Commonality in Liquidity Shocks and Market Collapse: Theory and Application to the Market for Perps*

Chitru S. Fernando
Michael F. Price College of Business, University of Oklahoma

Richard J. Herring
The Wharton School, University of Pennsylvania

Avanidhar Subrahmanyam
The Anderson School, UCLA

August 2003

Keywords: market liquidity, commonality in liquidity, systemic liquidity risk, market collapse, perpetual floating rate notes

---

* Please address all correspondence to Chitru S. Fernando, Michael F. Price College of Business, University of Oklahoma, 307 West Brooks, Room 205, Norman, OK 73019-4005. Tel. (405) 325-2906; Fax: (405) 325-7688; Email: cfernando@ou.edu. A previous draft of this paper was circulated as "Liquidity Shocks, Systemic Risk, and Market Collapse: Theory and Application to the Market for Perps."

We thank Franklin Allen, Sugato Bhattacharyya, Tarun Chordia, John Cochrane, Gunter Dufey, Michael Fleming, Campbell Harvey, Prem Jain, Steve Jones, Richard Kihlstrom, Paul Kleindorfer, Arvind Krishnamurthy, Ananth Madhavan, Tom Noe, Raghu Rajan, Russ Robins, Patrik Sandas, Nejat Seyhun, Chester Spatt, Paul Spindt, Andy Winton, Kathy Yuan, and seminar participants at the 2002 American Finance Association meetings, the 2002 RFS-Northwestern Conference on Imperfect Capital Markets, the 2003 Georgia Tech Conference on International Finance, Wharton, Michigan, Alabama, American University, Calgary, Claremont Graduate University, Indiana, Iowa, Oklahoma, Texas A&M, Tulane, Federal Reserve Board, and Federal Reserve Bank of New York for valuable discussions and comments. We also thank market participants in New York, London and Tokyo who shared their insights with us. We are grateful to the Weiss Center for International Financial Research for supporting the collection of data, and a grant from the Sloan Foundation to the Wharton Financial Institutions Center for supporting the completion of this research. Si Chen, Hector Campos, Nauman Malik, David Muir and Steve Mykijewycz provided excellent research assistance.

JEL classification: G12, G15, G18

Commonality in Liquidity Shocks and Market Collapse: Theory and Application to the Market for Perps

ABSTRACT

Traditional explanations of market collapse rely on the bursting of an asset price bubble or significant information asymmetry across market participants about fundamental value. We show that markets can collapse even though asset prices have not deviated from fundamental values and information is shared symmetrically among all market participants. We present a model in which markets collapse when investors shift their beliefs about market liquidity. While such shifts in liquidity may be a factor in explaining many market collapses, the collapse of the market for perpetual floating-rate notes (perps) seems to provide an especially clear illustration of the theory because a shift in liquidity beliefs appears to have been the primary determinant of the collapse of the market for perps. Such a shift can be precipitated by a common liquidity shock, and can be transitory or permanent. The latter proved to be the case with perps because perceptions of the liquidity of the secondary market for perps were permanently altered. In addition to providing new insights into why markets collapse, our findings are particularly relevant for unseasoned financial products that are often priced and marketed on the assumption that liquid secondary markets will develop. The collapse of the market for perps also highlights the importance of broad placement of securities. As our model illustrates, market liquidity arises endogenously from the diversity of liquidity needs across the investor base and therefore, the broader the investor base, the lower the probability of a common liquidity shock.

Commonality in Liquidity Shocks and Market Collapse: Theory and Application to the Market for Perps

> *Liquidity, according to Keynes, offers a classic example of the fallacy of composition: what is true for a part is not necessarily true for the whole. The ability to reverse positions and get out quickly vanishes when everyone tries to do it at once.* – Merton Miller (1991).

A market collapse is typically attributed in the literature to either the formation of an asset price bubble or the exacerbation of information asymmetry across market participants.[1] This literature applies most readily to markets for equity, junk bonds,[2] or more generally, markets where rational investors can disagree about future cash flows or can be prevented by various market imperfections, including the presence of irrational investors, from exploiting large price deviations from fundamental value.[3] But, these explanations seem less plausible in the case of markets for high-quality, fixed-income securities such as government and corporate bonds where the determination of fundamental value is usually straightforward, deviations from this value are easy to exploit, and trading tends to be dominated by sophisticated, institutional investors. Perpetual floating-rate notes (perps) fall into this latter category.

---

[1] A market collapse in the context of these explanations is a precipitous decline in asset prices unaccompanied by news about fundamentals. The bubble theories argue that market collapse is preceded by the movement of asset prices significantly above levels that can be justified by fundamentals, either due to irrational unsophisticated investors (e.g. Kindleberger (1978), DeLong, et al. (1990)) or even with rational investors (see Camerer (1989) and Allen and Gale (2000) for a review). Glosten and Milgrom (1985), Glosten (1989) and Bhattacharya and Spiegel (1991) show how markets can collapse without a preceding bubble, due to the widening of information asymmetry across investors. Hong and Stein (2002) show that with short-sale constraints and information asymmetry, negative information can be prevented from reaching the market until the market begins to decline, precipitating a market collapse.

[2] Well known episodes in this category are the collapse of the junk bond market, triggered by a series of defaults culminating in the default of the Campeau Group in September 1989, and the collapses of the LDC debt market, first in August 1982 triggered by the Mexican default and more recently in August 1998 triggered by the Russian default.

[3] Dammon, Dunn and Spatt (1993) and Green and Rydqvist (1997) describe bond pricing anomalies that may be attributed at least in part to irrational investors.

Perps are floating rate notes (FRNs) of infinite maturity, bearing a coupon indexed to a benchmark rate (usually the London Inter-Bank Offered Rate, LIBOR) and re-set at fixed intervals (usually every three or six months). The first perp was issued in 1984 by National Westminster Bank (NatWest), one of the four British clearing banks. Issuers of perps generally had very high credit ratings and perps were traded in well-organized markets by sophisticated investors, primarily banks and other institutions. The market for perps grew rapidly and the volume of perps outstanding reached $22 billion by the end of 1986. Perps traded at close to par value in the secondary market, which was highly liquid until it began to collapse precipitously in December 1986. Secondary market prices experienced drops ranging from 12-25%, and trading volume dried up for all perp issues. While the majority of the perps issued during the 1984-1986 period remain outstanding, the secondary market has not recovered.

We develop a model that emphasizes beliefs about the liquidity of the secondary market to explain market collapses such as the perps collapse, where future cash flows are not in doubt and information is shared symmetrically across all market participants. Central to our model is a simple Walrasian batch market in which risk-averse investors are symmetrically informed and trade only in response to personalized liquidity shocks. Trading is facilitated by risk-neutral market makers who contract a bid-ask price spread with investors to recover their costs of offering the market. In some states of nature, liquidity shocks are common or systemic, i.e. perfectly correlated across investors, preventing them from mutualizing their liquidity shocks by trading, and causing losses to market makers.[4] Thus, the decision by market makers to offer the market depends on their assessment of systemic liquidity risk, which in turn determines current

[4] Several recent studies have documented common factors in liquidity, including Chordia, Roll and Subrahmanyam (2000), Lo and Wang (2000), Hasbrouck and Seppi (2001), and Pástor and Stambaugh (2003). However, the potential for commonality in liquidity to cause market collapse has not been rigorously explored in the literature.

expectations about future market liquidity and the extent to which liquidity is factored into asset prices. Markets can collapse when common liquidity shocks trigger changes in beliefs about future liquidity, and the collapse can be permanent when the revised assessment of systemic liquidity risk exceeds an acceptable threshold.

As Kindleberger (1978) has noted, a market collapse is often viewed as the bursting of a bubble in which asset prices have diverged significantly above their fundamental values. Allen and Gale (2000) review a variety of models that can explain how bubbles can develop even with rational investors, and present their own theory, which relies on imperfect information and an agency problem that leads investors to bid up asset prices far above what they would be willing to pay if they were fully exposed to all potential losses. Our model does not depend on imperfect information regarding the fundamentals that determine asset prices, nor does it rely on agency problems.

