distress, the agent may take action such as adjusting consumption, selling assets, rescheduling debt or issuing equity, or a combination of the above. In this paper, we focus on the cases where the agent in financial distress prefers selling assets to borrowing more, issuing new equity or rescheduling debt.

Definition 2 *Distress selling refers to the sale of assets, which were originally intended to be held, in order to deal with financial distress.*

Section 3 explores in detail the conditions that give rise to distress selling. Once the agent begins selling assets into the market, a new asset price is determined jointly by the volume of distress sales and demand-side characteristics. Section 4 shows that the asset price tends to fall as the selling volume rises. Falling asset prices can in turn make it harder to meet cash commitments or to satisfy financial constraints. It is therefore possible that falling asset prices prompt additional rounds of distress selling.

Definition 3 *Asset market feedback refers to a situation where falling prices, due to initial selling, elicit further distress selling in the same market.*

Section 5 lays out various mechanisms through which asset market feedback can occur. In restricting attention to one and the same market, the paper leaves aside issues of contagion across asset markets.

[2] Another asset-related mechanism generating cash commitments that does not rely on the repayment of debt is variation margin on futures contracts.

2.2 Framework

The framework follows the stages of Figure 1. We consider a unit measure of agents, which can be households, firms, banks, or countries, depending on the interpretation attached to the variables. There are three periods, $t = 0, 1, 2$.[3] Period 1 is divided into two subperiods, labelled $t = 1^-$ and $t = 1$, with some abuse of notation. The asset price q is quoted in terms of a numeraire, which can be cash or consumption goods. Each period, a typical agent's cash flows are represented in (1), and the balance sheet positions described in (2).[4]

$$
\begin{array}{llcl}
t = 0: & qk + m & = & b + e \\
t = 1: & c' + m' + Rb + \rho & = & y' + b' + q'(k - k') + m \\
t = 2: & c'' + R'b' & = & y'' + q''k' + m'
\end{array}
\tag{1}
$$

$$
\begin{array}{c|c}
\multicolumn{2}{c}{t=0} \\
\hline
m & b \\
qk & e \\
 &
\end{array}
\qquad
\begin{array}{l|l}
\multicolumn{2}{c}{t=1^-} \\
\hline
m & Rb \\
\widehat{q}k & \widehat{e} \\
y' - \rho &
\end{array}
\qquad
\begin{array}{c|c}
\multicolumn{2}{c}{t=1} \\
\hline
m' & b' \\
q'k' & e' \\
 &
\end{array}
\qquad
\begin{array}{l|l}
\multicolumn{2}{c}{t=2} \\
\hline
m' & R'b' \\
q''k' & e'' \\
y'' &
\end{array}
\tag{2}
$$

In period 0, agents are endowed with e and borrow b, in order to hold m goods and purchase k units of the risky asset. R denotes the gross one-period interest rate at which agents can borrow. Debt is one-period, but agents can roll over or refinance elsewhere. How agents choose k, b, and m at $t = 0$ is not modelled here; regardless of the nature of this ex ante choice, agents are likely to react to the shock in $t = 1^-$ by adjusting their choices to k', b', and m'.

When making these choices, agents may be subject to financial constraints, which relate to their balance sheet (2) at each point in time. In $t = 0$, for instance, the balance sheet features the safe and liquid asset m, the value of risky assets qk, debt b, and net worth e. Financial constraints typically take the form of a ratio between two of these items. Financial constraints aimed at liquidity, such as reserve requirements, can be expressed as a ratio of liquid assets to short-term debt, $m/b \geq \alpha$. Financial constraints aimed at solvency can be expressed as a leverage ratio $b/e \leq \lambda$, or as a (risk-adjusted) capital adequacy ratio $e/(qk) \geq \kappa$. Financial constraints play a crucial role in generating distress selling and asset market feedback (Sections 3 and 5).

Agents enter the next period with k assets and Rb in debt when a shock is realised. To illustrate how agents react to this shock, we divide period 1 into pre- and post-trade subperiods, labelled $t = 1^-$ and $t = 1$ respectively. The shock occurs in $t = 1^-$ and can be either a liquidity shock, a solvency shock, or a combined shock. A pure liquidity shock only affects the current cash flow, leaving unaffected net worth on the balance sheet; for example, the amount the agent can refinance

[3] The final period can be understood as a terminal condition for pricing assets (as in Grossman and Miller 1988), or as a shortcut that represents the continuation of an infinite-horizon model.

[4] Asset values on the balance sheet are marked to market.

falls to $\widehat{b} < Rb$.[5] On the other hand, a pure solvency shock affects the balance sheet with no change in the current cash flow; for instance, the fundamental asset price falls to $\widehat{q} < q$, due to the arrival of new information.[6] A combined shock affects the current cash flow *and* leaves a permanent impact on the balance sheet, such as a negative shock to income y' or a positive shock to costs ρ. To focus on distress selling, we only consider adverse shocks and assume that, in the absence of shocks, asset holdings would remain constant ($k' = k$).

Following the shock in $t = 1^-$, cash inflows and available liquid assets may fall short of cash commitments, ie $y' + m < (Rb - \widehat{b}) + \rho$, and/or the agent's balance sheet violates any financial constraints that may be in place. If so, the agent faces financial distress and needs to take action to avoid default, bankruptcy or sanctions. This involves selling assets, when opportunities for debt forgiveness (reducing Rb) and refinancing (increasing $\widehat{b}$) have been exhausted, and when equity issuance (increasing $\widehat{e}$) is too costly. Let $\widehat{s} \equiv k - \widehat{k}$ denote the volume of the risky assets that, at the current asset price $\widehat{q}$, has to be sold to deal with financial distress. If the market price stays at $\widehat{q}$, cash commitments and financial constraints are satisfied after the sale of the assets $\widehat{s}$ and the choice of the amount of liquid assets $\widehat{m}$.

However, for reasons elaborated in Section 4, distress selling tends to push the market price below the fundamental asset value $\widehat{q}$. This requires further asset sales to realise the full value of cash commitments or to reduce debt and asset positions to satisfy financial constraints, as indicated in Figure 1. Once this feedback process ends at $t = 1$, $s' \equiv k - k'$ denotes the final volume of the assets sold, q' represents the final asset price, $b'(\leq \widehat{b})$ the final amount of debt, and m' the final amount of liquid assets. Note that $s' = (k - \widehat{k}) + (\widehat{k} - k')$, where the first term $(k - \widehat{k})$ shows initial distress selling and the second term $(\widehat{k} - k')$ additional selling due to asset market feedback. Cash flow at $t = 1$ in (1) indicate that the proceeds from selling the assets $q'(k - k')$, the reduction in liquid assets $m - m'$, and other net income $y' - \rho$ are used to repay $Rb - b'$, and the remainder c' is consumed. The balance sheet position at $t = 1$ in (2) shows the value of assets and liabilities after distress selling and asset market feedback.

In period 2, the market price of the asset equals q''. The proceeds from selling the assets $q''k'$ and any other revenue y'' are used to repay debt $R'b'$, and the remainder c'' is consumed. Negative consumption is precluded by limited liability; if unable to pay, the agent defaults and the shortfall $R'b' - (y'' + q''k')$ is passed on to the lender as a loss on the loan. In this context, default effectively means zero consumption.[7]

This framework can be adapted to different branches of the literature, each providing a different mapping between the identity of the agents involved, the nature of the assets, and the variables in (1)-(2). The variable k may represent financial assets, held for return, or real assets which can

[5] The agents need to pay lenders at least the net amount of $Rb - \widehat{b}$. At this point, only the amount of withdrawal is revealed; the agents' liability remains unchanged until the actual repayment is made.

[6] The hats on q and b represent values right after the shocks, but before any action such as trade and payment.

[7] We abstract from enforcement problems and strategic default; we do not consider separately the unwillingness to repay.

be productive or utility-yielding. In the case of households, housing would yield a utility flow $u(k)$, b would represent a mortgage and y' wage income. In the case of firms, assets could be productive inputs, so y' would be determined by a production or sales function $y' = f(k)$. Debt b may represent firms' borrowing from banks, or banks' borrowing from depositors. In the context of emerging market crises, changes in q can be associated with movements in the exchange rate.[8]

3 Distress selling

This section studies what triggers distress selling, taking as given the initial state of balance sheets. Later sections then focus on the price impact (Section 4) and on asset market feedback (Section 5) as possible consequences, as depicted in Figure 1. We show how specific models in the literature combine the ingredients of the above framework to generate distress selling. Although few models deal with distress selling explicitly, many implicitly admit distress selling for various combinations of shocks, cash flows and financial constraints. Throughout the paper we distinguish between liquidity-driven and solvency-driven selling, and classify the main approaches in the literature accordingly.[9]

3.1 Liquidity-driven distress selling

A pure liquidity shock affects only the timing of cash flows, leaving net worth unaffected. The shock may emanate from either the liability side or the asset side.

The leading example of liquidity shocks from the *liability side* is that of a bank run. In the early formal models following Diamond and Dybvig (1983), depositor withdrawals are not triggered by any prior change in economic fundamentals.[10] Deposit withdrawals are thus considered an initial shock in what follows. They constitute a pure liquidity shock affecting only the timing of cash flows: the more depositors withdraw early, the fewer withdraw later.

In our analytical framework, this can be formalised as follows. The economy consists of a single bank and a unit mass of savers. The bank accepts deposits of \$1 from each saver ($b = 1$), of which k is invested in long-term assets ($q = 1$), and m is kept as reserves to meet withdrawals by depositors in period 1 (we assume $e = 0$). For reasons familiar from banking theory, the deposit contract promises a fixed amount $\bar{c}$ to all depositors, whether they withdraw early or late.[11] In the

[8] When (1)-(2) are expressed in terms of dollars, then a depreciation reduces the dollar value of domestic assets k. Alternatively, when (1)-(2) are in domestic currency, then q should instead be attached to foreign-currency-denominated debt b.

[9] Of course, the simplest way of generating distress selling is to just *assume* that certain asset holders go bankrupt and liquidate their assets. Exogenous initial failures are common in interbank stress testing models (eg Upper and Worms 2004, Cifuentes et al 2005) and in models of bank bail-outs (eg Acharya and Yorulmazer 2006). The volume of sales reaching the market is also treated as exogenous in some dealer models in finance (eg Grossman and Miller 1988).

[10] Bank run is just the inefficient equilibrium among two possible Nash equilibria in a simultaneous game.

[11] Allen and Gale (1998) justify the deposit contract in terms of risk-sharing. All depositors are risk-averse,

original Diamond and Dybvig model, the asset is a long-term investment project that can only be liquidated early at $r < 1$. However, the notion of distress selling involves selling assets at $t = 1$ at an endogenous market price $\widehat{q}$, rather than liquidating an investment at a fixed return r. Thus, we are interested in the case where the long-term asset is marketable.

Suppose a measure λ of depositors seeks to withdraw $\bar{c}$ at $t = 1^-$. (This corresponds to a refinancing shock in (1), as only $\widehat{b} = (1 - \lambda)\,\bar{c}$ can be rolled over.) If $\lambda\bar{c} > m$, the bank must sell assets to meet withdrawals, and the volume of sales is given by the following distress selling function:

$$\widehat{s} = \frac{\lambda\bar{c} - m}{\widehat{q}}, \tag{3}$$

as long as $\widehat{s} \leq k$. The bank will default if intended withdrawals exceed the liquidation value of assets,

$$\lambda\bar{c} > m + \widehat{q}k.$$

In a monetary economy with fractional reserve banking, the effect of withdrawals on distress selling can be considerably larger. Suppose the bank observes a reserve requirement of the form $m \geq \alpha b$ at all times, where α is the reserve requirement ratio. In addition to meeting withdrawals, the bank must therefore maintain reserves to back the remaining deposits, $\widehat{m} \geq \alpha\,(1 - \lambda)\,\bar{c}$. As reserves can only be raised by selling assets, the bank must sell at least

$$\widehat{s} = \max\left[\frac{(\lambda\bar{c} - m) + \alpha\,(1 - \lambda)\,\bar{c}}{\widehat{q}},\ 0\right]. \tag{4}$$

The reserve requirement thus tends to produce additional distress selling ($\alpha > 0$), and does so in more states of the world. With reserves sufficient to meet withdrawals ($m > \lambda\bar{c}$), there was no need to sell in (3). Now, with the reserve requirement in place, the bank will have to sell some of the assets unless it holds a large buffer ($m \geq \lambda\bar{c} + \alpha\,(1 - \lambda)\,\bar{c}$).[12] Moreover, in a fractional reserve system it is important to distinguish between an individual bank and the system as a whole. The individual bank in (4) obtains reserves at the expense of other banks in the system when no additional reserves are injected. No amount of distress selling can raise aggregate reserves above $\widehat{m} = m - \lambda\bar{c}$, so the banking system can only support $\widehat{m}/\alpha$ deposits,[13]

$$\widehat{b} = b - \lambda\bar{c}/\alpha.$$

Deposits must therefore fall by a multiple of the initial withdrawals $\lambda\bar{c}$, which can only be accomplished by further distress selling. This illustrates the multiple contraction of deposits which

so the optimal contract promises depositors constant consumption in as many states as possible. Since types are unobservable, late consumers can always pretend to be early consumers, and withdraw their deposits early. Incentive compatibility requires that late consumers get at least as much as early consumers.

[12] Since the Federal Reserve did not perform its role as a lender of last resort, banks held reserves well in excess of the legal requirement (Friedman and Schwarz 1963). A greater α in (4) accentuates distress selling.

[13] This example assumes a unit mass of identical banks, each with $m = \alpha b$.

Friedman and Schwartz blame for the severity of the Great Depression.

The most famous instances of bank runs were the banking panics of the Great Depression. In the United States, three waves of bank runs in which depositors withdrew currency *en masse* caused a scramble for reserves. Banks had to distress-sell their marketable assets, primarily their bond portfolios, which forced a decline in bond prices (Friedman and Schwartz 1963). Banking panics have become rare since the widespread adoption of lending of last resort and deposit insurance, apart from occasional runs on individual banks (eg Continental Illinois National Bank in 1984). But the notion of bank runs can be understood more broadly to apply to other intermediaries. For example, a run by Korean investors to redeem their holdings of investment trusts forced the trusts to sell assets (Remolona and Wooldridge 2003). However, this qualifies as distress selling only in the presence of fixed cash commitments. Financial distress is precluded in the case of a mutual fund whose shares are pegged to the market value of assets.

Distress selling can also be triggered by liquidity shocks on the *asset side*, for instance when revenues accrue later than expected. This situation is likely to be applicable quite broadly to firms and households. The following example draws from the literature on project finance subject to agency problems (eg Suarez and Sussman 2005, or Diamond and Rajan 2005). Entrepreneurs purchase a machine on credit in order to run their project ($b = q$, $k = 1$). All projects are profitable, but projects differ in the timing of cash flows. Following Suarez and Sussman (2005), normal projects yield y both in periods $t = 1$ and 2, but slow projects yield $2y$ in $t = 2$. While inconsequential in terms of net present value, slow projects cause financial distress if entrepreneurs in $t = 1$ face cash commitments that cannot be delayed or refinanced.

Such a situation arises when the threat of liquidation is part of the incomplete-contract solution to an agency problem. If only the entrepreneur can operate the project, and output is not verifiable by court (and hence cannot be contracted upon), the entrepreneur can always default and claim that the project yielded no output in $t = 1$. Repayment can be induced by the threat of liquidation. Liquidation is triggered when the entrepreneur fails to pay a predetermined amount Rb at $t = 1$. Normal projects provide sufficient cash flow ($y > Rb$), but slow projects are liquidated. In this event, the lender repossesses a fraction β of the project's assets and sells them. Each slow project generates distress selling of

$$\widehat{s} = \beta k. \tag{5}$$

Evidence suggests that creditors indeed influence the asset liquidation decision of financially distressed firms (Brown et al 1994). Creditors in this context are outside financiers, while in bank runs the creditors are uninsured depositors.