Of course, markets can collapse even in the absence of a pronounced bubble in asset prices. Such market collapses can be explained by a worsening of information asymmetry about asset price fundamentals across market participants as in Glosten and Milgrom (1985), Glosten (1989), or Bhattacharya and Spiegel (1991). In these models, uninformed investors withdraw from the market for fear of being taken advantage of by better-informed market participants. The withdrawal of uninformed investors reduces demand for the asset and causes prices to fall. We achieve a comparable result in our model without assuming that information regarding asset-pricing fundamentals is asymmetrically distributed across investors.[5] This difference has important implications about how a crisis can be resolved. If the collapse is caused by an exacerbation of asymmetric information, it can be resolved by alleviating the information

[5] However, the implications of our model are similar to Glosten (1989) in that reducing competition will reduce the

asymmetry. If the collapse is caused by a common liquidity shock, however, prices will rebound only if market participants believe that the risk of a recurrence of such shocks is small. Hong and Stein (2002) develop a model in which investors form different opinions about fundamental value based on private information signals, but the information of pessimistic investors does not initially enter the market due to short-sale constraints. The continued lack of participation ("price support") by pessimistic investors even after a market decline due to negative information received by optimistic investors can cause a market collapse that is seemingly out of proportion to the observed news event. In contrast, our model does not depend on information asymmetry or short-sale constraints.

We define a "liquid market" as a market where participants can execute large transactions at short notice with minimal impact on the price. An asset will be liquid if it is traded in a liquid market.[6] Generally, the liquidity of a secondary market depends on its depth, breadth and resiliency as well as its organizational structure and the reliability of clearing and settlement arrangements. Liquidity in our model, as in Diamond and Dybvig (1983), is a characteristic determined by the diversity of liquidity needs among investors who hold the asset. In our model, market participants form beliefs about future liquidity by observing past trading, and these liquidity beliefs in turn determine their valuation of the asset. Since liquid assets are more easily marketable, they will be priced at a premium to illiquid assets. We define the price differential between liquid and illiquid assets as the "marketability premium".[7]

---

susceptibility of market makers to systemic liquidity shocks.

[6] Of course, even in the absence of a liquid market, high-quality short-term securities are regarded as liquid due to their imminent cash settlement.

[7] Amihud and Mendelson (1986), Boudoukh and Whitelaw (1993) and Longstaff (1995, 2001) develop models in which liquidity is priced. Studies by Amihud and Mendelson (1991), Warga (1992), Kamara (1994) and Krishnamurthy (2002) have empirically documented price differences across treasury securities that are attributable to their liquidity differences.

Like Romer (1993) and Hong and Stein (2002), we assume that trading can reveal information that affects asset prices, but the information in these models is about asset fundamentals. In contrast, we focus on the information generated by the trading process about the potential liquidity demands of market participants, especially the extent to which these demands are correlated.

We explain the availability of markets, the cost of transacting in them, asset prices, and trading volume as the outcome of the demand for liquidity by individual market participants and their beliefs about the future availability of a liquid secondary market. This extends the work of Amihud and Mendelson (1986) and Brennan and Subrahmanyam (1996), who relate asset prices to transactions costs and other liquidity measures. While the behavior of market participants that precipitates market collapse in our model can be characterized as herding (Scharfstein and Stein (1990), Bikhchandani, Hirshleifer and Welch (1992) and Banerjee (1992)), in our model market participants collectively update their beliefs about future market liquidity by observing past market behavior, in contrast to the existing literature where herding occurs when one set of individuals learns sequentially from another.

The rest of the paper is organized as follows. In Section 1, we discuss the rise and fall of the market for perps. In Section 2, we develop our basic theoretical model, which relates asset prices to the liquidity of the secondary market. In Section 3, we examine how investor beliefs about future market liquidity can be formed by observing past states of the market, and how changes in these beliefs can lead to shifts in market liquidity. In Section 4, we discuss potential alternate explanations for the collapse of the perp market, and provide a brief postscript on attempts to restore liquidity to the market. Section 5 provides some concluding observations.

1. The Rise and Fall of the Perp Market

The perp market was launched in April 1984 with an inaugural issue by NatWest, and perps were quickly hailed as a successful financial innovation.[8] In this section, we examine the rise and fall of the perp market, and link its initial success to the growth of investor confidence about the liquidity of the secondary market for perps, and its collapse to a common liquidity shock that substantially increased expectations of the reoccurrence of a common liquidity shock and led market makers to abandon the market permanently.

1.1 The rise

Floating Rate Notes (FRNs), both dated and perpetual, have particular investor appeal when interest rates are expected to be volatile because the principal value of the FRN is likely to be much more stable than that of a conventional, fixed-rate bond of identical maturity. Indeed, if the borrower's relative credit standing (as reflected in the spread over the benchmark rate) has not changed since issuance, the FRN will normally be repriced at par on the day the coupon is reset.

Issuance of perps was especially attractive to banks that were experiencing pressures to increase their regulatory capital during the mid-eighties and saw perps as being well suited for this purpose because interest payments on perps, unlike dividends on preferred stock, could be deducted in computing taxable income.[9] Banks sought permission to count issuance of perps as

---

[8] Citicorp is often credited with having issued the first perp in 1980. But, since this issue gave investor the right to put the perp to Citicorp in March or October at each coupon reset date, the instrument effectively had a fixed, if indefinite, maturity that could be determined by the investor and traded accordingly. This issue is better regarded as a quasi-perp.

[9] All issues of perps include a provision that allows the borrower to automatically call the perp if the tax authorities disallow the deductibility of the interest paid on perps as a business expense. US banks were very late in entering the market because there was a presumption that the Internal Revenue Service (IRS) would construe the interest paid

capital for regulatory purposes. The Bank of England (Britain's central bank) did not permit the first issue of perps by NatWest to qualify as regulatory capital. But, in rejecting this request, the Bank of England set conditions under which a perp could be counted as regulatory capital.[10] Regulators in several other countries followed the Bank of England's lead so that issuance of perps became a feasible solution to the perceived need to increase regulatory capital.[11]

The challenge in marketing perps was to convince prospective investors that perps were close substitutes for fixed-maturity, floating-rate notes and money market instruments. Underwriters argued that the floating-rate feature made the interest-rate risk on perps equivalent to that on any other floating rate instrument. Moreover, they addressed concerns about the infinite maturity of perps by arguing that they could be sold any time at a price close to par in a broad, deep secondary market. Investor confidence in the liquidity of the secondary market was thus key to pricing perps in line with money market and other finite-maturity, floating-rate instruments of comparable quality. The initial rapid growth of issues suggests that underwriters were increasingly successful in this regard.

---

on perps as the equivalent of dividends and therefore not tax-deductible. Just before the market collapsed, Goldman Sachs introduced a perp structure for Citibank that seemed likely to gain a favorable ruling from the IRS. This involved giving investors the right to put the security back to Citibank after a specified period so that the perp was, for all practical purposes, equivalent to a long-dated FRN that had received a favorable ruling from the IRS.

[10] The critical requirement was that perps must be automatically converted into preferred stock in the event of default with the number of preferred stock shares equal to the principal amount of the perp plus all arrears of interest and all interest accrued. Most perps were dollar-denominated and so the Bank of England also required that, in the event of a default by a British issuer, the dollar amount should be converted into pounds at the prevailing exchange rate. In effect, investors who had dollar-denominated debt would end up with pound-sterling-denominated preferred shares.

[11] Following the Bank of England, several other central banks—including those in Australia, Canada, France and the United States —established conditions under which perps could be counted as capital for regulatory purposes. Many of these conditions were less favorable to the investor than those established by the Bank of England. The Japanese authorities were about to authorize the use of perps to meet capital requirements when the market began to collapse in December 1986.