The cases covered so far suggest that distress selling can arise when a liquidity shock clashes with cash commitments in (1).[14] Yet in the absence of frictions, this combination alone is insufficient

[14] Further examples of liquidity shocks could be given, eg settlement fails in financial markets, where traders do not receive payment when the security delivered is rejected by the counterparty (Fleming and Garbade 2005).

for generating distress selling. The *raison d'être* for credit lines is that borrowing allows to smooth unexpected cash flow shocks (Agarwal et al 2006). Banks, as the main liquidity providers, have in turn access to refinancing facilities: the interbank market can accommodate idiosyncratic liquidity shocks (Bhattacharya and Gale 1987, Allen and Gale 2000), and open market operations or lending of last resort can overcome aggregate shocks (Section 7.2).

Liquidity shocks triggers distress selling only if such borrowing facilities are absent or costly, or if agents are subject to financial constraints. In the case of project finance the threat of liquidation (an endogenous borrowing constraint) precludes refinancing. In the basic bank run model, financial constraints are implicit in the assumption of a single bank drawing all the resources of the economy: there are no outside investors, no other banks and no central bank. However, if a bank can borrow externally, liquidity shocks become inconsequential unless the interbank market is beset by agency problems (Flannery 1996), or the economy as a whole is unable to pledge sufficient resources (Holmström and Tirole 1998).

3.2 Solvency-driven distress selling

Distress selling can also be triggered by solvency shocks, typically in conjunction with financial constraints. Pure solvency shocks do not involve an immediate cash flow problem, but they affect the value of assets on agents' balance sheets, which can give rise to selling pressure in the presence of financial constraints. We consider realisations of market risk and credit risk separately.

Market risk

Market risk is the potential for losses arising from movements in market prices. Consider a minor market correction, a reassessment of the fundamental asset price based on new information: q falls to $\widehat{q}$. Many investors need not act upon such unrealised portfolio losses, but some may run up against financial constraints such as margin requirements or trading rules. Exchanges and brokerage houses routinely impose margin requirements to limit leverage and mitigate counterparty risk. Being expressed in terms of current values, such requirements mark assets to market and may force investors react to both realised and unrealised losses.

This can trigger distress selling as follows. In the context of our framework, margin requires that a fraction μ of the value of a position be covered by own funds, $e \geq \mu qk$ in (2). This is equivalent to restricting borrowing to the remaining fraction, $b \leq (1-\mu)\, qk$.[15] A typical investor's margin account at a brokerage house evolves in parallel to the balance sheets (2), with $e = \mu qk$ and $b = (1-\mu)\, qk$ if the investor assumes the maximum leverage. When the asset price falls to $\widehat{q} < q$, nominal debt b remains unchanged, so margin falls by the loss implicit in the marked-to-market

[15] If the agent holds a safe asset $m > 0$, then $e \geq \mu qk$ implies $b - m \leq (1-\mu)\, qk$. In terms of solvency, only the difference $b - m$ matters: money offsets debt, and any extra borrowing to hold the safe asset does not count. Thus we can set $m = 0$ without loss of generality. For simplicity, $R = R' = 1$.

position, $(q - \widehat{q})\,k$. The margin requirement is therefore violated in $t = 1^-$, if it was binding initially,

$$\widehat{e} = e - (q - \widehat{q})\,k < \mu \widehat{q} k. \tag{6}$$

To comply with the margin requirement, the brokerage house issues a margin call of $(1 - \mu)\,(q - \widehat{q})\,k$. If the investor replenishes his account by this amount, he can maintain his position $(\widehat{k} = k)$. Otherwise, the margin call must be met by selling assets.[16] By reducing his position to $\widehat{k}$, the investor raises $\widehat{q}(k - \widehat{k})$ in cash that can be used to reduce his borrowing,

position	financing
$\widehat{q}\widehat{k}$	$\widehat{b} = b - \widehat{q}(k - \widehat{k})$
	$\widehat{e} = e - (q - \widehat{q})k.$

Assets are sold until $\widehat{k}$ is again in line with remaining net worth.[17] Solving for $\widehat{e} = \mu \widehat{q}\widehat{k}$ yields

$$\widehat{q}(k - \widehat{k}) = \frac{1-\mu}{\mu}(q - \widehat{q})k \quad \Rightarrow \quad \widehat{s} = \frac{1-\mu}{\mu}(\frac{q}{\widehat{q}} - 1)k. \tag{7}$$

The greater the loss $(q - \widehat{q})k$ and the greater initial leverage $(1 - \mu)/\mu$, the more money must be raised by distress selling. This simple result shows that distress selling may explain why margin requirements lead to excess volatility, multiple market prices, or insufficient arbitrage across markets in a number of models (Chowdhry and Nanda 1998, Aiyagari and Gertler 1999, Kupiec and Sharpe 1991, Gromb and Vayanos 2002).

The policy literature often presents market crashes as inherent liquidity events, because margin calls confront agents with liquidity needs: they often have to be met in the means of payment, by a transfer of bank deposits. What triggers this liquidity problem, however, is a solvency shock: no margin call would have been issued had the market value of the position not declined. Margin calls are the mechanism whereby falling asset prices generate liquidity needs. Margin calls were an important element in the major market crashes of the 20th century. In 1929, when margin was not regulated but set by brokers, margin buying first lifted stock prices before margin calls exacerbated their decline (Bierman 1998). Margin requirements were also central to the market dynamics of the 1987 crash; margin-eligible securities were subject to margin calls and forced sales (Seguin and Jarrell 1993), and margin calls brought severe difficulties to many brokerage houses and their banks (Brimmer 1989).

Many financial institutions adopt constraints on trading and risk exposures for risk management purposes (Borio 2004). Such rules are not fundamentally different from margin requirements in our context. Leverage rules, such as a target leverage ratio, work the same way. An even closer link between falling prices and distress selling is established by strategies that seek to contain

[16] This is the case if y' equals zero in (2).

[17] Such distress selling does not affect $\widehat{e}$ as long as $\widehat{q}$ remains unchanged. If the asset price falls, feedback arises (see Section 5.2).

trading losses. Stop-loss orders, for example, dictate selling an asset when its price falls below a predetermined floor, say $\underline{q}$. The goal is to limit losses to $\left(q - \underline{q}\right) k$. But an upper bound on losses is equivalent to a lower bound on net worth,

$$\underline{e} = e - \left(q - \underline{q}\right) k.$$

This parallels expression (6) in the context of margin requirements.[18] Accounts of the major market crashes of 1929 and 1987 emphasise the role of trading strategies including stop loss orders and portfolio insurance alongside that of margin requirements (eg Presidential Task Force of Market Mechanisms 1988, Gennotte and Leland 1990). The market turbulence of 1998 also featured both elements: financial market stress produced a global wave of margin calls (Committee on the Global Financial System 1999) which brought LTCM to the brink of liquidation, as well as those hedge funds that had replicated its convergence trades (Mehrling 2000, Scholes 2000).

Credit risk

We now consider solvency shocks due to credit risk, the potential that a borrower or counterparty will fail to meet its obligations. Credit risk can materialise, for example, through interbank claims, business or consumer loans, or trading counterparty exposures. When such claims cannot readily be reduced, an entity may instead choose to sell marketable assets in the face of a binding financial constraint.

Capital adequacy requirements are a case in point. They prescribe that a bank's capital should exceed a fraction of the value of risky assets on the bank's balance sheet, to allow the bank to withstand losses up to a threshold. To illustrate, suppose a bank holds qk worth of marketable assets, and has extended loans to other entities worth $a \equiv \Sigma a_i$.[19] Current capital regulation requires that bank capital (total assets less liabilities b) cover a fraction of risky assets, $e \geq \kappa \left[qk + a\right]$ every period. Assuming this initially holds with equality,[20] it is straightforward to compare the effects of two solvency shocks.

A loss on marketable assets ($\widehat{q} < q$), given a, leads to the same distress selling function (7) as the margin requirement (κ replaces μ). Similarly, loan losses or counterparty failures ($\widehat{a} < a$), given q, change the capital requirement to

$$\frac{qk + \widehat{a} - b}{q(k - \widehat{s}) + \widehat{a}} \geq \kappa. \tag{8}$$

The failure of counterparty j, for instance, would reduce the value of the loan book to $\widehat{a} = a - a_j$, reducing assets and capital both by a_j. Capital falls by a greater proportion than assets whenever

[18] A similar logic extends to value-at-risk constraints (Danielsson et al 2004), which can be thought of as second moment loss limits.

[19] This modifies (1) and (2) to $qk + a = b + e$. The variables m, m', y', y'', c', and ρ are set to zero.

[20] This assumption is only for expositional purposes. In reality, most banks hold a buffer over required capital.

the bank is leveraged ($b > 0$). If loans are not reduced, marketable assets must be sold to bring risky assets in line with capital,

$$\widehat{s} = \frac{1-\kappa}{\kappa}(a - \widehat{a}).$$

In the Nordic and Japanese banking crises, both non-performing loans and falling asset prices have put pressure on asset holdings through capital requirements (Berg 1998, Nakaso 2001). In the case of Japan, binding capital requirements accelerated the disposal of banks' corporate equity portfolios: since 1996, about 60% of holdings have been sold (McGuire 2007). Consistent with the notion of distress selling, banks tended to sell shares across the board.[21]

The scope of this mechanism goes beyond regulatory capital requirements; banks also adopt capital ratios for reasons of internal risk management, monitoring incentives, or market discipline. For instance, banks in the interwar period, well before the advent of modern regulatory standards, targeted their asset risk and capital ratios to achieve low deposit risk (Calomiris and Wilson 2004). The logic also extends to other financial institutions, as well as to other types of financial constraints, such as exposure limits, or investment policies on asset quality that restrict institutional investors to hold investment grade securities: a downgrade below this threshold will require that a security be sold.

Solvency shocks may also lead to asset sales in the absence of binding financial constraints. For instance, a decline in the future value of an ongoing project may induce moral hazard when entrepreneurs run their projects on borrowed funds (Gorton and Huang 2004). A negative solvency shock reduces the project's capitalisation, and thereby raises the entrepreneur's incentive to add risk in $t = 1$ (raising the spread of the distribution of y''). Then, under some circumstances, borrowers and lenders can agree to sell the project to entrepreneurs with sufficient equity to have no incentive to add risk. Does this qualify as distress selling, or as the voluntary disposal of a distressed project? A solvency shock leads to financial distress in this case, since borrowed funds have to be repaid in the future. The fact that selling an asset after a bad shock may be the best among several options is not inconsistent with the notion of distress selling.

3.3 Income- and cost-driven distress selling

We have considered pure liquidity and pure solvency shocks so far. It is more common in macroeconomics to consider what was called combined shock in Section 2. For instance, firms face a temporary decline in productivity and output (Kiyotaki and Moore 1997, Bernanke et al 1999, Chen 2001, Wagner 2007), or they have to reinvest at some cost to ensure the continuation of their project (Holmström and Tirole 1998, Lorenzoni 2005, Gai et al 2006, Wagner 2007). These scenarios raise cost ρ relative to income or output y' in (1). A combined shock affects both cash flow and net worth on the balance sheet, as lost income or additional expenses are not recovered.

[21] Upon returning to profitability in 2004, his evidence suggests that banks became more reluctant again to sell the shares of those corporations to which they acted as main banks.

The financial accelerator model of Kiyotaki and Moore (1997) illustrates how such a shock affects cash flow and borrowing constraints in a macroeconomic context. In their model, producers use real assets, such as land, to produce output in a process that takes one period, $y' = (a + c)\, k$, where ck is non-tradable. Producers have skills specific to their project, and their human capital is inalienable, in the sense that they cannot be forced to continue the project. Creditors are aware that the project's output cannot be seized, so that they will lend at most the value of the productive assets serving as collateral. This gives rise, in each period, to a borrowing constraint of the form $b \leq q'k/R$, involving the next period's asset price. Producers are patient and prefer to maximise their investment in productive assets. To do so, they incur maximum debt and consume only the non-tradable part of their current output, hence $y' - c' = ak$. In steady state, the producer uses the income from selling goods to meet interest payments on debt, $(R - 1)\, b = y - c = ak$.[22]

Suppose in $t = 1$ an individual producer faces a temporary productivity shock $\widehat{a} < a$. Output and consequently income fall by $(a - \widehat{a})\, k$ relative to the steady state without shock. The consequences are best broken into logical steps. First, the shock presents a cash flow problem, because the producer's income falls short of the interest due, $\widehat{a}k < (R - 1)\, b$. The difference can only be met by selling assets,

$$q(k - \widehat{k}) = (R - 1)\, b - \widehat{a}k = (a - \widehat{a})\, k.$$

This is comparable to the liquidity-driven distress sales of Section 3.1, where a fixed cash commitments had to be met. The second step is to recognise that not only the interest payment comes due. The borrowing constraint tightens endogenously when some of assets serving as collateral are sold. The producer can no longer borrow $b' = b$, but his reduced asset holdings only support $\widehat{b} = q\widehat{k}/R$. In addition to repaying interest, a portion of the principal comes due: $Rb - \widehat{b} = (R - 1)\, b + q(k - \widehat{k})/R$. Equating this with the sources of funds, $\widehat{a}k + q(k - \widehat{k})$, yields a larger volume of sales,

$$q(k - \widehat{k}) = \frac{R}{R - 1}\, (a - \widehat{a})\, k. \tag{9}$$

This is comparable to the case of where the shrinking of the collateral base tightened the margin requirement.[23] The two steps indicate that both liquidity and balance sheet considerations are involved. The income shock requires distress selling to meet interest payments, and sale of assets tightens the borrowing constraint. Had the producer not run up against his borrowing constraint, distress selling would neither have been necessary nor optimal (the future productivity of assets remained unchanged). While our example of an individual producer is suggestive, the aggregate shock considered by Kiyotaki and Moore requires a fuller analysis taking account of dynamic feedback (Section 5.3).

[22] To derive this expression from (1), we insert steady state values $q'' = q' = q$ and $k' = k$, hence $b' = b = qk/R$. The model does not contain the remaining variables in (1), ie $m = m' = \rho = 0$.

[23] This corresponds to μ in the denominator of (7). Without this effect, the value of sales only needs to match the margin call.

Our presentation of distress selling in this section has been formulated in terms of excess supply (in line with Definition 2). Had we assumed instead that agents sell all assets and repurchase the desired amount every period, distress selling would show up as deficient demand rather than as excess supply.[24] From a cash flow perspective, the distinction is immaterial (assuming zero transaction costs).[25] From a balance sheet perspective, the distinction matters, since unrealised losses are realised upon selling assets. But marking assets to market has the same effect. Our presentation is therefore unaffected by which turnover assumption is chosen.

4 Pricing

The previous section examined what triggers distress selling. The disposal of assets would constitute excess supply at the current price q. In this section, we discuss the valuation of such sales from the perspective of buyers.[26] Taking the initial volume of selling $\widehat{s}$ as given, we explore which demand-side characteristics produce a fall in the asset price to clear the market. Gauging the price impact is important, since it may feed back on distress selling and produce instability (Section 5) as well as broader macroeconomic effects (Section 6). By contrast, if the asset price does not fall, the process in Figure 1 is cut short: sellers realise the funds they need with no impact on other agents' financial condition.

Our discussion of pricing emphasises two dimensions. The first is *liquidity*: on one extreme, the asset price is determined by the availability of cash in the market, on the other it is determined by fundamental valuation. In the latter case, the degree of *concavity* plays a central role, in the form of preferences (risk aversion) or production technologies (diminishing marginal returns). Only the combination of perfect liquidity, risk neutrality and linear technologies would leave the asset price unchanged in the face of distress selling. All other cases produce standard downwards-sloping demand curves, albeit with an intertemporal component since assets - unlike goods - can be resold in future periods.