Banks, especially Japanese banks, were eager to invest in floating-rate, dollar-denominated instruments during the eighties, became the main buyers of perps.[12] They found perps an attractive way to increase returns over interbank placements (which yielded LIBOR or less) at what appeared to be little additional risk.

From 1984 to the end of 1986 the spread over LIBOR steadily declined, indicating an increasing marketability premium as investors gained confidence in the liquidity of the secondary market, coupled with strong demand. The first perps were priced at margins over LIBOR that were as much as 20-25 basis points higher than comparable FRNs; but, by mid-1986, the margin had declined to around 10-15 basis points. Figure 1 illustrates this rising confidence in the marketability of perps as reflected in the secondary market price on an issue by Barclays Overseas Investment BV, one of the earliest issues of perps. We will argue from a theoretical standpoint that as investors grew more confident in the liquidity of the secondary market, their subjective probability of a systemic liquidity shock declined and the marketability premium increased, thus reducing the yield spreads attached to perps. It is also possible that increased competition among market makers drove down bid-ask spreads, further increasing liquidity and the marketability premium. The spread relative to the LIBOR benchmark seemed sufficiently attractive to induce some governments, such as the Kingdoms of Belgium, Denmark and Sweden, to issue perps, although they had no tax or regulatory incentive to do so. Other quasi-government issuers included the World Bank and Hydro-Quebec. The volume of perps outstanding stood at $3.5 billion by the end of 1984, $16 billion by the end of 1985, and $22 billion by the end of 1986, accounting for 29% and 46%, respectively, of total FRN issuance in

[12] Market observers estimate that as much as 80% of the perps outstanding were placed with Japanese financial institutions. Overall, banks held an estimated 90% of outstanding perps (IFR, December 6, 1986, p. 3633).

the latter two years (Meerschwam (1987)). Through 1986, nearly 60 perps were issued (Table 1 provides further details).

[Insert Figure 1 and Table 1 about here]

Transactions in the secondary market for perps were cleared and settled through Euroclear and CEDEL, the two principal systems for clearing Eurobonds, both of which are designed to accomplish simultaneous delivery of assets against payment (Kamata (1990)). This forestalled any potential investor concerns about "settlement risk"—the risk that a counterparty would not fulfill its settlement obligation or that the settlement mechanism would break down—and helped to sustain the confidence of investors in the liquidity of the secondary market.

The perp market was a dealer market, which maximized the potential for liquidity relative to other market structures. The market's liquidity increased steadily as evidenced by transactions costs and the size of the standard lot for which dealers would quote a price. By November 1986, more than fifty dealers stood ready to quote two-way prices for standard lots of $5 million at a 10 basis point spread (Williams and Hole (1987)). Although volume data for individual issues is not available, an indirect indication of volume can be inferred from the number of perp issues in the Euroclear listing of the twenty most actively traded money market issues each month. As Figure 2 indicates, perps were among the most actively traded money market instruments through the first quarter in 1987. Average aggregate daily volumes of as much as $1 billion were recorded by Euroclear during this period.

[Insert Figure 2 about here]

1.2 The collapse

The success of the perp market was short-lived. The proximate cause of the collapse in the market for perps appears to have been a rumor of an international agreement on bank capital requirements that would require banks to deduct holdings of perps (and other capital securities) issued by other banks in computing their capital for regulatory purposes.[13] Although the proposed regulations pertained only to British and American banks, the potential implications for banks in Japan were clear (Wagster (1996)). As one market participant observed, "The Ministry of Finance in Tokyo must eventually insist on similar provisioning, particularly if Japanese banks are allowed to offer perpetual debt themselves. That will just about kill off the market," (IFR, December 6, 1986, p. 3633).

Since the majority of perps were issued by banks, even the possibility of this kind of change in regulations provided a powerful incentive for banks holding perps to sell. That appears to have been what happened on Wednesday, December 3, 1986, when the rumor hit the market. Almost all of the core fifty dealers in the perp market were overwhelmed with sell orders and suspended normal trading. The rumored regulatory change produced a one-way market. It caused banks (that held most of the outstanding perps) to attempt to sell at the same time. In our model, we characterize this as a liquidity shock (an event changing the marginal valuation of

[13] The Basel Committee on Banking Regulation and Supervisory Practices (Basel Committee) was expected to take the view that the banking system would be more resilient, and the danger of contagion would be less, if nonbanks held capital claims on banks. The basis for this rumor was the proposed Anglo-American Accord on the assessment of capital adequacy. The proposed regulations were officially released in the United States on January 8, 1987, but major banks were well aware of the general outlines of the approach. The part of the proposal that was of particular relevance to the market for perps was the decision regarding bank holdings of other banks' capital instruments. The official release (Comptroller of the Currency, Federal Deposit Insurance Corporation and Federal Reserve Board, 1987, p.7) noted that the Bank of England already deducts such holdings from capital: "...except for limited concessions to allow some banks to play an active role in market-making in the primary (new issues) and/or secondary markets. This policy will be maintained. The U.S. authorities accept the principle underlying this policy and will monitor bank holdings of capital instruments issued by other banks and may, as appropriate, deduct these

perps) that affected most holders of perps in the same way at the same time. Although secondary market trading enables individuals to mutualize idiosyncratic liquidity shocks, the market mechanism breaks down when the shocks apply simultaneously in the same direction for all investors, and that is precisely what happened to the secondary market for perps.

As participants noted at the time, "We have seen the door slammed shut on the only way in which investors can really leave this market—trading liquidity.... The whole psychology of this market has now changed—it's never going to be the same again," (IFR, December 6, 1986, p. 3632). Another participant observed, "The liquidity myth has been exploded with perpetuals. We all now know that liquidity is only there when nobody wants to use it -- if everybody wants to pile out, then the market can't accommodate it," (IFR, December 6, 1986, p. 3632). Along the same lines, another market participant (IFR, January 10, 1987, p. 3) concluded, "The crisis is basically one of confidence, and perpetuals are undergoing a general re-evaluation of worth separate from any underlying change in the quality and credit of the debt involved and external influences such as interest rates."

Ironically, the rumor proved to be false, although market participants could not confirm this until the Basel Committee issued a Consultative Paper a year later, officially rejecting this unfavorable treatment of perps and other bank capital issues.[14] By then, however, the damage to investor confidence in market liquidity was irreparable. From Wednesday, December 3, 1986,

---

items on a case-by-case basis."

[14] The Committee's Consultative Paper of December 1987 (p.9) stated: "The Committee carefully considered the possibility of requiring deduction of banks' holdings of capital issued by other banks.... Several G-10 supervisory authorities currently require such a deduction to be made in order to discourage the banking system as a whole from creating cross-holdings of capital, rather than drawing capital from outside investors. The Committee is very conscious that such double-gearing (or "double-leveraging") can have systemic dangers for the banking system by making it more vulnerable to the rapid transmission of problems from one institution to another and some members consider these dangers justify a policy of full deduction of such holdings... Despite these concerns, however, the Committee as a whole is not presently in favor of a general policy of deducting all holdings of other banks' capital, on the grounds that to do so could impede certain significant and desirable changes taking place in the structure of domestic banking systems."

the secondary market began to collapse. Market makers withdrew from the market in anticipation of continuing losses. Typical dealer-to-dealer price spreads increased from 10 basis points to 50 basis points while at the same time standard lot sizes declined from $5 million to $1 million (Williams and Hole (1987)). The number of active market makers plummeted from 50 to fewer than 10 by March 1987, and these functioned mainly as brokers—trying to match buyers with sellers—rather than standing ready to buy or sell at a stated spread. After December 1986, only perps issued by the British clearing banks made the list of the twenty most active issues maintained by Euroclear. As illustrated in Figure 2, by May 1987, perps had dropped from the list altogether. In the absence of a liquid secondary market, the new issue market completely disappeared.