4.1 Liquidity

We first consider the liquidity dimension. With perfect liquidity, the asset price is governed by fundamental valuation; on the other extreme, it is determined only by the availability of funds.

[24] Market equilibrium $(k - k') = h'$ can be written as $k = k' + h'$, where h' denotes asset demand by other agents.

[25] In (1), financing $Rb - b'$ with $q'(k - k')$ is equivalent to financing $Rb + q'k'$ with $b' + q'k$.

[26] A model of distress selling requires some heterogeneity – otherwise, there is no debt and asset trade in equilibrium. We treat sellers and buyers as separate groups of agents and deal with them in different sections, even though distress sellers bought assets in $t = 0$ for the same motives as those outlined here for buyers.

Perfect liquidity

The consumption-based asset pricing model (C-CAPM), a leading theory of fundamental asset valuation, determines the value of assets by means of a representative agent's first-order condition for asset holding (Lucas 1978, Cochrane 2004). The value of an asset is the sum of expected future dividend streams discounted by the ratio of marginal utilities of consumption. By using this fundamental valuation as a *pricing* equation, the presence of sufficient liquidity is implicitly assumed.[27] Extending this logic to the context of distress selling, the asset price would only decline if agents valued the additional assets less (see Section 4.2).

Perfect liquidity may not be attainable for a number reasons. One is market imperfections such as transactions costs. Staying close to C-CAPM, Aiyagari and Gertler (1999) let the sales by margin-constrained traders be absorbed by agents akin to the representative agent of C-CAPM. When these agents face quadratic adjustment costs in changing their inventories, absorbing a greater volume of distress sales $\widehat{s}$ is costly. The agents must be compensated by a lower price, which gives rise to a downward-sloping demand curve. Another factor limiting liquidity is the presence of financial constraints on the buyers' side. Since their effect on buyers is analogous to that on sellers (covered extensively in Sections 3 and 5), this section only presents the case of completely inelastic funds, the opposite of perfect liquidity.

Cash-in-the-market pricing

Suppose a fixed amount of money M is available in the market, and this amount falls short of the fundamental value of assets offered for sale. For a given volume of initial sales (Section 3), the equilibrium price simply equals the cash available per unit sold,

$$q'\widehat{s} = M \rightarrow \quad q' = M/\widehat{s}.$$

The lower M, the lower the market price of any given volume of $\widehat{s}$. Given M, the pricing function $q'(\widehat{s})$ is downward-sloping and unit-elastic. Here it is limited liquidity, rather than fundamental valuation, that determines the price of assets.

This is sometimes referred to as cash-in-the-market pricing (CIMP, Allen and Gale 1998). CIMP becomes a theory once it justifies why M can be invariant with respect to $\widehat{s}$ and q'. One reason is that market participation is an ex ante choice (Allen and Gale 1998, Gorton and Huang 2004).[28] Risk-neutral speculators make a choice in period $t = 0$ between safe assets ('cash') and long-term assets, taking into account that only cash can be used to purchase distress-sold assets

[27] This works when all wealth can be used to purchase assets, because the value of assets constitutes wealth. The definition of wealth thus mirrors the equilibrium condition equating demand and supply.

[28] Allen and Gale's speculators are outside their banking model, in the sense that they do not draw from the same aggregate resources. Gorton and Huang endogenise the ex ante choice of becoming an entrepreneur (invest long-term) or a speculator (hold cash).

in $t = 1$. When there is a possibility of buying assets cheaply, speculators will keep M of their wealth in cash. Since this choice is made in $t = 0$, M is predetermined in $t = 1$. Distress selling, if it occurs, must be associated with a equilibrium price q' below fundamental value, otherwise no positive M would ever be chosen ex ante.

In its strong form, CIMP embodies the assumption that no other resources, in the form of savings or money creation, are available at the time of distress selling; it presumes a fixed number of buyers, all subject to binding financial constraints. But large discounts will attract idle balances from elsewhere in the economy. Donaldson (1992) examines the incentives of money holders ('reserve agents') to offer cash to distress selling banks in his description of banking panics before the founding of the Federal Reserve. He shows that reserve agents who observe the shortage of cash in the market will strategically tender their savings at the highest possible price (ie buy assets at low q'). This is a specific example whereby cash in the market becomes elastic in response to price incentives.

It is no coincidence that CIMP has been advanced in models of banking crises.[29] Banking crises are extreme events associated with severe asset price declines suggesting that the availability of funds plays a role in the pricing. During Japan's financial sector problems of the 1990s, for instance, non-performing loan write-offs were associated with a number of properties being sold at judicial auctions following financial distress of borrowers. Using these auctions data, Saita (2003) constructed a hedonic index aggregating the actual transaction prices. This index fell by 80% between 1992-2002, and the fastest pace was reached at the peak of the banking problems in 1998. The fact that the index stood consistently lower than indices based on appraisals is indicative of limited liquidity. The sharp declines of real estate prices in the Nordic banking crises convey a similar picture (von Peter 2004). Also during the Asian crisis, asset sales were made at large discounts of 40% on average (Faccio and Sengupta 2006).

4.2 Concavity

When liquidity in the market is responsive to incentives for asset holding, valuation plays the central role in the pricing of assets. For the price impact we study, valuation involves two separate sources of sensitivity. The first is risk aversion, ie concavity in the utility function. The second is marginal productivity, ie concavity in the production function.[30]

Risk aversion

Risk neutral agents are indifferent with respect to uncertainty, but risk-averse agents require a risk premium to compensate for the uncertainty associated with holding risky assets. Risk aversion is

[29] See Allen and Gale (1998), Gorton and Huang (2004), and Acharya and Yorulmazer (2006).

[30] While beyond the scope of this paper, we note that concavity can also have general equilibrium consequences that could weaken the overall response of prices (eg Cordoba and Ripoll 2004).

a standard ingredient in asset pricing theories such as C-CAPM. The main impact of risk aversion in the context of this paper can be illustrated with a simpler fixed-horizon model.

Grossman and Miller (1988) popularised the idea that risk-averse dealers must be enticed to absorb a temporary order imbalance of financial assets. In contrast to CIMP, dealers decide their allocation at the time distress sales reach the market. A typical dealer in $t = 1$ chooses his holdings in the risky asset to maximise expected utility from future consumption, given wealth W,

$$\max_{h'} \quad E\, u(c'') \quad \text{s.t.} \quad c'' = q''h' + (W - q'h'), \tag{10}$$

where q'' stands for the asset's payoff or continuation value (including dividend). As a standard portfolio allocation problem, the first-order condition is an excess return pricing equation.[31] Under constant absolute risk aversion λ and normal returns with a variance of σ^2 around $E(q'')$, the dealer's optimal position defines a standard demand curve, downward-sloping in price,

$$h' = \frac{E(q'') - q'}{\sigma^2 \lambda}. \tag{11}$$

Clearly, risk-averse dealers will only hold a long position when compensated by expected excess return. When there are other, risk-neutral agents in the economy, dealers will hold a zero position initially. With n dealers absorbing distress sales, market clearing requires $nh' = \widehat{s}$, and the equilibrium price equals

$$q' = E(q'') - \sigma^2 \lambda \widehat{s}/n. \tag{12}$$

Distress selling $\widehat{s}$ thus drives the asset price below its risk-neutral valuation $E(q'')$. The price impact is more pronounced when dealers are more risk-averse, when the asset is more risky, or when there are fewer dealers to absorb a given volume of distress selling.

Note that dealers' spending on assets is responsive to the asset price, in contrast with CIMP.[32] But the responsiveness of spending is limited by the degree of risk aversion. This can be seen in two ways, relating to agents' horizon and to market entry, respectively. First, dealers choose to limit the amount they spend on assets due to risk aversion. This is not due to financial constraints.[33] Rather, the short horizon in (10) means that dealers have to accept a given asset price q'' in $t = 2$, exposing them to the risk of low consumption. An infinite horizon, by contrast, would allow traders to wait and exploit the expected asset price recovery – they would purchase more willingly, which would moderate the price decline today.[34] Second, the *number* of dealers participating in

[31] The portfolio choice between safe and risky assets is of the standard form $E\left[u'(c'')(r - r^f)\right] = 0$, where $r = q''/q'$ and $r^f = 1$ in our example.

[32] This is confirmed by computing $\frac{d\,(q'h')}{d\,q'} < 0$ for $q' > E(q'')/2$.

[33] In (11), the value of $q'h'$ can exceed wealth W by any amount of borrowing. Imposing financial constraints on dealers would further reduce the market price relative to (12). With margin requirements, for instance, funding will affect market liquidity (Brunnermeier and Pedersen 2006). Financial constraints translate into higher *effective* risk aversion (Danielsson et al 2004).

[34] This shows that postulating a demand curve (12) for *every* period in a dynamic model assumes that dealers

the market, n, is also limited by risk aversion. This number can be pinned down by the condition that the expected utility of buying the batch $\widehat{s}/n$ must equal the utility of just keeping a zero position (Grossman and Miller 1988, Bernardo and Welch 2004). This is akin to a market entry condition in industrial organisation.

The risk-averse dealer model has been developed in the context of high-frequency trading in financial assets. In fact, it is with market crashes in mind that the approach has been widely adopted.[35] The model predicts that dealers' inventory positions should systematically relate to asset price movements when accommodating buying and selling pressure. Using inventory data of NYSE specialists over an 11-year period, Hendershott and Seasholes (2007) confirm the model's prediction that dealers unwind their positions at higher prices than those at which they bought.

Diminishing marginal returns

Real assets can be utility-yielding or productive, so their valuation will reflect the properties of utility or production functions in which they enter. When these functions are concave with respect to the asset, reflecting diminishing marginal returns, asset holders will value additional units less at the margin. Since the distribution of assets may affect cash flows and production (Section 6), the macroeconomics literature has taken particular interest in the role assets in output fluctuations.[36] In order to work with an endogenous distressed asset price, it is important to deviate from q-theory and consider assets as separate from goods.[37]

Consider a risk-neutral firm that chooses productive assets to maximise next period's profits,

$$\max_{h'} \quad E\,c' \quad s.t. \quad c' = f(h') - (Rq' - q'')\,h'. \tag{13}$$

The optimal choice equates marginal productivity with the user cost of holding assets, ie the purchasing price less the expected resale price,

$$f'(h') = Rq' - Eq'', \tag{14}$$

If f is concave, $f'(h')$ is decreasing, reflecting diminishing marginal productivity.[38] This determines h' uniquely, since the firm takes the user cost as given. (Note that a financially constrained firm

behave in a myopic fashion and can be taken advantage of (eg Brunnermeier and Pedersen 2005, Pritsker 2005). To justify such behaviour in multi-period settings, one can resort to overlapping generations models (eg DeLong et al 1990, Shleifer 2001), or introduce a risk of forced liquidation at some point in the future (eg Bernardo and Welch 2004).

[35] See Bernardo and Welch (2004), Morris and Shin (2004), Gennotte and Leland (1990), Brunnermeier and Pedersen (2005, 2006), and Cifuentes et al (2005).

[36] For productive assets, see Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997), Bernanke et al (1999), and Chen (2001). For analogous arguments for utility-yielding assets, see Miles (1995) and Iacoviello (2005).

[37] Standard q-theory views productive assets as 'installed goods'. Reversing this process would allow assets to be uninstalled and sold as goods at the price of one apiece. The cost of distress selling then boils down to the adjustment cost, a purely technological quantity.

[38] This is in contrast to a linear AK-technology, where every unit of capital has the same productivity A.

has a higher marginal productivity f', because it employs fewer assets.) Suppose n such firms, each already holding h assets, absorb the sales by the distressed sector. As market clearing requires $n\,(h'-h)=\widehat{s}$,

$$q' = f'\left(h + \widehat{s}/n\right)/R + Eq''/R. \tag{15}$$

The asset price falls in line with the lower productivity of the additional units. The more concave f, the faster marginal productivity declines, and the greater the price impact of any given volume of distress sales $\widehat{s}$. This again defines a demand curve that is downward-sloping in q', given Eq''. Should Eq'' fall, the demand curve would shift down because the asset becomes less attractive (user cost rises) for any given q'.[39]

Diminishing marginal returns is a form of concavity distinct from risk aversion considered above. The variance of q'' around its expectation plays no role in the pricing.[40] This becomes clearer still in models where assets fully depreciate (eg Bernanke and Gertler 1989, Gai et al 2006), as if they were perishable goods: setting $q''=0$ in (15) reduces the value of assets to their *current* marginal productivity.

The price impact in (15) is stronger for smaller n, as was the case for (12). This again raises the question of what determines the number of firms on the demand side, if not risk aversion. One possibility is asset specificity (eg Riordan and Williamson 1985, Shleifer and Vishny 1992). Many assets are specialised in nature: they cannot be redeployed costlessly outside a specific industry. Oil rigs, steel plants, and pharmaceutical patents have no reasonable uses other than in their specific industry (in contrast to land, for example, which has multiple uses). Such assets, when distress-sold, should be managed by industry peers. But peers are not only limited in number, they face the same cyclical and financial environment as the distress selling firms.

In their model on liquidation values, Shleifer and Vishny (1992) assume that industry peers generate more cash flow from a specific asset than outsiders would, that is, $y_{ins} > y_{out}$.[41] The contribution of the model is to specify when industry peers are unable to take over the assets, so they are sold to deep-pocket outsiders who value them less. An aggregate shock to the whole industry leaves all industry peers with similar difficulties in meeting debt payments. Why would outsiders not simply lend to insiders who make superior use of the assets? This may not be possible due to borrowing constraints.[42] Under these conditions, $q' = \min\left\{\beta\, y_{ins}, y_{out}\right\}$. The asset price falls in line with industry peers' condition, parameterised here by β, until it reaches the floor

[39] Valuation is inherently intertemporal, since real assets, unlike goods, can be resold after use. This makes pricing in general equilibrium difficult: future asset prices can be found only with the knowledge of future distributions of assets between sectors which in turn depend on prices. This is one reason why distress selling is rarely made explicit in the macroeconomics literature.

[40] Superimposing risk aversion would lead to a lower asset price for the same reasons as in (12), especially if production is also stochastic.

[41] This is merely a technological difference, but we think of y_{ins} as related to (15).

[42] Shleifer and Vishny invoke an agency problem that necessitates an initial debt overhang to constrain management. Combined with the fact that specialised assets reduce liquidation value (hence limit debt capacity), this implies that insiders face binding borrowing constraints.

established by outsiders' valuation. Evidence from various industries supports this idea. Distressed airlines, for instance, sell airplanes at lower prices than do unconstrained airlines, and do so more frequently to industry outsiders during recessions (Pulvino 1998). Similarly, during the decline in commercial real estate values in the late 1980s and early 1990s, real estate was sold at distressed prices to better capitalised outsiders (Brown 2000). The approach has also been extended beyond corporate finance to analyse distress selling by banks (Donaldson 1992, Wagner 2007), bank loan sales (Diamond and Rajan 2005), and optimal bank bailouts (Gorton and Huang 2004, Acharya and Yorulmazer 2006).

The two-part nature of the demand side, with industry peers and deep-pocket outsiders, combines elements seen throughout this section. It allows diminishing marginal returns to play a role, without discarding the notion of perfect liquidity at the lower level of outside valuation. To distress sellers, outsiders provide a welcome source of liquidity that averts a deeper price decline. To the economy as a whole, however, the presence of outsiders means that assets may end up in second-best use. Thus the pricing floor comes in exchange for inefficient production, a point revisited in the context of output effects (Section 6).

5 Asset market feedback

Once distress selling takes place and asset prices fall, the question is whether some mechanism leads falling prices to elicit further distress selling. Beyond feeding back on the group of initial sellers, falling asset prices also spread financial distress to other asset holders. Yet the conditions for asset market feedback to arise are more stringent than one might think. It appears unnatural that falling prices be associated with increased net supply. Typical demand and supply curves, and the concept of stabilising speculation more generally, would suggest the opposite. The very notion of feedback begs the question: why would agents sell more assets into a falling market and realise losses? Low prices, by themselves, should normally limit selling, and a greater expected return should attract purchases by new investors and by existing asset holders, which stabilises the market.

In this section, we identify four different channels of asset market feedback. First, falling asset prices can exacerbate cash flow problems, causing more distress selling. Second, falling prices tighten financial constraints if assets are marked to market. Third, as the financial condition of borrowers is propagated into future periods, dynamic feedback can arise. Finally, falling prices may affect expectations and strategic behaviour. We will examine these channels in turn. Additional macroeconomic channels of feedback are conceivable, but are outside the scope of this paper.[43]

[43] Fisher's (1933) debt-deflation theory, for example, relies on feedback through the price level. The repayment of debt in aggregate reduces the quantity of inside money; this produces deflation and thereby raises the burden of debt, leading to further distress selling. Similarly, in the context of emerging market crises, a fall in the exchange rate raises the burden of foreign-denominated debt (eg Aghion et al 2001).

5.1 Cash flow

Feedback through cash flow arises when agents rely on selling assets to raise a given amount of cash in order to meet cash commitments. At a lower market price, a greater quantity of assets must be sold to raise a given nominal amount $s'q' = C$. This is the feedback captured by the upward arrow on the lower left of Figure 1. The bank run model (Section 3.1) illustrates this case: the distress selling function (3) indicates that a given amount of withdrawals, $C = \lambda\bar{c} - m$, has to be met selling assets. Selling $\widehat{s} = C/q$ would suffice if the demand side of the asset market were perfectly elastic. However, if the asset price declines for reasons elaborated in Section 4, assets will continue to be sold until $s'q'$ reaches C. Since $s' > \widehat{s}$ when $q' < \widehat{q}$, the bank ends up with fewer assets ($k' < \widehat{k}$) as a result of the endogenous price decline (see Figure 2).[44]

In principle, this feedback is relevant to all entities facing fixed cash commitments, eg intermediaries reinvesting ρ to continue a project (Gai et al 2006), or firms paying Rb to avert default, or households selling assets to meet mortgage payments. (By contrast, it does not apply to mutual funds whose shares are pegged to the market value of assets.) The feedback is stronger when cash commitments actually *rise* as the asset price falls. In fact, in the bank run model of Allen and Gale (1998), the falling asset price raises the *size* of the run λ and hence the amount of withdrawals ($\lambda\bar{c} - m$). This happens because late consumers understand that distress selling depletes the bank's resources: the assets sold in $t = 1$ will not be available to meet their withdrawals at $t = 2$. They join the run to secure the payout promised to early consumers. For this reason, the equilibrium bank run will involve all depositors and full liquidation of bank assets ($\lambda = 1$). Furthermore, withdrawals at *other* banks may also rise, since observing a run on one bank may prompt depositors at other banks to run as well (Aghion et al 2000).

In these models, depositors foresee the eventual insolvency of banks. That liquidity problems can turn into solvency problems has long been recognised, well beyond the literature on bank runs. Losses incurred through distress selling as well as costly refinancing play a central role in that context (Minsky 1963, 1982). This means it is possible in Figure 1 to go down on the left side and come up on the right side. In raising concerns about solvency, this leads naturally to a discussion of financial constraints.

5.2 Financial constraints

A second feedback channel, represented by the upward arrow on the lower right of Figure 1, runs through financial constraints. The precondition for this to happen is that financial constraints relate to assets that are marked to market, rather than recorded at historical cost.

The adverse effect of asset market feedback on solvency can be illustrated by a historical episode. The experience of the Great Depression shows that the presence of a resale market may

[44] Cases where this cannot be accomplished include the example of C exceeding cash in the market M (Section 4).

be economically harmful, because it undermines the solvency of distress sellers and other agents (eg $q' < r$ in Section 3.1). Friedman and Schwartz (1963) report that banks' capital was impaired less by non-marketable assets than by bonds for which an active market with continuous quotation of prices existed. This led to the paradoxical outcome that those assets that banks had regarded as most liquid turned out to threaten their solvency the most.

This feedback channel comes into play earlier in the presence of financial constraints that aim to keep agents *at a distance* from insolvency. As discussed in the context of market risk, a decline in the asset price affects margin requirements (Section 3.2). Following the initial decline to $\widehat{q}$, constrained agents would sell assets in line with their remaining margin, which defines the point $\{\widehat{q}, \widehat{s}\}$ in Figure 2. Whether or not it was the financial constraint that triggered distress selling, the constraint is the mechanism causing asset market feedback. As the initial sales exert pressure on the price, equation (7) becomes

$$s' = \frac{1-\mu}{\mu}(\frac{q}{q'} - 1)k. \tag{16}$$

Unlike a regular supply function, the distress selling function is downwards-sloping in q': more assets are dumped as their price falls, until an equilibrium is reached at $\{q', s'\}$. The arrows in Figure 2 represent the iterative process whereby assets are marked to a falling market, the margin constraint is updated, further margin calls are issued, and further selling pressure in turn lowers the price. Furthermore, financial distress spills over, because the erosion of margin involves not only the initial sellers but also other market participants. The financial distress occasioned by successive rounds of margin calls is a common theme of market crashes, and is described with care for institutional arrangements by Brimmer (1989).

Regardless of whether they are due to agency problems, regulation or risk management, the financial constraints covered in this paper work essentially the same way.[45] By forcing debt to fall in line with the market price of assets, they produce a downward-sloping asset supply function. Disregarding any potential future gains, constrained agents are forced to sell into a falling market. This is why the future asset price q'' appears nowhere in (16), in contrast with the unconstrained expressions (12) or (15). Financial constraints thus replace an intertemporal asset holding decision by a relation between debt and asset prices which accelerates the market decline. For this mechanism to operate, it is not necessary that financial constraints bind strictly, nor is it necessary to rule out all state contingency.[46] As shown, trading rules such as stop-loss orders or portfolio insurance work in an equivalent way.[47] Feedback through financial constraints is one way of ratio-

[45] Borrowing constraints may also be self-imposed by a precautionary motive or some behavioural reason. Fisher (1933), in his debt-deflation theory of the Great Depression, focussed on 'over-indebtedness' as a trigger of distress selling, but leaves open why agents perceive their indebtedness to become excessive.

[46] In Aiyagari and Gertler's (1999) stochastic environment, it can be optimal to curb asset holdings to prevent the financial constraint from binding in future periods. In Gai et al's (2006) version of Lorenzoni (2005), feedback occurs in spite of state-contingent contracts.

[47] Gennotte and Leland (1990) demonstrate that the extra selling generated by a put-option replicating strategy,

nalising 'feedback trading', which many models write directly as a net supply function of the form $s' = \beta(q - q')$ (eg DeLong et al 1990).

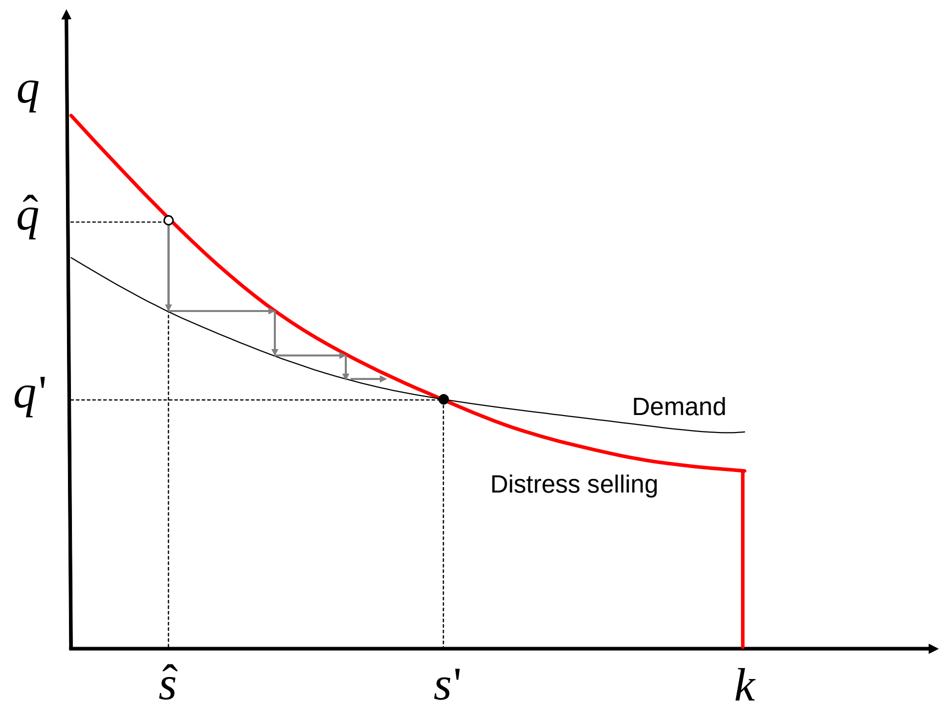

Figure 2: Asset market feedback through financial constraints

Whether this feedback channel is sufficiently strong to produce financial instability depends on the measure of agents operating under financial constraints. Importantly, this measure becomes larger as asset prices fall if financial distress spreads beyond the group of initial sellers.[48] First, the lower the asset price, the fewer agents can maintain the required distance to insolvency. Second, the more widespread the incidence of default and bankruptcies, the more credit losses will materialise and spill over to lenders and trading counterparties. The interaction of market and credit risk can force potential buyers to switch to the selling side.[49] Graphically, this shifts out supply *and* shifts in demand in Figure 2.

The interaction between market and credit risk, also referred to as systemic risk, can be sketched by combining earlier expressions (Section 3.2). Using the capital adequacy requirement (8), for

especially when unobserved, can lead to a market crash where prices collapse following a relatively minor shock.

[48]This explains why financial constraints attract more commentary in extreme circumstances such as market crashes.

[49]The Counterparty Risk Management Policy Group II emphasised the interaction between market and credit risk. See also Borio's (2004) description of market distress.

example, one can derive a distress selling function that reacts to both market and credit losses,

$$s' = \frac{1-\kappa}{\kappa}\left[(q-q')\,k + (a-a')\right].$$

If the market price decline $q' < q$ makes a counterparty default, then the bank faces a counterparty credit loss on top of the market loss. The bank may have to sell more assets, which accelerates the market decline and may push other entities into insolvency. Or the bank may fail, which transmits direct losses to its creditors and counterparties whose claims fall in value. The process continues until s', $(q-q')$ and $(a-a')$ have reached an equilibrium where the remaining entities no longer need to sell and where losses across entities are consistent with each other. The literature on interbank contagion has developed methods for modelling these interdependencies (Cifuentes et al 2005, Elsinger et al 2006, Shin 2006). While the process of contagion across entities involves rounds of distress selling and feedback, it is not necessarily unstable. But if the process does become unstable, it can end in a systemic crisis regardless of the nature or size of the initial shock.

5.3 Propagation

A third feedback channel involves the dynamics of asset prices in a macroeconomic context. While cash flow and financial constraints still play a role, the emphasis moves to the intertemporal dimension. As said, the initial asset price decline affects the financial condition of borrowers today. But in addition, constrained borrowers curb investment and thereby compromise future earnings. How this propagation into future periods feeds back on distress selling today is best illustrated within a financial accelerator model.

Proceeding from the Kiyotaki-Moore (1997) model of Section 3.3, we ask whether asset market feedback strengthens or weakens the distress selling identified in (9). The answer is not obvious since two opposite effects are at work. Writing (1) in $t=1$ outside the steady state gives

$$k'\left[q' - q''/R\right] = q'k + \widehat{a}k - Rb. \tag{17}$$

Producers spend all their net worth (right-hand side) on the downpayment for purchasing assets (since $b' = q''k'/R$ can be borrowed). A decline in the current asset price q' lowers net worth, which tends to reinforce distress selling; however, a lower q' also reduces the downpayment for any given q'', which encourages buying assets. For this contemporaneous feedback, the first effect is slightly stronger.[50]

But the *dynamic* feedback through future asset prices is far more potent. If q'' falls in (17), distress selling clearly increases, since a lower q'' tightens the borrowing constraint *and* makes

[50]Differentiating (17) shows that k' falls as q' does, since $\left.\frac{dk'}{dq'}\right|_{q''=q}$ is proportional to $[(R-1)\,b - \widehat{a}k] > 0$ (see Section 3.3).

assets less attractive to unconstrained agents in (15).[51] (In terms of Figure 2, supply shifts up *and* demand shifts down.) But why would q'' fall? This is because the borrower's financial condition is propagated to future periods. Lower asset holdings today imply lower production and net worth in future periods, $y'' = (a + c)\, k'$. The decline in net worth means that producers will spend less on assets in the future.[52] This reduces future asset prices, and the current price falls in response, which triggers a new round of lower net worth, less investment, less spending, etc. The declines of q' and q'' interact, reducing net worth and tightening the borrowing constraint.[53]

The logic of dynamic asset market feedback can also work through the cost of credit, instead of its quantity. For example, when output is verifiable only through a costly audit, external finance is more costly than internal funds.[54] Bernanke et al (1999) show that the external finance premium rises with a firm's leverage $q'k'/e'$,

$$E(R_k') = s\,(q'k'/e')\, R^f,$$

where R^f is the risk-free rate, $s'(x) > 0$ if $x > 1$, and $E\,(R_k')$ is both the firm's borrowing cost and its expected return on capital.[55] Firms' demand for capital, and hence for credit, is constrained by net worth e'. Since net worth reflects current losses, a falling asset price causes dynamic feedback by raising the external finance premium demanded by creditors over the coming period. This raises the cost of credit above the return to capital unless the firm reduces debt by selling assets; even so, future cash flow deteriorates in the face of higher financing cost and lower earnings.

Dynamic feedback is a factor that may shape contractual arrangements. In the project finance model (Section 3.1), a lower expected asset price raises the extent of collateralisation β built into the contract. The liquidation of slow projects leaves lenders with $n\beta$ repossessed assets that are sold on the market. But selling any given β raises less money when asset prices are low. A lower future asset price therefore requires a greater volume of distress selling.[56] Anticipating this, projects are collateralised to a greater extent ex ante, $\beta'(q') < 0$ in (5).

The consideration of credit frictions for macroeconomic fluctuations is the hallmark of the financial accelerator literature. While financial frictions play a role in firms' investment decisions and business cycle dynamics (Hubbard 1998, Lown and Gertler 1999, Levin et al 2004), their importance sharply rises in the wake of financial crises (Bernanke 1983, Mishkin 1991, Calomiris 1995). In the context of the Asian crisis, Faccio and Sengupta (2006) found that mostly companies

[51] A lower expected resale value deters demand. This helps resolve the tension that a fall in the current asset price should boost asset demand.

[52] The right-hand side of (17) becomes ak' from next period onwards.

[53] Most reasonable calibrations produce less propagation than in Kiyotaki and Moore's model (Cordoba and Ripoll 2004). Adding capital-constrained intermediaries, however, may increase propagation (eg Chen 2001).

[54] Such a formulation allows for unsecured debt. Being rooted in asymmetric information, such constraints are likely to be relevant for many firms and most individuals.

[55] In equilibrium, a firm will purchase capital until its expected return is equal to the marginal cost of external finance. In terms of (1), $R_k' = [f'(k') + q'']\,/q'$. See also (14).

[56] This comes from the lender's participation constraint for a given repayment Rb required of normal projects.

with high leverage and poor growth prospects resorted to asset sales. Apart from the price impact, distress selling can be costly due to transaction costs. Evidence from Thailand between 1997-99 suggests that voluntary sales remained minimal – almost all the property sales consisted of the assets sold by the Financial Restructuring Agency when it closed sixty finance companies (Renaud 2000).