Secondary market prices fell sharply during this period.[15] Figure 3 plots the value from November 1984 through August 1988 of a price index of eleven perps issued by British Clearing Banks. The sudden collapse and lack of recovery of the secondary market is clearly evident.

[Insert Figure 3 about here]

The events of December 1986 had exposed the narrow investor base of the secondary market for perps. The episode made clear that the liquidity of the perp secondary market depended critically on confidence in the breadth of the market—on the belief that other investors would not change their portfolio preferences in the same way at the same time. When a liquidity shock affected all the bank holders of perps, the negative implications of the overwhelming concentration of perps in the hands of Japanese banks for the prospect of additional systemic liquidity shocks became all too evident.

[15] Issues by the World Bank and Citicorp that gave holders the option of putting the notes back to the issuer each quarter at par value did not experience such price declines.

In the next two sections, we develop our theoretical model to explain how common liquidity risk can give rise to market collapse despite symmetrically informed market participants and lack of uncertainty about future cash flows. While the model is motivated and illustrated by the perp collapse, we argue that it is applicable in any market setting characterized by a significant level of common liquidity risk.

2. The Basic Model

In this section, we develop our basic theoretical model and relate liquidity to asset prices by considering three cases that are differentiated by assumptions about the liquidity of the secondary market. In the first case, investors experience idiosyncratic liquidity shocks and the secondary market permits investors to mutualize their liquidity shocks by trading. The second case is identical to the first in all respects except that no secondary market is available. Comparing these two cases permits us to show how the liquidity of the secondary market affects asset prices. In the third case, investors experience a systemic liquidity shock. Since a systemic liquidity shock cannot be mutualized through trading, the secondary market will collapse resulting in a price that is identical to the second case in which there is no secondary market.

2.1 Liquidity shocks and trading

We model a two-period economy with a group of N risk averse investors who are identical at time 0. Each investor is endowed at time 0 with one unit of the single risky asset and one unit of the riskless asset. The risky asset pays off a random quantity of the numeraire riskless asset, $\tilde{v}$, at time 2, where $E(\tilde{v}) > 1$. All investors know that the return, $\tilde{v}$, is distributed normally with mean $\bar{v}$ and variance σ_v^2. The risk-free return is assumed to be zero. Investors

maximize negative exponential utility functions of their wealth at time 2, W_2:

$U(W_2) = -\exp(-aW_2)$, where $a \geq 0$ is the coefficient of risk aversion.

All investors experience identically distributed liquidity shocks at time 1, with the distribution of these shocks being known *ex ante* at time 0. In general, such shocks can arise due to a broad range of events that give rise to a change in the investor's valuation of the risky asset without new information about its fundamental payoff. In the literature, liquidity shocks have been most frequently motivated as arising from shocks to preferences as in Diamond and Dybvig (1983) or to endowments as in Glosten (1989) or Bhattacharya and Spiegel (1991). While such shocks will also give rise to changes in the investor's marginal valuation of the security, for ease of exposition, we shall follow the formulation of Michaely and Vila (1995) and Michaely, Vila and Wang (1996), and model such shocks as idiosyncratic tax or regulatory effects that change the way in which individual investors value a security even in the absence of new information regarding the cash flows associated with the security.[16] This approach fits the example of perps particularly well since the proximate cause of the collapse was a rumored regulatory change that would have effectively imposed a regulatory tax on some investors who held perps. We characterize this shock as a random additive increment, $\tilde{\theta}_i$, to the payoff $\tilde{v}$ of the risky asset to investor *i*. $\tilde{\theta}_i$ is also distributed normally with mean 0 and variance σ_θ^2, and is independent of $\tilde{v}$. As in Karpoff (1986), differences in personal valuation caused by these shocks induce trading when it is possible.

[16] Especially in the case of tax or regulatory changes, liquidity shocks can be viewed as personalized information shocks, since they are informative about the personalized payoff from the asset to each investor. As we show later, they are also informative about the manner in which investors will trade and value the asset. We thank Chester Spatt for this insight.

The correlation of liquidity shocks across investors is determined by the realization of one of two possible states, "idiosyncratic" or "systemic" which will be revealed at time 1. In the idiosyncratic state, liquidity shocks are independently distributed across investors. In the systemic state, liquidity shocks are perfectly correlated across all investors. The implications are quite straightforward. If the idiosyncratic state occurs, there is mutual benefit to trading at time 1 since shocks are uncorrelated. By trading, investors can mutualize the risk of the idiosyncratic liquidity shocks. But if shocks are perfectly correlated, investors are unable to mutualize their liquidity shocks by trading at time 1 and prices will simply adjust to reflect the shock, just as in a Milgrom-Stokey (1982) no-trade equilibrium. The secondary market will collapse.

We assume that trading at time 1 occurs in a Walrasian batch market in which all trades clear at the same price subject to a bid-ask spread. Trading is facilitated by M identical, competing, risk-neutral market makers each of whom incurs a fixed cost of C in setting up the market for each round of trade. To facilitate a closed-form solution, we do not model inventorying of securities by the market maker. Implicitly the costs of maintaining an inventory of securities are proxied by the fixed cost C of setting up the market. These costs are recovered by the bid-ask spread. In a no-trade equilibrium that accompanies a common liquidity shock, market makers lose the cost sunk into setting up the market.

All market participants use a Bayesian updating framework (developed in Section 3) to update their *ex ante* probability beliefs about the state of the market by observing past states. The market makers offer a market only if, *ex ante*, the (subjective) probability that an idiosyncratic state will prevail exceeds a cut-off level beyond which their expected profit is non-negative. If investors expect that the secondary market will be liquid at time 1, they will attach a value to being able to rebalance their portfolios optimally at time 1, based on what they learn at time 1

about their liquidity shocks. This value (marketability premium) will be reflected in the time 0 equilibrium price of the risky asset. For tractability, we assume that market makers set bid-ask spreads as follows:

$$P_{1i} = P_1 + \lambda \Delta X_{1i}\,, \tag{1}$$

where $\lambda > 0$ is determined by competition among market makers.[17] P_1 is the market-clearing price in the absence of transactions costs, ΔX_{1i} is the trade size of individual *i* and P_{1i} is the actual price paid or received by individual *i*.

2.2 Equilibrium at t = 1 and t = 0

With the transactions costs described in the preceding section, the investor's time 1 problem can be expressed as:

$$\underset{X_{1i}}{Max}\ E_1\left[-\exp\left\{-a\left[W_{1i} + X_{1i}(\tilde{v} + \hat{\theta}_i - P_1) - \lambda(X_{1i} - X_{0i})^2\right]\right\}\right] \tag{2}$$

where $\hat{\theta}_i$ is the liquidity shock realized by investor *i*. We consider three cases in turn.

2.2.1 Case 1: Idiosyncratic liquidity shocks and a liquid secondary market at t = 1

This would be the case of perfect investor heterogeneity (maximum market breadth for given *N*), where each investor's liquidity need is uncorrelated with the liquidity needs of the other investors. In this case, the equilibrium price at time 1, P_1^1 becomes:

$$P_1^1 = \overline{v} + \hat{\theta}_A - a\sigma_v^2 \tag{3}$$

[17] The transactions cost structure that we are assuming here is equivalent to the structure in Kyle (1985), where λ is the inverse measure of market depth. However, the rationale is different in Kyle's model since λ is derived from his assumptions about information asymmetry.

where

$$\hat{\theta}_A = \sum_{i=1}^{N} \frac{\hat{\theta}_i}{N} \tag{4}$$

and the optimal portfolio adjustment of individual i, $\Delta X_{1i} = X_{1i} - X_{0i}$ will be:

$$\Delta X_{1i} = \frac{\hat{\theta}_i - \hat{\theta}_A + a\sigma_v^2(1 - X_{0i})}{a\sigma_v^2 + 2\lambda} \tag{5}$$

and the total volume of trade at time 1, Q_1, will be:

$$Q_1 = \frac{\sigma_\theta}{a\sigma_v^2 + 2\lambda}\sqrt{\frac{N(N-1)}{2\pi}} \tag{6}$$

While the cost of transacting does not affect P_1^1, it depresses the volume of trade. When λ becomes very large, Q_1 shrinks and the market effectively shuts down.

Noting that $\hat{\theta}_A \to 0$ as $N \to \infty$, we observe that a liquid secondary market enables investors to adjust to liquidity shocks at an equilibrium price which is not affected by the liquidity shocks. Such a market provides a valuable option to investors. Even if an investor does not plan to sell the asset before maturity, the investor's future portfolio allocation preferences are inevitably subject to uncertainty and so the opportunity to sell the claim in a liquid secondary market enhances the investor's willingness to buy the claim in the primary market. We examine next how this is reflected in the time 0 price.

The investor's time 0 problem reduces to:

$$\underset{X_{0i}}{Max}\ E_0\left[-\exp\left\{-a\left[W_{0i} + X_{0i}(\tilde{P}_1 - P_0) + \tilde{X}_{1i}(\tilde{v} + \tilde{\theta}_i - \tilde{P}_1) - \lambda(\tilde{X}_{1i} - X_{0i})^2\right]\right\}\right] \tag{7}$$

yielding the time 0 equilibrium price, P_0^1:

$$P_0^1 = \bar{v} - a\sigma_v^2 - a\frac{\sigma_\theta^2}{N} - \frac{2\lambda}{\left[a\sigma_v^2 + 2\lambda + a\sigma_\theta^2\left(\frac{N-1}{N}\right)\right]} a\sigma_\theta^2\left(\frac{N-1}{N}\right) \tag{8}$$

As $\lambda \to 0$ and $N \to \infty$, $P_0^1 \to \bar{v} - a\sigma_v^2$. Given idiosyncratic liquidity shocks, N becomes a measure of market breadth. Hence, with frictionless trading and an infinitely broad market, investors will no longer price the risk of their idiosyncratic liquidity shocks, since this risk can be perfectly mutualized by trading.

Total expected market maker revenue, R^1, will be given by:

$$R^1 = E\sum_{i=1}^{N} \lambda(\Delta\tilde{X}_{1i})^2 = \frac{\lambda\sigma_\theta^2(N-1)}{(a\sigma_v^2 + 2\lambda)^2} \tag{9}$$

2.2.2 Case 2: Idiosyncratic liquidity shocks with no secondary market at t = 1

In contrast to the previous case, investors do not expect to be able to satisfy their liquidity needs at time 1 because there is no secondary market. Since there is no portfolio rebalancing at time 1, the investor's time 0 problem reduces to:

$$\underset{X_{0i}}{Max}\ E_0\left[-\exp\left\{-a\left[W_{0i} + X_{0i}(\tilde{v} + \tilde{\theta}_i - P_0)\right]\right\}\right] \tag{10}$$

yielding the time 0 equilibrium price, P_0^2:

$$P_0^2 = \bar{v} - a\sigma_v^2 - a\sigma_\theta^2. \tag{11}$$

In contrast to the case when the market is liquid at time 1, the risk of a liquidity shock at time 1 is fully discounted in P_0^2 because there is no possibility for investors to mutualize these shocks by trading.[18]

[18] Note that even in the previous case, it follows from (8) that the same result obtains in the limit when $\lambda \to \infty$. When transactions costs become very high, the secondary market shuts down.

Since there is no difference in the fundamental determinants of the price of the risky asset between Cases 1 and 2, the price differential between the two cases is entirely determined by the absence of the secondary market in Case 2. The price differential Φ, the marketability premium, is:

$$\Phi = P_0^1 - P_0^2 = \frac{a\sigma_\theta^2(N-1)}{N}\left[1 - \frac{2\lambda}{a\sigma_v^2 + 2\lambda + a\sigma_\theta^2\left(\frac{N-1}{N}\right)}\right] \geq 0 \tag{12}$$

Given idiosyncratic liquidity shocks, we can infer that the liquidity-driven price differential Φ is higher, the greater the demand for liquidity (as measured by the volatility of liquidity shocks σ_θ^2), the greater the market breadth (as measured by the number of investors *N*) and the lower the transactions costs. Note that the latter, which is parameterized by λ, will be minimized by the competition among market makers. Given a level of liquidity demand, λ provides a measure of the degree of liquidity supplied to the market by the market makers. In the limiting case of $\lambda \rightarrow 0$ and $N \rightarrow \infty$ that we considered previously, Φ will converge to $a\sigma_\theta^2$. At the opposite end of the liquidity spectrum, the case of $\lambda \rightarrow \infty$, Φ will converge to 0. Thus, the marketability premium, Φ, will be bounded by $0 \leq \Phi \leq a\sigma_\theta^2$, and the value of Φ will reflect the *degree* of marketability.

2.2.3 Case 3: Systemic liquidity shocks causing an illiquid secondary market at t = 1

In this case, the investor's situation will be identical to the previous case in which there was no secondary market. Since investors expect to experience the same liquidity shock at time 1, they will have no opportunity to mutualize these shocks by trading. Thus, the secondary market will break down and the price will adjust without trade as in Milgrom and Stokey (1982).

The risk of liquidity shocks will again be fully discounted in the time 0 equilibrium price. Hence, the time 0 price in this case, P_0^3, will be equal to the time 0 price in Case 2, P_0^2. Obviously, both trading volume and market maker revenue will be zero in Cases 2 and 3.

2.3 Transition from a liquid to an illiquid secondary market

It is clear from the above analysis that if the secondary market collapses, the security will experience a price decline of $\Phi \geq 0$ reflecting the elimination of the marketability premium. This is consistent with the price drop observed in the perp market. Moreover, as we will discuss later, the price drop experienced by perps is consistent with the price differentials between liquid and illiquid securities in other markets.

The analysis of the three cases in this section proceeded on the assumption that market participants had perfect foresight about the liquidity of the secondary market, and rationally incorporated their beliefs in asset prices. Furthermore, the decision by market makers to open or close the secondary market was assumed to be exogenous to the model. Next, we focus on the question of how market participants form beliefs about future market liquidity, and how this process can lead to an endogenous shift in the liquidity of the secondary market that affects asset prices.

3. Beliefs about Liquidity

In this section we extend our theoretical framework to examine how beliefs about liquidity in the secondary market evolve and change, drawing on the literature on herding and informational cascades (Scharfstein and Stein (1990), Bikhchandani, Hirshleifer and Welch

(1992) and Banerjee (1992)) as well as the literature on market breakdowns in the presence of asymmetric information (Glosten and Milgrom (1985) and Bhattacharya and Spiegel (1991)).

Informational cascades occur when individuals deduce the information of preceding market participants sequentially by observing their behavior. Similarly, in our model individuals deduce the degree of liquidity of the secondary market by observing past states of the secondary market. As we demonstrate, when the true probability of a systemic liquidity shock is low, a continued sequence of experiences with a liquid secondary market can cause market participants to underestimate the probability of a systemic liquidity shock. In our model, market participants update their beliefs in Bayesian fashion, so that their subjective probability of a systemic liquidity shock progressively diminishes as the sequence of periods without a systemic liquidity shock continues. This can cause security prices to deviate from the level that reflects the true probability of a systemic liquidity shock. A reevaluation occurs only when market participants experience a liquidity shock that turns out to be systemic.

3.1 Bayesian updating framework

Market makers offer markets at time 1 and investors value the risky asset at time 0 based on their subjective (uniform across all market participants) probability estimate of the occurrence of the state in which liquidity shocks are systemic (*illiquid* state). At the outset, we assume that the subjective probability estimate of the *illiquid* state is low enough for market makers to open the secondary market. The indicator $\chi_t = 1$ if the illiquid state occurs and 0 otherwise.