5.4 Expectations and strategic behaviour

The last feedback channel we cover works through expectations. The distinguishing feature is that asset prices play dual role: they not only affect cash flow and financial constraints, but also influence the formation of expectations or induce strategic behaviour.

The first example relates to price discovery in the context of differentially informed traders. Recalling the pricing model of Section 4.2, suppose only few dealers observe the volume of distress selling $\widehat{s}$; the remaining uninformed dealers interpret the observed price dip as a signal of a lower fundamental future price q''; to attract the interest of uninformed dealers, q' has to fall much further (Gennotte and Leland 1990). Therefore, the updating of expectations regarding future prices feeds back on today's valuation and holdings. This effect is aggravated when falling prices produce additional sales due to hedging activity, especially when this activity is unobserved.

Another example involves delegated portfolio management subject to agency problems. If this is a highly specialised activity that only fund managers, not their investors, understand, and the ability of fund managers is not directly observable, then investors may take past performance as a signal of the manager's ability (Shleifer and Vishny 1997). Hence, when a fund posts a poor return, perhaps only because asset prices fall (or spreads diverge) more generally, investors may withdraw money, forcing the fund manager to liquidate positions.[57] Although this outcome is reminiscent of bank runs, the feedback does not involve pre-existing financial constraints but investors' reassessment of fund managers' ability.

A third example concerns strategic trading in a 'market run'. The logic of bank runs is transposed to a market context where investors act strategically. Central to this approach is a price mechanism in which investors' sell orders are batched together at an average price. This gives investors a strategic incentive to sell early if there is a risk of having to sell next period (Bernardo and Welch 2004).[58] If they sell assets today, they expect to receive the average expected in-run price, $q'(s'/2)$. By contrast, if they are forced to sell tomorrow, *after* everybody else, they are sure to get the post-run price given by $q'(s')$ in (12). Bernardo and Welch show that investors optimally front-run others, provided the risk of liquidation is not small.[59] The fear that others sell

[57] Shleifer and Vishny (1997) apply this logic to arbitrage, to argue that arbitrage can become ineffective exactly at a time when expected returns are greatest. There is empirical evidence of distress selling by open-ended mutual funds consistent with the idea of performance-based arbitrage (Coval and Stafford 2007).

[58] The presence of this implicit borrowing constraint is necessary for the results.

[59] It is clear that the average pricing mechanism is central to this result. Under simultaneous market clearing, as assumed in Section 4, sellers would know that they will only fetch the value of the last unit sold.

leads investors to sell their own position before the price reaches a floor. Such preemptive trading adds selling pressure, on top of initial sales, in a way analogous to late consumers running the bank.

Preemptive selling can also be derived as a threshold strategy using global games techniques (Morris and Shin 2004).[60] Suppose a trader gets fired if the asset price q' falls below his loss limit $\underline{q}_i$. Loss limits are private information, whereas the expected future price $E(q'')$ becomes common knowledge at the beginning of period 1. If $E(q'')$ falls below a threshold q^*, Morris and Shin show that the trader will liquidate his position. Importantly, $q^* > \underline{q}_i$: even though traders are risk-neutral, they sell *before* their threshold is reached for fear that sales by others might cause the market price to breach their own loss limit.

Another form of preemptive selling is predatory trading. It is the practice of large strategic traders to sell precisely those assets that distressed agents are known to be about to sell. This allows predators to sell high and, by accentuating the price decline, repurchase the assets at a lower price once the distressed party has liquidated (Brunnermeier and Pedersen 2005). Predators may also sell on the expectation that other traders' financial constraints become binding (Attari et al 2005). There is evidence on the incentives for such behaviour in the context of mutual fund liquidations (Coval and Stafford 2007). But, does predatory trading qualify as distress selling? The predators are not financially distressed. Rather, they sell in anticipation of a price decline due to others' distress sales, which adds to selling pressure, and then they promptly repurchase the assets. However, it is also possible that predators end up distress selling: when subject to margin requirements, they may become distressed when the price falls below a threshold (Brunnermeier and Pedersen 2005).

Feedback through expectations and strategic behaviour comes perhaps closest to Kindleberger's (1996) famous characterisation of market crashes. In emphasising fear and panic, Kindleberger makes an explicit case for the presence of irrational behaviour. He applies this label to aggregate behaviour which, however, may also result from rational behaviour of uncoordinated individuals who act strategically or under binding financial constraints.[61] The models in this section indeed rely on financial constraints operating in the background, be it a borrowing constraint (Bernardo and Welch 2004), a trading rule (Morris and Shin 2004), or margin requirements (Brunnermeier and Pedersen 2005).

[60] They also use the average pricing mechanism, but loss limits replace the risk of liquidation as the key financial constraint.

[61] This is one reason we did not cover behavioural elements in this paper. While important in reality, it is unclear whether behavioural elements such as loss aversion or cognitive dissonance exacerbate distress selling. Loss aversion, for example, makes agents more sensitive to losses than to gains around some reference value (eg Berkelaar et al 2004). This may actually lead to safer portfolios and less leverage ex ante, and a greater reluctance to sell at a loss once prices fall.

6 Economic consequences

This section discusses the adverse economic consequences of distress selling and asset market feedback, in terms of output and distribution. Note that we focus less on market instability itself and more on the *economic* cost of distress selling. In terms of output effects, we distinguish between ex-post and ex-ante effects. Ex-post effects include the effect on the allocation of physical assets, and the reduction in credit provision and investment. Ex-ante effects are the effects of a fall in asset prices on ex-ante investment and production decisions, as well as the effects of heightened downside risk on the choice of buffers and thus investment. At the end of the section, we also consider the welfare implications of redistribution due to distress selling while total output is unchanged.[62]

6.1 Output effects

In this subsection, we first present two ex-post effects, and then two ex-ante effects of distress selling and asset market feedback. The ex-post output effects are closely related to the inefficient usage of productive *real* assets or the cost of breaking up the relationship between the supplier of credit and the borrowing firm. The sale of *financial* assets, ie claims on cash flows from a real asset, by a distressed agent to an undistressed agent does not have a direct impact on the total output or the size of the "social pie", as long as both the seller and the buyer have the same ability to collect cash flows from the holder of the real asset. Thus, the discussion about the ex-post effects is mostly related to real assets or bank loans. On the other hand, the analysis of the ex-ante effects on investment applies to both real and financial assets.

Inefficient allocation of assets

If the total stock of real assets is fixed, output effects can arise through a redistribution of assets among agents with different technologies. We consider two different production technologies: (1) linear production technology; (2) concave production technology.

The first case relates to the situation where the distressed seller is the best user of a productive asset. As described in Section 4.2.2, only industry peers can make full use of specialised assets such as oil rigs and airplanes (Shleifer and Vishny 1992). Thus, output decreases when an initial shock affects a critical number of firms in the industry, so that the assets are sold to industry outsiders. To be precise, the associated output loss then equals $(y_{ins} - y_{out})\, s_{out}$, where $s_{out} (\leq \widehat{s})$ denotes the volume of distress selling absorbed by outsiders. This suggests a useful distinction between distress selling of the efficient sort (between industry peers) and that of the inefficient sort (to outsiders). Similarly, Suarez and Sussman (2005) and Holmström and Tirole (1998) show that the liquidation of firms that are economically viable, but financially distressed, disrupts long-gestation projects

[62] Bankruptcy costs are transfers from the bankrupt firms to other parties in the process, and thus we do not consider them as economic costs.

and therefore reduces future output.

Next, we consider two types of firms with production technologies, which are concave in the level of capital. The optimal way of allocating a fixed amount of capital k is to equate the marginal product of capital for both types of firms. Kiyotaki and Moore (1997) consider a setup where a productive asset, such as land, is used by two sectors as a productive input, as described in Section 4.2.2. The efficient allocation of inputs between the sectors is achieved when the marginal productivity across sectors is equalised, ie $f'(k_f^*) = g'(k_g^*)$, where $f(\cdot)$ and $g(\cdot)$ denote the production functions of the respective sectors and $k_f^* + k_g^* = k$. If sector f absorbs the distress sales by sector g, the distribution of capital becomes inefficient, ie $f'(k_f^* + \widehat{s}) < g'(k_g^* - \widehat{s})$, and total output falls. The inefficiency again increases with the volume of transferred capital $\widehat{s}$. To the extent that asset market feedback raises the volume of sales ($\widehat{s} < s'$), it also increases the impact on total output.

Credit crunch

When distress selling and asset market feedback lower asset prices on banks' balance sheet, and in turn their net worth, capital-constrained banks are likely to reduce lending. They may roll over fewer loans or even call loans if possible. Since it is difficult for bank borrowers to quickly replace their credit relationships with other lenders on equal terms, a contraction in credit supply can occur, which has an impact on real activity (Ashcraft 2005).

Canova (1994) points out that, given a solvency shock, banks might actively seek the liquidation of outstanding loans, exacerbating the credit crunch. In a similar vein, it is the case in financial accelerator models that a negative shock to firms' profits or asset prices reduces net worth of the firms and increases the external finance premium (Sections 3.3 and 5.3). This, in turn, decreases borrowing and thus investment in productive assets. In the macroprudential context, Borio (2006) stresses that forcing financial institutions to retrench in bad times, in the aggregate, could exacerbate distress selling and/or a credit crunch, thereby possibly making financial distress worse.

One example is Japan's so called "lost decade". The sharp decline in stock and property prices in Japan during the 1990s led to severe loan losses for Japanese banks. Capital-constrained banks reduced lending, which had contributed to the slowdown of Japanese economy in the late 1990s and early 2000s (see Inaba et al (2003) for the impact of the land price collapse on the real economy in Japan). Peek and Rosengren (2000) show that the Japanese banking crisis reduced loan supply by Japanese banks in the US, and had real effects on US real estate activity. Another example is the credit crunch in the US around 1990. Bernanke and Lown (1991) document that a collapse in the New England real estate bubble forced banks in the region to write down loans, which depleted their equity capital. In order to meet regulatory requirements, New England banks had to sell assets and scale back their lending.

Fall in asset prices and ex-ante investment

In this subsection, we consider the ex-ante choice of demand for and the supply of productive assets in the presence of the risk of distress selling in the future. In Section 4 we discussed conditions under which asset prices fall below their fundamental values ($q' < \widehat{q}$). Compared with the price distribution of an asset without the possibility of distress selling and asset market feedback, the fall in the asset price can decrease the mean, increase the volatility and introduce negative skewness of the ex-post price distribution. Therefore, distress selling and asset market feedback makes the asset more risky and less attractive, which is reflected in a lower ex-ante price q.

This change in the ex-ante asset price affects the decisions on the investment or production of the asset. In particular, given the lower price of the asset, the producers of the asset decide to produce less. Therefore, the possibility of low future asset prices due to distress selling and asset market feedback discourages investment in the production of the productive asset. One example is the construction sector whose activity depends on the future real estate price.

To show this point clearly, suppose capital producers transform i units of consumption goods into I units of new capital goods (productive assets), according to the production function $I = i^{\alpha}$, where $\alpha < 1$ (similar to the setup in Bernanke and Gertler 1989). The capital goods are expected to be sold at price q, where q is determined by the demand by firms which use the capital goods to run profitable projects. The capital producers choose inputs i to maximise profits $qI - i$. The optimal choice of i shows investment, ie the demand for consumption goods as inputs, is increasing in q,

$$i^d = (\alpha q)^{\frac{1}{1-\alpha}} \quad \Rightarrow \quad I = (\alpha q)^{\frac{\alpha}{1-\alpha}} .$$

Therefore, given the above upward sloping supply curve of the capital good, the ex-ante production of capital is lower in the presence of distress selling and asset market feedback than in their absence. Therefore, the lower asset price q lowers output.

The above set-up does not consider the participation decision by the agents, that is, the decision of an agent whether to become a capital producer (entrepreneur) or a lender. Gorton and Huang (2004) show in a general equilibrium model with entrepreneurs and lenders that the ex-ante investment decision by entrepreneurs is made based on rational expectations about how the liquidation price is formed in the liquidation market in the future.

Additional channel through which a lower ex-ante asset price affects the ex-ante investment is collateral. Assuming that firms need to pledge collateral to obtain loans, when collateral value falls due to the possibility of distress selling and asset market feedback, firms have more difficulty financing their productive projects.

Increased buffer holding and ex-ante investment

Another impact of the deterioration in the ex-post asset price distribution on ex-ante investment is through the amount of ex-ante buffer holding by financial intermediaries. Given a longer left-hand tail of the distribution of the asset price q' with potentially larger skewness owing to distress selling and asset market feedback, banks may want to keep a larger amount of capital buffer to avoid financial distress, compared to a situation without distress selling and asset market feedback. Therefore, given a fixed amount of its own capital, banks may decide to lend less to firms, which can in turn reduce investment by firms.

Note that this channel does not work through the lower ex-ante asset prices as in the previous subsection. Even when there is no change in the *expected* price $E[q']$ of the assets on a bank's balance sheet, a longer left-hand tail of the asset price distribution induces a bank to hold more capital buffer in consideration of typical value-at-risk models and to reduce the amount of loans extended.

6.2 Distributional effects

Distress selling often involves distributional effects in models that allow for heterogeneity of agents and trade among them. When asset prices fall owing to distress selling and asset market feedback, indebted sellers of the assets lose in real terms, while buyers can gain from purchasing the assets at depressed prices and then sell them later at higher prices. For example, Allen and Gale (1998) show that distress selling lowers the asset price and thus consumption by depositors, and at the same time provides a windfall profit to speculators.

Note that in their model, total output in the economy is solely determined by the return shock, but that distress selling reduces the utility of sellers (here, depositors), while increasing that of speculators. While such redistribution might not admit any Pareto improvement, under certain assumptions on the weights used in the social welfare functions, the redistribution can lower the social welfare.

7 Policy options

In the previous section, we have discussed how distress selling and asset market feedback may have deleterious effects on aggregate output and welfare. In this section, we investigate what policy options can be used to minimise the adverse consequences of distress selling and asset market feedback. Note that, while much of this section stresses the benefits of relaxing standards as distress selling and asset market feedback take place, it is desirable to tighten them as risk builds up.

The overall framework in Section 2 is useful for understanding policy options available at each stage in the process of distress selling and asset market feedback. Our discussion below will follow the stages in Figure 1. Alternatively, one can classify the policy options as related to either regulatory and accounting rules, or to the contingent provision of public resources. Discussions on exposure limits, borrowing and liquidity constraints, circuit breakers, and marking-to-market rules relate to the former, while those on insurance against shocks and creation of asset demand relate to the latter. Also, one can divide the policy options into (1) ex-ante measures preventing distress selling, which are taken or committed before shocks are realised, and (2) ex-post measures mitigating the negative effects of distress selling and asset market feedback, taken at discretion after shocks are realised and distress selling is about to occur.

Note that we do not analyse the optimal ex-ante choice of regulatory tools given the trade-offs between the benefits of regulatory constraints (such as positive ex-ante effects on incentives) and the cost of the constraints (such as negative ex-post effects on financial stability). Moreover, we are aware of the possibilities that the expectation of government relaxing regulatory constraints such as capital requirements during the financial distress or that the expectation of government providing insurance against negative shocks can encourage more risk-taking by banks and aggravate the moral hazard problem. The ultimate answer to the question of optimal ex-ante choice of regulatory instruments can only be given in a general equilibrium context, in consideration of the possible tradeoffs and time consistency problems. This analysis is beyond the scope of this paper.[63] In this section, we list the possible instruments as they apply to different stages in the mechanism outlined in Figure 1.

7.1 Initial state: diversification in positions and strategies

In our notational framework, at $t = 0$ each agent decides the amount of borrowing (b), the asset portfolio (k, m), and, although not modelled explicitly, how to change these variables at $t = 1$ after shocks realise. The initial state of agents' balance sheets at $t = 0$ influences the likelihood and volume of distress selling at $t = 1$. In particular, the degree of diversification (or concentration) in asset holdings, the distance agents maintain from violating their financial constraints, and the degree of homogeneity in risk management practices matter for the strength of distress selling and asset market feedback.

First, concentration of exposures on the asset side of the balance sheets matters for distress selling. Any policies reducing concentration on one asset class work toward reducing the likelihood that distress will take place, as well as the volume of distress sales triggered by any given *shock to the asset class*. Regulators can take measures to enhance diversification such as imposing exposure limits on balance sheets. One example is the guideline on commercial real estate exposure ceilings issued by the US bank regulators in 2005 when they noticed severe concentration of some banks' exposures on the commercial real estate sector. Another example is the guideline, issued by the Hong Kong Monetary Authority (HKMA) in 1994 when banks' exposure to the property market

[63] Acharya and Yorulmazer (2006) attempt to model this trade-off. When a sufficiently large number of banks fail, there are too many banks to liquidate, and thus inefficient users of assets may end up owning the assets, as was pointed out in Section 6. In order to avoid this allocational inefficiency, it may be ex-post optimal for the regulator to bail out some failed banks. However, they show that ex ante, this gives banks an incentive to herd by investing in correlated assets, thereby making aggregate banking crises more likely.

grew rapidly, that banks should limit their exposure to the property market to 40% of the loan book.[64]

Ex ante, margin requirements, haircuts on collateral and other buffers provide useful cushions to losses and reduce the likelihood of distress. However, when they become binding ex-post, they prompt distress selling and generate further losses (Borio 2004). As was shown in Section 5, if these constraints are too tight, they might exacerbate distress selling through feedback mechanisms. Therefore, it is desirable for indebted asset holders to keep some buffer above the level financial constraints prescribe. Regulators can provide incentives for indebted asset holders to hold buffers. An example in point is US Prompt Corrective Action (PCA), in which the minimum total risk-adjusted bank capital ratio is 8%, while the recommended ratio is 10%. Currently, most US banks hold excess capital above the recommended ratio, and the average total risk-adjusted capital ratio of all US banks is above 13% (FDIC 2006). Another example is statistical provisioning introduced in Spain in 2000, under which banks build up extra provisions in good times, so that they can be used in bad times (Fernandez de Lis et al 2000). The difference between the two is that PCA forces action prior to the exhaustion of excess capital, while statistical provisioning relaxes provisioning requirements in case of systemic downturn.

Finally, risk management practices for banks or traders can also affect distress selling. Trading and risk management rules that seem effective and rational from the point of view of an individual trader can potentially have disruptive market-wide effects when applied simultaneously by a significant portion of market participants (see Section 5.2). Given an aggregate shock to asset values, homogeneous action rules based on the same risk management practices can induce a generalised selling of assets, which strengthens the fall in asset prices due to lack of industry buyers or insiders in the market. The Counterparty Risk Management Policy Group II (2005) points out that the fact that many financial institutions use broadly similar analytical tools to model price changes in response to external events heightens the risk of precipitous price changes in the face of crowded trades. Blum (2006) also shows it is possible that convergence in risk measurement and risk management across banks reduces individual default probability of banks but increases systemic risk. Therefore, if it is necessary to foster convergence in risk measurement and management among banks, policymakers need to make sure that individual banks understand the potential increase in systemic risk in their risk assessments. Crockett (2000) suggests that the calibration of regulatory and supervisory arrangements in consideration of systemic risk can be implemented through the supervisory review process in the Basel II framework.

[64] However, note that having a fixed threshold for a class of asset holdings for each individual firm can have the side effect of limiting demand. To see this point clearly, consider an industry consisting of many firms holding one class of assets. These firms can value the asset at or near the fundamental price, while the industry outsiders value them at a much lower price. Suppose that most of the firms hold the asset up to the exposure limit. Given an idiosyncratic *shock not related to the asset class*, a small number of firms in the industry need to sell some of the assets but the other firms cannot purchase the assets owing to the binding exposure limit. Therefore, the asset has to be sold to industry outsiders, which lowers the price of the assets and triggers asset market feedback.

7.2 Shocks: public provision of insurance

The second category of policy options involves the public provision of insurance against negative shocks, that is, containing triggers of distress selling and reducing feedback through the asset market. The official sector can provide insurance against liquidity or solvency shocks and achieve a socially better outcome, depending on the characteristics of shocks.[65] There are two broad categories of shocks: idiosyncratic and aggregate shocks. Purely idiosyncratic shocks will not push asset prices below fundamental value (Shleifer and Vishny 1992). Moreover, in most cases, individual agents could in general diversify away idiosyncratic shocks through trade among themselves, so there is little room for official intervention. On the other hand, prudential authorities need to play a role in the case of aggregate shocks. They can also play an important role when idiosyncratic shocks lead to contagion and generate systemic distress while individual agents cannot insure away these shocks.

Aggregate shocks

We first discuss the provision of insurance by central banks against aggregate liquidity shocks, and then public insurance against an aggregate deterioration in asset values. The public sector can provide these kinds of insurance because it is outside the industry which is subject to aggregate shocks, and it has access to financial resources large enough to provide insurance against those shocks. Note that the central bank typically provides liquidity to banks when they face aggregate liquidity shocks. However, it is also possible that the central bank provide liquidity through banks to other sectors facing liquidity problems (see Calomiris 1994 for an example).

First, in most countries, the official sector has provided banks and other market participants with insurance against aggregate liquidity shocks. Freixas et al (2000) and Wood (2000) provide discussions on the reasons for the existence and effectiveness of the central bank's role as Lender of Last Resort (LLR).[66] Liquidity shortages stem from either the liability or the asset side of banks' balance sheets (see Section 3.1). Diamond and Dybvig (1983) show that the introduction of deposit insurance eliminates the possibility of a bank run and thus inefficient liquidation of productive projects. On the other hand, Diamond and Rajan (2005) and Holmström and Tirole (1998) examine liquidity shortages stemming from the asset side of the agents' ledger. In particular, Diamond and Rajan (2005) consider exogenous delays in the generation of project cash flows by borrowing firms, and show that a liquidity infusion by the central authority can reduce the liquidity shortage and prevent bank failures. Holmström and Tirole (1998) show that, given a combined

[65] White (2004) examines the rationale for the use of safety net intruments by the official sector.

[66] Open market operations may be used instead of discount window (central banks providing short-term loans to commercial banks in need of liquidity). Even though there is some similarity between open market operations and the lending by LLR to banks, open market operations are done at an aggregate level. Also, open market operations are restricted to banks with eligible securities, which are more restrictive compared to the eligibile collateral for LLR lending. Moreover, open market operations are slower than discount window in terms of providing immediate liquidity.

shock (liquidity and solvency shock ρ) to an initial investment project, treasury bond issuance reduces liquidation, and raises total output and expected aggregate investment.

There are many episodes of liquidity support provided by the central bank in the face of *unanticipated* liquidity shortages. For example, on September 11 terrorist attacks in 2001, banks experienced liquidity shortages because of the impairment of the payments system. The Federal Reserve provided ample liquidity to the banking system through discount window loans and open market operations (see McAndrews and Potter 2002, and Lacker 2004).

Another episode is the *ex-ante* supply of liquidity ahead of Y2K by the Federal Reserve, as explained by Sundaresan and Wang (2005). The Fed created state-contingent policy measures such as Y2K options. In particular, through discount windows, the Federal Reserve Bank of New York offered a large quantity of free liquidity options that matured around the Millennium Date Change. In addition, through several auctions, the Federal Reserve Bank of New York also sold a large amount of liquidity options to bond dealers. Sundaresan and Wang (2005) state that the issuance of these options by the central bank is consistent with the prediction of Holmström and Tirole's (1998) model that state-contingent securities are warranted to mitigate potential liquidity shortages. Basically, the US central bank eliminated the concern of counterparty default risk by placing itself as a reliable counterparty.

Second, insurance against aggregate solvency shocks can be provided by the official sector. In many Asian and Nordic countries, the official sector recapitalised the banking industry suffering from the aggregate collapse of asset values during the crises (see Lindgren et al 1999, and Sandal 2004 for detailed accounts on each country). Recapitalisation of insolvent banks obviates the need for distress sales or liquidation of assets and thus help maintain financial stability and reduce output cost.

Aggregate solvency shocks involve the deterioration of fundamental values of the assets themselves on the banks' balance sheets. Moreover, it is possible that aggregate solvency shocks on the value of collateral for bank loans (typically, real estate) cause liquidation of the loans. Kocherlakota and Shim (2007) show that deposit insurance by taxpayers against aggregate shocks on collateral value, with no shock on the bank's asset value, can improve social welfare.[67]

Idiosyncratic shocks and contagion

As in the case for the aggregate shocks, the central bank can mitigate contagion[68] by providing liquidity to troubled banks directly as a LLR, and the deposit insurer can mitigate contagion by

[67] Note that the traditional notion of deposit insurance is the industry coinsurance against an idiosyncratic *solvency* shock for a bank. Deposit insurance in Kocherlakota and Shim (2007) is different in the sense that taxpayers subsidise the banking sector when the aggregate *collateral* value (ie housing and land prices) falls, but collect premium when the *collateral* value stays high.

[68] Many researchers have shown interest in the mechanisms of contagion due to idiosyncratic but sizable shocks. Contagion channels identified are those that work through common exposure to similar risks, as in Diamond and Rajan (2005) and Kiyotaki and Moore (1997), and contagion through interbank loans, ie balance sheet interconnections as in Allen and Gale (2000), Elsinger et al (2006) and Shin (2005).

quickly recapitalising a failed bank. Cifuentes et al (2005) consider both channels of contagion - direct balance sheet interlinkages among financial institutions, and contagion via changes in asset prices and feedback through marking-to-market. Regarding of policy choices, they show that liquidity requirements can be as effective as capital requirements in forestalling contagious failures. The next subsection analyses how the management of regulatory constraints may act to contain the negative impact of distress selling.

7.3 Financial constraints: flexibility and intertemporal smoothing

Fixed and tight regulatory constraints may lead to distress selling and reinforce the asset market feedback process (Sections 3 and 5). The third category of policy options relates to increasing the flexibility of the regulatory framework and allowing smoothing over time, while preserving the intended goals of the constraints, eg limiting leverage, risk-taking, and liquidity shortages. In this subsection, we investigate how regulators may alleviate financial constraints. We start with borrowing constraints and then discuss liquidity requirements.

Given a drop in the value of assets, the regulator can relax borrowing constraints such as capital requirements or margin constraints, so that firms in distress need not sell assets. Cohen and Shin (2002) propose that the haircut that is applied to the securities provided under a collateral agreement be adjusted (downward) when markets are under stress, and that similar considerations be given to the calculation of margin requirements for positions taken on organised derivatives exchanges. Chowdhry and Nanda (1998) argue that it is optimal to adjust margin requirements to counteract non-fundamental price changes, but not optimal to do the same for fundamental price changes.

History has witnessed that regulators sometimes exert forbearance during the downturns in business cycles and assets markets, and relax capital requirements or margin constraints. The UK Financial Services Authority (2002a, 2002b) documents that, in response to the decline in European stock markets in the summer of 2002, the FSA relaxed the solvency rule so as to preempt the destabilising forced sales of stocks by the major market players. Also, there are many instances where collateral constraints were set lower against a fall in asset prices. Hardouvelis (1990) shows that, in the US stock market, higher or rising margin requirements have been associated with lower stock price volatility, lower excess volatility, and smaller deviations of stock prices from their fundamental values.[69] The Japanese authorities tightened margin trading to stem an overheating of the market in 1986. But later in 1987 following the stock market crash, the Japanese authorities lowered margin requirements and also relaxed lending limits on equity portfolios, in order to

[69] Hsieh and Miller (1990) and Pruitt and Tse (1996) express rather negative views about the effectiveness of varying margin requirements as a policy tool. Fortune (2001) and Kwan (2000) also voice caution in using counter-cyclical margin constraints. Recently, however, Hardouvelis and Theodossiou (2002) show that when stock prices tumble and margin calls are issued by brokers, it would be stabilising to avoid further margin calls and to reduce the cost of arbitrage by temporarily lowering the level of initial margin requirerments. For a summary of studies on margin requirements, see Fortune (2001).

alleviate cash shortages and distress selling (BIS 1988). Note, however, that supervisors engage in forbearance in the hope that business cycles and asset markets will rebound soon. If asset prices remain low and the recession persists, as was the case for the US during the savings and loan crisis in the 1980s, and for Japan in the 1990s, regulatory forbearance can increase the problem by delaying necessary adjustments on banks' balance sheets (see Friedman 2000 for detailed accounts on this point).

The central bank can also accept a broader range of assets as collateral (ie relax collateral eligibility requirements) to mitigate distress selling. For example, months before Y2K, the US Federal Reserve expanded the menu of eligible securities as collateral in repo transactions to include mortgage-backed securities. This change was made to ensure that the potential demanders of liquidity from the central bank were able to deliver securities as collateral in a period of market stress. Delston and Campbell (2002) state that, in a systemic banking crisis, all banks that require assistance will typically receive funding, and any usual collateral requirements will be ignored in the interests of saving the banking system. Note, however, that when banks expect that collateral eligibility standards will be relaxed during market turmoil, banks may have an incentive to take excessive risks by holding assets that would not be accepted as collateral under normal circumstances (Fischer 1999).

Reserve requirements are in place in many countries to make sure that banks hold sufficient liquidity buffers against sudden withdrawal of deposits (see Section 3.1.1). However, this requirement can induce distress selling if a bank actually faces severe withdrawal of deposits so that remaining liquidity is lower than required by the regulation. Thus, given a temporary liquidity drain, regulators can relax the constraints on holding liquid assets so that banks do not have to sell assets further to obtain liquidity immediately. When the banking sector demonstrated signs of instability in July 2004, the Central Bank of Russia decided to reduce required reserve ratios to prevent a systemic banking crisis. Specifically, the required reserve ratios for funds attracted from corporate entities in rubles and funds attracted from corporate entities and private individuals in foreign currency were reduced from 10% to 3.5% and the required reserve ratio for funds attracted from private individuals in rubles was reduced from 7% to 3.5% (Gray 2006).[70]

7.4 Pricing (1): creation of asset demand

The fourth category of policy options is about providing *support to market prices* in the face of distress selling. In order to avoid that the market price falls below fundamental value, policymakers can help create asset demand in various ways. The first is to facilitate entry of potential buyers

[70] Rochet (2005) proposes that, instead of a reserve requirement which is used only with a small probability, the central bank could commit ex-ante to liquidity support or credit lines, as shown in Section 7.2, under conditions defined and monitored by the supervisors to limit moral hazard and forbearance. He (2000) argues that properly desgined procedures, clearly laid-out authority and accountability, as well as disclosure rules regarding official emergency liquidity support will promote financial stability, reduce moral hazard and protect LLR from undue political pressure.

into a specialised market, which helps sustain the market price at the best price. Specifically, policymakers can at least temporarily lift entry restrictions on domestic firms, which are in place as part of anti-trust regulations or entry barriers to foreign firms. However, it might take time for a new firm to step into the market, and thus be difficult to create asset demand in time. Moreover, even though new firms enter a market, they may not be able to function as well as incumbent firms. Especially, when a dominant market maker fails, it is difficult for the other firms to perform the same role supporting the market prices. Brewer and Jackson (2000) find that the monitoring services provided by Drexel Burnham Lambert for the bonds it underwrote was not replaced easily by other financial intermediaries in the junk bond market.