Market participants form a subjective probability estimate of the occurrence of the illiquid state by observing a sequence of prior market states. We denote the probability of the illiquid state as π, which corresponds to the proportion of states in the sequence that turns out to

be illiquid. The prior probability density function of π is assumed to be a beta distribution with parameters $\alpha > 0$ and $\beta > 0$:[19]

$$f(\pi|\alpha,\beta) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)}\pi^{\alpha-1}(1-\pi)^{\beta-1}, \quad 0 \le \pi \le 1 \tag{13}$$

and has an unconditional expected value of:

$$E(\pi) = \frac{\alpha}{\alpha+\beta} \tag{14}$$

α and β are chosen appropriately based on the available prior information about π. As shown by DeGroot (1970), the posterior probability distribution after observing a sequence of $n + 1$ states is also a beta distribution with parameters $\alpha' = \alpha + y$; and $\beta' = \beta + n - y$:

$$g(\pi \mid \chi_{t-n-1},\ldots,\chi_{t-1}) = \frac{\Gamma(\alpha'+\beta')}{\Gamma(\alpha')\Gamma(\beta')}\pi^{\alpha'-1}(1-\pi)^{\beta'-1} \tag{15}$$

where y is the total number of illiquid states observed in this sequence.

Consequently, we assume that market participants form their subjective probability beliefs as follows:

1. If the preceding $n + 1$ events are liquid states, the subjective probability assessment after observing $n + 1$ liquid states will be:

$$E\left[\pi \,\middle|\, \sum_{\tau=t-n-1}^{t-1} \chi_t = 0\right] = \frac{\alpha}{\alpha+\beta+n} \tag{16}$$

   As n increases, the subjective probability of an illiquid state goes to zero.

2. If the immediately preceding event is an illiquid state, then a new sequence of observations begins and the market participants form their subjective probability assessment using the posterior probability distribution, as follows:

[19] The beta distribution is widely used to represent distributions of variables that naturally lie between 0 and 1, such

$$E(\pi \,|\, \chi_{t-1} = 1) = \frac{\alpha + 1}{\alpha + \beta} \tag{17}$$

Note that:

$$\frac{\alpha}{\alpha + \beta + n} < \frac{\alpha}{\alpha + \beta} < \frac{\alpha + 1}{\alpha + \beta} \tag{18}$$

This means that as the number of periods (n) without a systemic shock increases, the subjective probability of a systemic liquidity shock will continue to decline relative to the unconditional probability of such a shock. The occurrence of a systemic liquidity shock will cause market participants to overestimate initially the probability that a systemic liquidity shock will reoccur. But, if the secondary market reopens, as the number of periods without an additional systemic liquidity shock increases, the subjective probability of a systemic liquidity shock will again decline, ultimately falling below the unconditional probability. This shift in subjective probability of a systemic liquidity shock is the critical determinant of whether market makers will open the secondary market.

3.2 Liquidity shifts

Given the market set-up costs (C), the number of market makers (M), the total expected market maker revenue derived in (9), and the assumption that bid-ask spreads are set competitively such that the market makers' expected profits will be zero, we show in the appendix that the necessary condition for a market to be offered is:

$$\frac{(1-\xi)\,\sigma_\theta^2 (N-1)}{8\,a\sigma_v^2\, MC} \geq 1 \tag{19}$$

---

as proportions and probability estimates. See DeGroot (1970), Zellner (1971), and Guttentag and Herring (1984).

where ξ is the *ex ante* subjective probability attached by the market makers to a systemic liquidity shock. For a given value of λ, dealers are more likely to make a secondary market (the left-hand-side of (19) is more likely to exceed one), the lower the subjective probability of a systemic liquidity shock (ξ), the lower the fixed costs of making a market (C), and the lower the number of market-makers (M). As in Glosten (1989), increases in the number of competitive market makers may render the secondary market more vulnerable to collapse. In Glosten's model the result is driven by the reduction in the ability of market makers to withstand losses to informed traders when competition reduces their profits. In our model, the result is drive by the reduction in the ability of market makers to withstand a systemic liquidity shock.

Equation (19) defines a threshold level of the subjective probability of a systemic liquidity shock above which dealers will not be willing to make a secondary market because they do not expect it to be profitable. The threshold level is the value of ξ that equates the left-hand-side of (19) to one. Whether the secondary market is reopened after a systemic liquidity shock depends on the unconditional probability $E(\pi)$ of a systemic liquidity shock. It follows from (18) that prior to the first occurrence of a systemic liquidity shock, the *ex ante* subjective probability of a systemic liquidity shock (ξ) will fall below $E(\pi)$. But after the occurrence of a systemic liquidity shock ξ will rise above $E(\pi)$. If $E(\pi)$ is sufficiently high, ξ may rise above the threshold level at which market makers can expect to earn non-negative profits. As a result, they will not reopen the secondary market. In contrast, when the unconditional probability of a systemic liquidity shock is sufficiently low, even though ξ rises above $E(\pi)$, market makers will expect to earn non-negative profits and so they will reopen the secondary market.

Our theoretical framework thus shows how the availability of a secondary market can give rise to a marketability premium and how this marketability premium can grow as investors

gain confidence in the liquidity of the secondary market.[20] As illustrated in Figure 1, this is consistent with our observations from the perp market. We also show how this confidence can collapse in the event of a systemic liquidity shock, leading to either transitory or permanent illiquidity in the secondary market depending on how the expectations of market participants are changed by the systemic liquidity shock.

More broadly, Davis (1989) and Guttentag and Herring (1984) have shown that innovative financial instruments may be particularly subject to disaster myopia because the empirical record for judging how they will perform over a variety of conditions is very limited and those who market a new instrument have an incentive to emphasize the robustness of its features. The consequence is that buyers often have a very imperfect *a priori* understanding of the attributes of a new instrument. It is not unusual for buyers of new instruments to extrapolate favorable performance into the future.[21] Because the secondary market in perps was well organized, with low transaction costs and more that fifty dealers providing immediacy by standing willing to buy or sell perps at stated prices, it must have been tempting to dismiss the probability of a market collapse as inconsequential.

Our model describes how systemic liquidity risk can cause a market collapse despite lack of any information asymmetry across market participants or a significant deviation of asset prices from their fundamental value. While we argue that the model is consistent with the perp collapse and has relevance for other markets where narrow ownership or other factors increase systemic liquidity risk, it is nonetheless useful to consider whether other explanations are

[20] The marketability premium grows with increasing confidence about liquidity since λ declines as market makers lower their estimate of ξ.

[21] This normal tendency toward disaster myopia was undoubtedly exacerbated by the general inexperience of many market participants. One senior banker admitted that, "When I look around the trading areas of my bank, and realize that most of the dealers are well under 30 years of age, and have never been exposed to a consistent bear market, I realize that this is probably the greatest single area of exposure I have," (IFR, December 6, 1986, p. 3653).

applicable as well. We turn to this question in the next section, drawing from the available evidence on the performance of the perp market especially following the collapse.

4. Alternative Explanations and a Postscript on the Perp Market

What other hypotheses might explain the collapse of the market for perpetual floating rate notes? We consider some plausible alternative explanations (including the applicability of the theoretical market collapse hypotheses discussed previously in the paper) while highlighting the relevant evidence from the perp market.

4.1 Was there a decline in credit quality?

Was the collapse of the market for perps driven by a credit shock rather than a liquidity shock? Was there a credible reason to expect an imminent decline in credit quality? For example, did the rumored tightening of capital adequacy requirements cause investors to fear that more banks would have trouble meeting minimum capital standards and thus default on their perps? While it is true that increases in credit risk can be expected to have a greater impact on the prices of financial instruments that have no final maturity than on finite maturity instruments, this hypothesis is not consistent with the available evidence. Figure 4 shows the price behavior of three obligations of National Westminster Bank (NatWest), one of the four British clearing banks: a perp (indeed, the first perp issued), preference shares (which were subordinate to the perp), and a long-dated floating rate note (FRN). After trading steadily at its par value, the price of the NatWest perp shows a sudden decline, which coincided with the collapse of the perp market. Clearly, this collapse cannot be attributed to a decline in the creditworthiness of NatWest

since the prices of its long-dated FRNs and preference shares held steady while the prices of its perps dropped.