Considering these limitations, policymakers can adopt a more direct and less time-consuming method to create asset demand. In particular, they can play the role of a "deep-pocket" investor during market turmoil or industry-wide recessions. Policymakers as industry outsiders can either hold financial assets, or manage real assets by hiring insiders or providing liquidity to industry insiders, until the assets are resold at a price close to fundamental value.

One example is the purchase of bonds by the US Federal Reserve during the Great Depression. In April 1932, facing the sharp decline in the prices of government and corporate bonds owing largely to the pressure on banks to liquidate their assets, the US Federal Reserve performed large-scale open market purchases, which helped raise the bond prices and thus improve the capital positions of the commercial banks temporarily (Friedman and Schwartz 1963). A recent example is the purchase of stocks by the HKMA in the Hong Kong equity market in August 1998 (Goodhart and Dai 2003). Facing speculative attacks in the foreign exchange market as well as precipitating equity prices,[71] The HKMA decided to purchase a massive amount of stocks to avoid a market crash. The intervention was successful, and the stock market recovered quickly after the intervention.[72] Another more recent example is the purchase of government bonds by the Korean central bank in 2003 (Remolona and Wooldridge 2003). Confronted with mass redemptions by Korean investors in March 2003, investment trusts were forced to sell assets, and as a result, corporate and government bond prices plummeted. In response, the Bank of Korea bid for 2 trillion won and the government also postponed scheduled auctions of government bonds in order to help stabilise the government bond market.

Another form of intervention is the asset management corporations (AMCs) established during the financial crises in many Asian countries such as Indonesia, Korea, Malaysia, and Thailand (see BIS 1999). They were set up to facilitate banking sector restructuring and avoid the precipitation of illiquid asset prices due to distress selling.[73] Finally, Kiyotaki and Moore (2001) suggest that the

[71] The Hong Kong stock market had fallen from 10,563 on May 1, 1998 to 6,660 on August 13, 1998 - a 40 per cent decline (Goodhart and Dai 2003, p. 28).

[72] The Hang Seng Index (HSI) closed at 7,830 on August 28, 1998, an 18% per cent rise compared to 6,660 on August 13, 1998. the HSI later rose to 7,880 in September, and 10,150 in October 1998 (Goodhart and Dai 2003, p. 37).

[73] Note that AMCs controlled by the public sector do not always operate in the most efficient way, and they have

central bank purchase an illiquid collateral asset in an open market operation. This is, however, difficult to implement because of the conservative criteria for the eligibility for the securities used in open market operations, unless one relaxes the criteria as discussed in Section 7.3.

7.5 Pricing (2): containment of excessive price movements

The fifth category of policy options tries to prevent a *rapid* decline in market prices. Circuit breakers such as price limits and trading halts can help contain distress selling. Japan, France and Spain used such measures in 1987 when dealing with stock market crashes (BIS 1988). These measures work in a way similar to the suspension of deposit payments in Diamond and Dybvig (1983). These measures are useful during market panic triggered by non-fundamental information. These are instances of heightened uncertainty when the distinguishing between fundamentals and non-fundamentals is extremely difficult. If trading is suspended, market participants can have time to analyse and verify the causes of the fall in prices.

If the fall in prices was based on overreaction or non-fundamental information, the market will return to normality after it reopens. Such halts may also give informed traders an opportunity to enter the market and provide liquidity, and allow traders more time to respond to intraday margin calls or to remove stop-loss orders (Harris 1998). However, if the price fall reflects fundamental deterioration in asset values, market suspension is unlikely to stem the fall in prices. Subrahmanyam (1994) shows that, if expected, circuit breakers may cause agents to suboptimally advance trades in time, thus increasing price variability.

Moreover, with the level of price limits known and a distressed seller about to sell a large quantity of assets in the market, it is possible that predatory traders will try to sell the assets quickly in the market, accelerating the price decline. One way of reducing predatory trading motives is to introduce a form of compulsory insurance for distress sellers by the other market participants. This scheme will internalise the externalities predatory traders try to exploit and thus prevent excessive price volatility. During the Long Term Capital Management (LTCM) crisis in September 1998, the Federal Reserve Bank of New York facilitated 14 of the world's largest banks and securities firms to recapitalise LTCM in order to prevent rapid liquidation of its trading positions (US GAO 1999). Knowing that they should recapitalise the distress seller, the other traders in the market will have a weaker incentive to engage in predatory trading. Note, however, that like other insurance schemes, this coinsurance scheme is subject to the moral hazard problem and may distort ex-ante incentives of risk taking.

Finally, policymakers can improve information dissemination in the market and reduce distress selling. If there are relatively few informed investors in a market, relatively small unobserved supply shocks can have pronounced effects on current market prices (Section 5.4). Moreover, if investors are unaware of others' hedging plans, a further fall in prices due to hedging again

their own shortcomings.

lowers expectations on prices by uninformed investors, which in turn lowers prices faster. As suggested by Gennotte and Leland (1990), policymakers can (1) induce market-makers, who can tell information-based selling from liquidity-driven selling, to provide liquidity to the market, and (2) increase market knowledge or disclosure about the size and trading requirements of hedging programs.

7.6 Feedback: relaxation of mark-to-market rules

The final category is about preventing low market prices from quickly feeding back through their impact on balance sheets. The market prices are usually believed to be a good gauge of fundamental asset values. However, we showed in Section 5 that, when the value of assets is marked to market and the liabilities are valued according to book value accounting, the fall in prices below the fundamental value due to distress selling can leads to asset market feedback.

The natural question arising in this context is why the immediate mark-to-market rules are not relaxed.[74] If immediacy in marking-to-market is not required, the seller can wait for better pricing opportunities, raise additional funds, and try to restructure debt, all of which will contribute to reducing the severity of distress selling. Also, if market participants are not sure whether the source of initial price changes was non-fundamental information or a fundamental shock, it is better to allow time to wait and see. On the other hand, relaxing marking-to-market for too long can have the perverse effect of promoting the incentives to postpone the reflection of the negative shocks on the financial reports or even encourage firms to take excessive risks, ie to gamble for resurrection. Therefore, considering this trade-off, the regulators and accounting standard setters could decide ex ante an optimal time lag to apply mark-to-market rules with, or allow ex post an exception to the immediate mark-to-market rule during a period of market distress. Another alternative would be to have mark-to-market rules but complement this information with measures of risk and measurement error, so that we can avoid distress selling under pressure (see Borio and Tsatsaronis 2005).

8 Conclusion

This paper examined an anatomy of distress selling and asset market feedback in the context of a framework with a common notation. The framework contributes to a better understanding of the process of distress selling and asset market feedback, and what policymakers can do to address

[74] This question has been already asked by many researchers. Plantin et al (2005) show that marking-to-market creates externalities in the form of balance sheet spillover effects. They claim that, for liquid markets, marking-to-market is superior, while for illiquid markets, historical cost is superior. IMF (2003) points out possible trade-offs between transparency of mark-to-market values and market volatility. In particular, it emphasises the need to balance the requirement for continuously updated risk measurement and control against inducing sales of positions to stay within limits during a crisis.

its adverse economic consequences. By providing a unified framework, the paper draws together different strands of the literature, and offers a menu of ingredients for constructing models of financial instability.

In view of future research, a number of issues warrant attention. Financial constraints appeared to be necessary in models that allow for distress selling and asset market feedback. Are financial constraints becoming more prevalent due to modern risk management techniques, or less prevalent due to financial market innovation? Perhaps distress selling and asset market feedback can occur in the absence of any financial constraints, as is implicit in Fisher's theory of debt-deflation. Another issue is that most theories divide agents exogenously into sectors or blocks, of which one will sell and the other will buy. The relative measure of sellers and buyers is, however, crucial for financial stability, and future work should explore how asset price fluctuations and distance to financial constraints change this measure in a dynamic general equilibrium setting. A further issue concerns the optimal design of policy. Since most policy options give rise to ex-post *and* ex-ante effects, research should attempt to identify those that implement an optimal trade-off.

References

Acharya, Viral V., and Tanju Yorulmazer, 2006, "Cash-in-the-market Pricing and Optimal Resolution of Bank Failures", Review of Financial Studies, forthcoming.

Agarwal, Sumit, Brent Ambrose, and Chunlin Liu, 2006, "Credit Lines and Credit Utilization", Journal of Money, Credit, and Banking, Vol. 38, No. 1, pp. 1-22.

Aghion, Philippe, Philippe Bacchetta, and Abhijit Banerjee, 2001, "Currency crises and monetary policy in an economy with credit constraints", European Economic Review, Vol. 45, pp. 1121-1150.

Aghion, Philippe, Patrick Bolton, and Mathias Dewatripont, 2000, "Contagious bank failures in a free banking system", European Economic Review Vol. 44, pp. 713-718.

Aiyagari, S. Rao, and Mark Gertler, 1999, ""Overreaction" of Asset Prices in General Equilibrium", Review of Economic Dynamics, Vol. 2, pp. 3-25.

Allen, Franklin, and Douglas Gale, 1998, "Optimal Financial Crises", Journal of Finance, Vol. 52, No. 4, pp. 1245-1284.

Allen, Franklin, and Douglas Gale, 2000, "Financial Contagion", Journal of Political Economy, Vol. 108, No.1, pp. 1-33.

Ashcraft, Adam, 2005, "Are Banks Really Special? New Evidence from the FDIC-Induced Failure of Healthy Banks", American Economic Review, Vol. 95, No. 5, pp.1712-1730.

Attari, Mukarram, Antonio S. Mello, and Martin E. Ruckes, 2005, "Arbitraging Arbitrageurs", Journal of Finance, Vol. 60, No. 5, pp. 2471-2511.

Bank for International Settlements, 1988, 58th Annual Report, Basel, BIS.

Bank for International Settlements, 1999, Bank Restructuring in Practice, BIS Policy Papers, No. 6.

Berg, Sigbjørn, 1998, "Bank Failures in Scandinavia", Chapter 11 in Caprio et al (eds.) *Preventing Bank Crises - Lessons from Recent Global Bank Failures*, Washington: The World Bank.

Berkelaar, Arjan B., Roy Kouwenberg, and Thierry Post, 2004, "Optimal Portfolio choice under Loss Aversion", Review of Economics and Statistics, Vol. 86, No. 4, pp. 973–987.

Bernanke, Ben S., 1983, "Nonmonetary Effects of the Financial Crisis in Propagation of the Great Depression," American Economic Review, Vol. 73, No. 3, pp. 257-276.

Bernanke, Ben S., and Mark Gertler, 1989, "Agency Costs, Net Worth, and Business Fluctuations", American Economic Review, Vol. 79, No. 1, pp. 14-31.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist, 1999, "The Financial Accelerator in a Quantitative Business Cycle Framework", in Taylor and Woodford (eds.), *Handbook of Macroeconomics*, Amsterdam: Elsevier Science, North Holland.

Bernanke, Ben S. and Cara S. Lown, 1991, "The Credit Crunch", Brookings Papers on Economic Activity, Vol. 1991, No. 2, pp. 205-247.

Bernardo, Antonio E., and Ivo Welch, 2004, "Liquidity and Financial Market Runs," Quarterly

Journal of Economics, Vol. 119, No. 1, pp. 135-158.

Bhattacharya, S and D. Gale, 1987, “Preference Shocks, Liquidity, and Central Bank Policy”, in W.A Barnett and K. J. Singleton (eds.), *New Approaches to Monetary Economics*, Cambridge University Press.

Bierman, Harold, 1998, *The Causes of the 1929 Stock Market Crash: a Speculative Orgy or a New Era?*, Westport and London: Greenwood Press.

Blum, Jürg, 2006, "Optimal Banking Regulation in the Presence of Systemic Risk", presentation at the workshop Micro-Models of Systemic Risk, organised by the Bank of England in May, 2006.

Borio, Claudio, 2004, "Market Distress and Vanishing Liquidity: Anatomy and Policy Options", BIS working paper, No. 158.

Borio, Claudio, 2006, "The Macroprudential Approach to Regulation and Supervision: Where do we Stand?", Chapter 7 in *Erfaringer og utfordringer Kredittilsynet 1986–2006* (the special volume celebrating the 20th anniversary of Kredittilsynet), kredittilsynet, Norway.

Borio, Claudio and Kostas Tsatsaronis, 2005, "Accounting, Prudential Regulation and Financial Stability: Elements of a Synthesis", BIS working paper, No. 180.

Brewer III, Elijah and William E. Jackson III, 2000, "Requiem for a Market Maker: The Case of Drexel Burnham Lambert and Junk Bonds", Journal of Financial Services Research, Vol. 17, No. 3, pp. 209-235.

Brimmer, Andrew, 1989, "Central Banking and Systemic Risks in Capital Markets", Journal of Economic Perspectives, Vol. 3, No. 2, pp. 3-16.

Brown, David, 2000, "Liquidity and Liquidation: Evidence from Real Estate Investment Trusts", Journal of Finance, Vol. 55, No. 1, pp. 469-485.

Brown, David, Christopher James, and Robert Mooradian, 1994, "Asset Sales by Financially Distressed Firms", Journal of Corporate Finance, Vol. 1, No. 2, pp. 233-257.

Brunnermeier, Markus, and Lasse H. Pedersen, 2005, "Predatory Trading", Journal of Finance, Vol. 60, No. 4, pp. 1825-1863.

Brunnermeier, Markus, and Lasse H. Pedersen, 2006, "Market Liquidity and Funding Liquidity", working paper, Princeton University and New York University.

Calomiris, Charles, 1994, "Is the Discount Window Necessary? A Penn-Central Perspective", Federal Reserve Bank of St. Louis Review, May/June, pp. 31-56.

Calomiris, Charles, 1995, "Financial Fragility: Issues and Policy Implications", Journal of Financial Services Research, Vol. 9, No. 3-4, pp. 241-257.

Calomiris, Charles, and Berry Wilson 1998, "Bank Capital and Portfolio Management: The 1930s ‘Capital Crunch’ and Scramble to Shed Risk”, Journal of Business, Vol. 77, pp. 421-456.

Canova, Fabio, 1994, "Were Financial Crises predictable?", Journal of Money, Credit and Banking, Vol. 26, No. 1, pp. 102-124.

Carlstrom, Charles T. and Timothy S. Fuerst, 1997, “Agency Costs, Net Worth, and Business

Fluctuations: A Computable General Equilibrium Analysis." American Economic Review, Vol. 87, No. 5, pp. 893-910.

Chen, Nan-Kuang, 2001, "Bank Net Worth, Asset Prices and Economic Activity", Journal of Monetary Economics, Vol. 48, pp. 415-436.

Chowdhry, Ghagwan, and Vikram Nanda, 1998, "Leverage and Market Stability: The Role of Margin Rules and Price Limits", Journal of Business, Vol. 71, No. 2, pp.179-210.

Cifuentes, Rodrigo, Gianluigi Ferrucci, and Hyun Song Shin, 2005, "Liquidity Risk and Contagion", Journal of the European Economic Association, Vol. 3, No. 2-3, pp. 556-566.

Cochrane, John, 2004, *Asset Pricing*, Princeton University Press.

Cohen, Benjamin H., and Hyun Song Shin, 2002, "Positive Feedback Trading in the US Treasury Market", BIS Quarterly Review, June, pp. 59-67.

Committee on the Global Financial System, 1999, "A Review of Financial Market Events in Autumn 1998", Bank for International Settlements.

Cordoba, Juan-Carlos, and Marla Ripoll, 2004, "Credit Cycles Redux", International Economic Review, Vol. 45, No. 4, pp. 1011-1046.

Counterparty Risk Management Policy Group II, 2005, "Toward Greater Financial Stability: A Private Sector Perspective", The Report of the Counterparty Risk Management Policy Group II.

Coval, Joshua, and Erik Stafford, 2007, "Asset Fire Sales (and Purchases) in Equity Markets", Journal of Financial Economics, forthcoming.

Crockett, Andrew D., 2000, "Marrying the Micro- and Macro-prudential Dimensions of Financial Stability", Remarks before the 11th International Conference of Banking Supervisors, BIS, Basel, Switzerland, September 20-21.

Danielsson, Jon, Hyun Song Shin, and Jean-Pierre Zigrand, 2004, "The Impact of Risk Regulation on Price Dynamics", Journal of Banking and Finance, Vol. 28, pp. 1069-1087.

De Long, J. Bradford, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldmann, 1990, "Noise trader risk in Financial Markets", Journal of Political Economy, Vol. 98, No. 4, pp. 703-738.

Delston, Ross S. and Andrew Campbell, 2002, "Emergency Liquidity Financing by Central Banks: Systemic Protection or Bank Bailout?", Paper presented to the IMF Legal Department and IMF Institute Seminar on Current Developments in Monetary and Financial Law, May 7-17, 2002.

Diamond Douglas W., and Phillip H. Dybvig, 1983, "Bank Runs, Deposit Insurance, and Liquidity", Journal of Political Economy, Vol. 91, pp. 401-419.

Diamond, Douglas W., and Raghuram G. Rajan, 2005, "Liquidity Shortages and Banking Crises", Journal of Finance, Vol. 60, No. 2, pp. 615-647.

Donaldson, R. Glen, 1992, "Costly Liquidation, Interbank Trade, Bank Runs and Panics", Journal of Financial Intermediation, Vol. 2, pp. 59-82.

Elsinger, Helmut, Alfred Lehar, and Martin Summer, 2006, "Risk Assessment for Banking Systems", Management Science, Vol. 52, pp. 1301-1314.

Faccio, Mara, and Rajdeep Sengupta, 2006, "Corporate response to distress: evidence from the Asian financial crisis", Federal Reserve Bank of St. Louis working paper 2006-044A.

Federal Deposit Insurance Corporation, 2006, *Quarterly Banking Profile, Third Quarter 2006*, available at http://www2.fdic.gov/qbp/2006sep/qbp.pdf

Fernandez de Lis, Santiago, Jorge Martinez Pages, and Jesus Saurina, 2000, "Credit growth, problem loans and credit risk provisioning in Spain", Working Paper 18, Banco de Espana.

Fisher, Irving, 1933, "The Debt-Deflation Theory of Great Depressions", Econometrica, Vol. 1, No. 4, pp. 337-57.

Fischer, Stanley, 1999, "On the Need for an International Lender of Last Resort", Journal of Economic Perspective, Vol. 13, No. 4, pp. 85-104.

Financial Services Authority, 2002a, "FSA Introduces new element to life insurers resilience tests", FSA/PN/071/2002, FSA, UK.

Financial Services Authority, 2002b, "Life Insurance Industry: FSA Statement", FSA/PN/074/2002, FSA, UK.

Flannery, Mark, 1996, "Financial Crises, Payment System Problems, and Discount Window Lending", Journal of Money, Credit and Banking (November, Part II), pp. 804-824.

Fleming, Michael J. and Kenneth D. Garbade, 2005, "Explaining Settlement Fails", Current Issues in Economics and Finance, Vol. 11, No. 9, Federal Reserve Bank of New York.

Fortune, Peter, 2001, "Margin Lending and Stock Market Volatility", New England Economic Review, No. 4, Federal Reserve Bank of Boston.

Freixas, Xavier, Curzio Giannini, Glenn Hoggarth and Farouk Soussa, 2000, "Lender of Last Resort: What Have We Learned Since Badghot?", Journal of Financial Services Research, Vol. 18, pp. 63-84.

Friedman, Benjamin M., 2000, "Japan Now and the United States Then: Lessons from the Parallels", in Ryoichi Mikitani and Adam S. Posen (eds.), *Japan's Financial Crisis and its Parallel to U.S. Experience*, Special Report 13, Institute for International Economics, Washington, D.C.

Friedman, Milton and Anna Jacobson Schwartz, 1963, *A Monetary History of the United States 1867-1960*, National Bureau of Economic Research Studies in Business Cycles 12, Princeton University Press, Princeton.

Gai, Prasanna, Sujit Kapadia, Stephen Millard and Ander Perez, 2006, "Financial Innovation, Macroeconomic Stability and Systemic Crises", working paper, Bank of England and London School of Economics.

Gennotte, Gerard and Hayne Leland, 1990, "Market Liquidity, Hedging, and Crashes", American Economic Review, Vol. 80, No. 5, pp. 999-1021.

Goodhart, Charles A.E. and Lu Dai, 2003, *Intervention to Save Hong Kong: The Authorities' Counter-Speculation in Financial Markets*, Oxford University Press.

Gorton, Gary, and Lixin Huang, 2004, "Liquidity, Efficiency, and Bank Bailouts", American Economic Review, Vol. 94, No. 3, pp. 455-483.

Gray, Simon T., 2006, "Central Bank Management of Surplus Liquidity", Handbooks in Central Banking Lecture Series, No. 6.

Gromb, Denis and Dimitri Vayanos, 2002, "Equilibrium and Welfare in Markets with Constrained Arbitrageurs" Journal of Financial Economics, Vol. 66, Issues 2-3, pp. 361-407.

Grossman, S.J., and M.H. Miller, 1988, "Liquidity and Market Structure", Journal of Finance, Vol. 43, No. 3, pp. 617–633.

Hardouvelis, Gikas A., 1990, "Margin Requirements , Volatility, and the Transitory Component of Stock Prices", American Economic Review, Vol. 80, No. 4, pp. 736-762.

Hardouvelis, Gikas A., and Panayiotis Theodossiou, 2002, "The Asymmetric Relation Between Initial Margin Requirements and Stock Market Volatility Across Bull and Bear Markets", Review of Financial Studies, Vol. 15, No. 5, pp. 1525-1559.

Harris, Lawrence E., 1998, "Circuit Breakers and Program Trading Limits: The Lessons Learned", in R.E. Ritan and A. M. Santomer (eds.) *Brookings-Wharton Papers on Financial Services*, pp.17-47.

He, Dong, 2000, "Emergency Liquidity Support Facilities", IMF working paper 00/79, IMF.

Hendershott, Terrence and Mark S. Seasholes, 2006, "Market Maker Inventories and Stock Prices", American Economic Review Papers and Proceedings, Vol. 97, No. 2.

Holmström, Bengt, and Jean Tirole, 1998, "Private and Public Supply of Liquidity", Journal of Political Economy, Vol. 106, No.1, pp. 1-40.

Hsieh, David A. and Merton H. Miller, 1990, "Margin Regulation and Stock Market Volatility", Journal of Finance, Vol. 45, No. 1, pp. 3-29.

Hubbard, Glenn, 1998, "Capital-Market Imperfections and Investment", Journal of Economic Literature, Vol. 36, pp. 193-225.

Iacoviello, Matteo, 2005, "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle", American Economic Review, Vol. 95, No. 3, pp. 739-764.

Inaba, Nobuo, Takashi Kozu, Takashi Hagahata, and Toshitaka Sekine, 2003, "Non-performing Loans and the Real Economy: Japan's Experience", paper presented at the BIS Central Bank Economists' Meeting on October 9-10, 2003.

International Monetary Fund, 2003, *Global Financial Stability Report*, September, Chapter III.

Kindleberger, Charles, 1996, *Manias, Panics and Crashes: A History of Financial Crises*, Third Edition, New York: John Wiley & Sons, Inc.

Kiyotaki, Nobuhiro, and John Moore, 1997, "Credit Cycles", Journal of Political Economy, Vol. 105, pp. 211-248.

Kiyotaki, Nobuhiro and John Moore, 2001, "Liquidity, Business Cycles and Monetary Policy", Clarendon Lectures, Lecture 2, November 27.

Kocherlakota, Narayana R., and Ilhyock Shim, 2007, "Forbearance and Prompt Corrective Action", Journal of Money, Credit and Banking, forthcoming.

Kupiec, Paul H., and Steven A. Sharpe, 1991, "Animal Spirits, Margin Requirements, and Stock Price Volatility", Journal of Finance, Vol. 46, No. 2, pp. 717-731.

Kwan, Simon, 2000, "Margin Requirements as a Policy Tool?", Federal Reserve Bank of San Francisco Economic Letter, 2000-09; March 24.

Lacker, Jeffrey M., 2004, "Payment System Disruptions and the Federal Reserve Following September 11, 2001", Journal of Monetary Economics, Vol. 51, Issue 5, pp. 935-965.

Levin, Andrew T., Fabio M. Natalucci, and Egon Zakrajsek, 2004, "The Magnitude and Cyclical Behavior of Financial Market Frictions", Finance and Economics Discussion Series Paper 2004-70.

Lindgren, Carl-Jahan, Thomás J. T. Balino, Charles Enoch, Anne-Marie Gulde, Marc Quintyn, and Leslie Teo, 1999, "Financial Sector Crisis and Restructuing: Lessons from Asia", IMF Occasional Paper No. 188, IMF.

Lorenzoni, Guido, 2005, "Inefficient Credit Booms", working paper, MIT.

Lown, Cara S., and Mark Gertler, 1999, "The information in the high-yield bond spread for the business cycle: evidence and some implications", Oxford Review of Economic Policy, Vol. 15, pp. 132-150.

Lucas, Robert E., Jr.,1978, "Asset Prices in an Exchange Economy", Econometrica, Vol. 46, No. 6, pp. 1426-1445.

McAndrews, James J. and Simon M. Potter, 2002, "Liquidity Effects of the Events of September 11, 2001", Economic Policy Review, November, Federal Reserve Bank of New York.

McGuire, Patrick, 2007, "Bank ties and firm performance in Japan: Evidence since 2000", Bank of Japan working paper, forthcoming.

Mehrling, Perry, 2000, "Minsky and Modern Finance - the Case of Long-Term Capital Management", Journal of Portfolio Management, Winter, pp. 81-88.

Miles, David, 1995, *Housing, Financial Markets and the Wider Economy*, New York: John Wiley & Sons.

Minsky, Hyman, 1963, "Can 'it' Happen Again?", Chapter 1, in Minsky, 1982, *Can 'It' Happen Again? Essays on Instability and Finance*, Armonk New York: M.E. Sharpe, Inc.

Minsky, Hyman, 1982, "Debt-Deflation Processes in Today's Institutional Environment", Banca Nazionale del Lavoro Quarterly Review, December.

Mishkin, Frederic, 1991, "Asymmetric Information and Financial Crises: A Historical Perspective", in Glenn Hubbard, (ed.) *Financial Markets and Financial Crises*, The University of Chicago Press.

Morris, Stephen, and Hyun Song Shin, 2004, "Liquidity Black Holes," Review of Finance, Vol. 8, No. 1, pp. 1-18.

Nakaso, Hiroshi, 2001, "The Financial Crisis in Japan during the 1990s: how the Bank of Japan responded and the Lessons learnt", BIS Papers, No. 6.

Peek, J. and Eric S. Rosengren, 2000, "Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States", American Economic Review, Vol. 90, No. 1, pp. 30-45.

Plantin, Guillaume, Haresh Sapra, and Hyun Song Shin, 2005, "Marking to Market, Liquidity and Financial Stability", paper for the 12th International Conference, Bank of Japan.

Presidential Task Force of Market Mechanisms, 1988, *Report of the Presidential Task Force of Market Mechanisms* (Brady Report), US Government Printing Office, Washington D.C.

Pritsker, Mathew, 2005, "Large Investors: Implications for Equilibrium Asset Returns, Stock Absorption, and Liquidity", Finance and Economics Discussion Series 2005-36, Division of Research and Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C.

Pruitt, S. and K. Tse, 1996, "The Price, Volatility, volume and Liquidity Effects of Changes in Federal Reserve Margin Requirements on Both Marginable and Nonmarginable OTC Stocks", in A. Lo, (ed.) The Industrial Organization and Regulation of Securities Industry, National Bureau of Economic Research Conference Report series, pp. 317-340. Chicago and London: University of Chicago Press.

Pulvino, Todd, 1998, "Do Asset Fire Sales Exist? An Empirical Investigation of Commercial Aircraft Transactions", Journal of Finance, Vol. 53, No. 3, pp. 939-78.

Remolona, Eli M and Philip D Wooldridge, 2003, "Overview: buoyant markets in weak economies", BIS Quarterly Review, June.

Renaud, Bertrand, 2000, "How Real Estate Contributed to the Thailand Financial Crisis", in Koichi Mera and Bertrand Renaud (eds.), 2002, *Asia's Financial Crisis and the Role of Real Estate*, Armonk, New York: M.E. Sharpe.

Riordan, Michael, and Oliver Williamson, 1985, "Asset specificity and economic organization", International Journal of Industrial Organization, Vol. 3, No. 4, pp. 365-378.

Rochet, Jean-Charles, 2005, "Regulation of Banks' Liquidity: Why and How?", presentation at the Bank of England Conference, the Future of Payments, May 19-20, 2005.

Saita, Y, 2003, "Land Prices in the Tokyo Metropolitan Area: A Hedonic Analysis of Judicial Auction", Bank of Japan Working Paper, No. 03-E-4.

Sandal, Knut, 2004, "The Nordic Banking Crises in the Early 1990s - Resolution Methods and Fiscal Costs", Chapter 3 in Thorvald G. Moe, Jon A. Solheim and Bent Vale (eds.) *The Norwegian Banking Crisis*, Norges Bank Occasional Papers No. 33, Norges Bank.

Scholes, Myron, 2000, "Crisis and Risk Management", American Economic Review, Vol. 90, No. 2, pp. 17-21.

Seguin, Paul, and Gregg Jarrell, 1993, "The Irrelevance of Margin: Evidence from the Crash of '87", Journal of Finance, Vol. 48, No. 4, pp. 1457-1473.

Shin, Hyun Song, 2006, "Risk and Liquidity in a System Context", BIS working paper, No. 212.

Shleifer, Andrei, 2001, *Inefficient Markets - an Introduction to Behavioural Finance*, Oxford: Oxford University Press.

Shleifer, Andrei, and Robert W. Vishny, 1992, "Liquidation Values and Debt Capacity: A Market Equilibrium Approach", Journal of Finance, Vol. 47, No. 4, pp. 1343-1366.

Shleifer, Andrei, and Robert W. Vishny, 1997, "The Limits of Arbitrage", Journal of Finance, Vol. 52, No. 1, pp. 35-55.

Suarez, Javier, and Oren Sussman, 2005, "Financial Distress, Bankruptcy Law and the Business Cycle", working paper, Saïd Business School and CEMFI.

Subrahmanyam, Avanidhar, 1994, "Circuit Breakers and Market volatility: A Theoretical Perspective", Journal of Finance, Vol. 49, no. 1, pp. 237-254.

Sundaresan Suresh M. and Zhenyu Wang, 2005, "Public Provision of Private Liquidity: Prior to the Millennium Date Change", working paper, Columbia University.

United States General Accounting Office, 1999, "Long-Term Capital Management: Regulators Need to Focus Greater Attention on Systemic Risk", Report to Congressional Requesters, GAO/GGD-00-3.

Upper, Christian, and Andreas Worms, 2004, "Estimating Bilateral Exposures in the German Interbank Market: Is There a Danger of Contagion?", European Economic Review, Vol. 48, pp. 827-849.

von Peter, Goetz, 2004, "Asset Prices and Banking Distress: A Macroeconomic Approach", BIS working paper, No. 167.

Wagner, Wolf, 2007, "Aggregate Liquidity Shortages, idiosyncratic Liquidity Smoothing and Banking Regulation", Journal of Financial Stability, Vol. 3, pp. 18-32.

White, William R., 2004, "Are Changes in Financial Structure Extending Safety Nets?", BIS working paper, No. 145.

Wood, Geoffrey E., 2000, "The Lender of Last Resort Reconsidered", Journal of Financial Services Research, Vol. 18, pp. 203-227.