[Insert Figure 4 about here]

Overall, the high credit quality of perps makes the credit decline hypothesis less plausible. The perp price index whose movement is depicted in Figure 3 is for perps issued by the four British clearing banks: NatWest, Barclays, Lloyds and Midland. These perps are rated at least "Aa" by Moody's and at least "A" by Standard & Poor's. We have not detected any change in these ratings either immediately preceding or following the market collapse.

The refutation of the rumor notwithstanding, it is possible that the market may have factored in a higher probability of future adverse regulation. However, there has been no such development in the 15 years following the collapse.

Ultimately, even if there was a reason for investors to factor in a lower credit quality, this should not have precluded them from trading. This is not what has happened. Although 47 perps remain outstanding, the loss of liquidity appears to be permanent.

4.2 Was there a price bubble?

Were the perps overpriced relative to their fundamental value prior to the collapse? From a theoretical standpoint, it is possible that perps were more susceptible to mispricing than securities that have a finite maturity.[22] Since all the perps were issued at par in the primary market and continued to trade at par in the secondary market, such mispricing, if any, had to have persisted from the outset.

[22] See Camerer (1989) for a review of the literature.

Perps were priced in the primary market relative to dated FRNs, initially at annual spreads of 20-25 basis points, but since both securities had the same duration (3 to 6 months depending on the coupon reset interval) and the same initial liquidity, the price differential presumably compensated investors for the higher holding period credit risk of perps. After the collapse, the annual yield differential increased by approximately an order of magnitude to around 200-250 basis points. A spread of this magnitude seems unrealistic for dated and perpetual securities of comparable credit quality. This seems to be confirmed by the fact that primary issuance of perps came to a halt following the collapse. Moreover, even if this higher spread was deemed reasonable by investors, we would have expected to see the market remain liquid at the lower prices. As noted previously, this did not happen. It seems more plausible that the higher yield spread following the collapse was compensation for the lack of liquidity in the market, as predicted by our model.

4.3 Was there information asymmetry?

It is possible that there was information asymmetry pertaining to perp fundamentals across different market participants. The theoretical literature reviewed previously (Glosten & Milgrom (1985), Glosten (1989), Bhattacharya & Spiegel (1991), and Hong and Stein (2002)) predicts that such information asymmetry can give rise to a market collapse. However, in the case of perps, there has been no significant information arriving in the market in the 15 years following the collapse (either pertaining directly to perp cash flows, or indirectly about regulation of the perp market) which would suggest that some perp market participants had information that others did not have prior to the collapse.

The theories of market collapse based on information asymmetry would predict a revival of liquidity when all the information privately held by investors is eventually reflected in prices. This has not happened in the perp market.

4.4 Was there a clientele effect?

Did the perp collapse reveal the presence of a clientele effect in the perp market where perps were substantially more attractive to one group of investors (in this case possibly the banks) than to investors at large?[23] If so, was the collapse triggered by the removal of this clientele effect (for example, due to removal of an implicit regulatory subsidy), causing the perps to become substantially less attractive to the preferred investor clientele? Were banks a preferred investor clientele in this market?

While banks were the dominant investors in this market, however, any potential regulatory subsidies (for example, the benefit of increasing regulatory capital by issuing perps) accrue only to bank issuers, not bank investors. We have not found any evidence of a benefit from holding perps that accrues exclusively to bank investors.

While there were some non-bank investors, this discussion does not address the question of why more non-bank investors did not enter the market to take advantage of the substantially lower prices. We defer this discussion to Section 4.6 where we discuss the broader question of why the market did not recover.

4.5 Was there an expected loss of a regulatory arbitrage opportunity?

Closely associated with the possibility of a clientele effect is the question of whether the collapse of the market for perps was simply the consequence of the anticipated removal of an

[23] We thank Chester Spatt for suggesting this hypothesis, and Larry Harris for further insights on this point.

opportunity for regulatory arbitrage (an implicit regulatory subsidy) that results when banks are permitted to hold reciprocal capital obligations on each other. This hypothesis also fails to fit the evidence. Japanese banks, which accounted for most of the holdings of perps, did not issue perps in this era and so they were not beneficiaries of an implicit regulatory subsidy. They were, of course, concerned about the imposition of an implicit regulatory tax on their holdings of perps and this led them to attempt to sell. It is true, however, that regulatory factors have inhibited the restoration of liquidity in the market by restraining the supply of perps at prices below par. We discuss this more fully in the next subsection.

4.6 Why didn't the perp market recover its liquidity?

After the collapse, why didn't nonbanks (who, even if the rumor had proved to be true, would not be penalized by the regulators for holding perps) buy the bank holdings of perps? Why didn't the market quickly equilibrate at a new lower price that would compensate investors for higher perceived risk with higher yields? Prices did fall, but the volume of trading activity never recovered. Ironically, the fundamental problem standing in the way of a recovery was also the lack of breadth in the market. The Japanese regulatory authorities permitted Japanese banks (which held the vast majority of perps) to defer recognition of the capital loss until the perps were sold. Market makers and other potential market participants believed that any rise in the prices of perps would be swiftly met by sales of perps by Japanese banks and so they were unwilling to buy. But, so long as perps traded below par, Japanese banks, which were under international pressure to increase regulatory capital, were not eager to sell below par and realize a capital loss, particularly since the stream of cash flows from perps was never in doubt. If Japanese banks had been obliged to mark their holdings to market, it is likely that the volume of

trading would have increased, albeit at lower initial prices, and perps would have been redistributed to a broader range of investors, thereby paving the way for a restoration of liquidity.

The collapse of the secondary market for perps caused a sharp decline in prices of 12% to 25% due to the collapse of the marketability premium. Although indicative prices continue to be reported for most outstanding issues of perps, they reflect sporadic transactions that are negotiated between the buyer and seller and not prices at which dealers are prepared to trade. As such, they are consistent with the discount applied to assets in other illiquid markets. For example, they are the same order of magnitude as the discount applied to letter stock reported by the SEC (1971), Pratt (1989), and Silber (1991) with regard to letter stocks.[24] Using the midpoints of the discount range for letter stocks relative to their freely traded counterparts, Pratt found that the discount was 25.8%. The SEC study found that most letter stock transactions were at a discount of 10% to 30% of the analogous securities traded freely on the public exchanges. Silber (1991) reports that letter stock are typically placed at discounts of 30% to 35% to the value of otherwise identical traded securities.[25]

Why didn't issuers of perps simply buy up the outstanding issues at discount prices in the secondary market? The Japanese banks that held most perps on their books at par have been unwilling to sell at a loss. Over the years 12 perps have been called for a variety of reasons (see Table 1), in each case at par value. In some cases regulations changed so that the outstanding

[24] Pratt (1989) notes that "A letter stock is identical in all respects to the freely traded stock of a public company except that it is restricted from trading on the stock exchanges for a certain period" and reports comparisons of the value of such letter stocks to their freely traded counterparts. Publicly traded corporations issue letter stock frequently in making acquisitions or raising capital when the time and cost of registering the new stock with the SEC would make the transaction impractical. Even though such stock cannot be sold to the public on the open market, it may be sold in private transactions under certain circumstances. Such transactions must be reported to the SEC where they become a matter of public record (Pratt, 1989, p.240).

[25] Koeplin, Sarin and Shapiro (2000) caution, however, that the entire discount cannot be attributed to illiquidity.

issue no longer qualified as regulatory capital. In other cases, banks simply found cheaper sources of funds.

Several attempts have been made to restore liquidity to perps (and arbitrage the price spread between perps and dated FRNs) by repackaging the promised cash flows as instruments with fixed maturities (Meerschwam (1987)). The basic idea was to add a high quality zero-coupon bond (an instrument that was *all* principal repayment with *no* interest payments) to the perp (an instrument with *only* interest payments and *no* principal repayment) to create a synthetic, dated FRN that would appeal to a broader range of investors. These efforts have met with limited success, ironically for the same reason that keeps the market illiquid in the first place: the unwillingness of Japanese banks to recognize a loss by exchanging their perps at below par value. The price differential between illiquid perps and liquid dated-FRNs seems to fully reflect the cost of arbitraging the price differential, in a manner similar to on and off-the-run treasury bonds (Krishnamurthy (2002)).

The perp episode emphasizes the importance of market breadth in establishing and maintaining liquid secondary markets. Market breadth can be achieved by placing the security with a broad range of investors during the initial public offering. From 1984 until December 1986, the secondary market became very liquid despite its narrow investor base. But the liquidity of the secondary market proved to be temporary. Once a systemic liquidity shock revealed the lack of breadth, the secondary market could not recover. Although it is still possible to have liquidity shocks that affect all investors in the same way at the same time with a heterogeneous investor base, they are likely to be transitory since investors' idiosyncratic liquidity shocks are likely to predominate most of the time and investors can expect to mutualize

their idiosyncratic shocks by trading in the secondary market. The marketability premium may fall briefly, but it is likely to be restored relatively rapidly.

5. Concluding Remarks

We have provided new insights into why markets collapse. As we have shown, markets can collapse even in the absence of the two conditions that are thought in the literature to give rise to a collapse: the bursting of a bubble concerning fundamental value or information asymmetry about the value of the fundamental determinants of asset prices. Our theoretical framework and the perp episode demonstrate that market collapse can be an endogenous phenomenon, having nothing to do with the fundamental value of assets, and everything to do with the liquidity needs of the investor clientele that holds the assets and their beliefs about whether these needs can be met in the future. Of course, the herding of investors during the collapse of a fundamental value bubble or in response to news about fundamentals can act in a manner similar to a systemic liquidity shock to exacerbate a market collapse.

Our framework readily extends to the case considered by Glauber (1997) in which everyone adopts the same trading model, leading to potentially harmful herding behavior. And as we have demonstrated, the triggers for such behavior need not arise from asset fundamentals. The growing empirical evidence of commonality in liquidity lends support to this view.

The perp episode emphasizes the importance of market breadth in establishing and maintaining liquidity in financial markets. As our model illustrates, market liquidity arises endogenously from the diversity of liquidity needs across the investor base and therefore, the broader the investor base, the lower the probability of a systemic liquidity shock. Market breadth can be assured through broad-based placement of securities. Our findings are

particularly relevant for unseasoned financial products that are often priced and marketed on the assumption that liquid secondary markets will develop.

Appendix

<u>The t = 1 equilibrium in case 1</u>:

Individual i's holding at time 1 is given by the first order condition to (2):

$$\bar{v} + \hat{\theta}_i - P_1 - a\sigma_v^2 X_{1i} - 2\lambda(X_{1i} - X_{0i}) = 0 \tag{A.1}$$

Noting that:

$$\sum_{i=1}^{N} X_{0i} = \sum_{i=1}^{N} X_{1i} = N \tag{A.2}$$

we can aggregate over the N agents to obtain the expression for the equilibrium price, P_1^1, in (3), from which (5) and (6) follow directly.

<u>The t = 0 equilibrium in case 1</u>:

At t = 0, the individual's problem becomes:

$$\underset{X_{0i}}{Max}\, E_0\left[\underset{X_{1i}}{Max}\, E_1\left[-\exp\left\{-a\left[W_{0i} + X_{0i}(P_1 - P_0) + X_{1i}(\tilde{v} + \theta_i - P_1) - \lambda(X_{1i} - X_{0i})^2\right]\right\}\right]\right] \tag{A.3}$$

which is equivalent to:

$$\underset{X_{0i}}{Max}\, E_0\left[-\exp\left\{-a\left[W_{0i} + X_{0i}(P_1^1 - P_0) + X_{1i}^*(\bar{v} + \theta_i - P_1^1) - \lambda(X_{1i}^* - X_{0i})^2 - \frac{1}{2}a(X_{1i}^*)^2\sigma_v^2\right]\right\}\right] \tag{A.4}$$

where X_{1i}^* and P_1^1 are the optimal time 1 holding and equilibrium price, respectively. This is of the form:

$$\underset{X_{0i}}{Max}\, E_0\left[-\exp\left\{-a\left[W_{0i}+\tilde{Z}(X_{0i})\right]\right\}\right] \tag{A.5}$$

Substituting from the time 1 first order condition, $\tilde{Z}$ reduces to:

$$\tilde{Z} = X_{0i}(P_1^1 - P_0) + \lambda(X_{1i}^{*2} - X_{0i}^2) + \frac{1}{2}aX_{1i}^{*2}\sigma_v^2 \tag{A.6}$$

and substituting for X_{1i}^* and P_1^1 yields:

$$\begin{aligned}\tilde{Z} = X_{0i}(\bar{v} - a\sigma_v^2 - P_0) - \lambda X_{0i}^2 + \frac{\left(a\sigma_v^2 + 2\lambda X_{0i}\right)^2}{2\left(a\sigma_v^2 + 2\lambda\right)} \\ + \frac{1}{2\left(a\sigma_v^2 + 2\lambda\right)}\Delta\tilde{\theta}_i^2 + \frac{\left(a\sigma_v^2 + 2\lambda X_{0i}\right)}{\left(a\sigma_v^2 + 2\lambda\right)}\Delta\tilde{\theta}_i + X_{0i}\tilde{\theta}_A\end{aligned} \tag{A.7}$$

where $\Delta\tilde{\theta}_i = \tilde{\theta}_i - \tilde{\theta}_A$. This expression is of the form:

$$\tilde{Z} = A + B(\Delta\tilde{\theta}_i^2) + C(\tilde{\theta}_A\Delta\tilde{\theta}_i) + D(\tilde{\theta}_A^2) + E(\Delta\tilde{\theta}_i) + F(\tilde{\theta}_A) \tag{A.8}$$

where $C = D = 0$, and A, B, E and F are non-random. Krishnan (1987) derives the moment generating function of a non-homogenous quadratic in a correlated bivariate normal. Disregarding terms uncorrelated with X_{0i}, we apply Krishnan's result directly to obtain:

$$\underset{X_{0i}}{Max}\, E_0\left[-\exp\left\{-a\tilde{Z}\right\}\right] \equiv \underset{X_{0i}}{Max}\left[aA - \frac{1}{2L_B}\left[M_1^2 + \frac{(L_B M_2)^2}{L_B}\right]\right] \tag{A.9}$$

where:

$$\begin{aligned} L_B &= 1 + 2aB\sigma_{\Delta\theta}^2 \\ M_1 &= (-a)\frac{a\sigma_v^2 + 2\lambda X_{0i}}{a\sigma_v^2 + 2\lambda}\sigma_{\Delta\theta} \\ M_2 &= (-a)X_{0i}\sigma_{\theta_A} \end{aligned} \tag{A.10}$$

$\sigma^2_{\Delta\theta}$ and $\sigma^2_{\theta_A}$ are the variances of $\Delta\theta_i$ and θ_A, respectively. Taking the first order condition with respect to X_{0i} and noting that in equilibrium, X_{0i} = 1, we obtain the market clearing price at t = 0:

$$P_0^1 = \bar{v} - a\sigma_v^2 - a\sigma_{\theta_A}^2 - \frac{2\lambda a\sigma_{\Delta\theta}^2}{a\sigma_v^2 + 2\lambda + a\sigma_{\Delta\theta}^2} \tag{A.11}$$

Noting that

$$\sigma_{\theta_A}^2 = \frac{\sigma_\theta^2}{N} \tag{A.12}$$

and

$$\sigma_{\Delta\theta}^2 = \sigma_\theta^2 \frac{(N-1)}{N} \tag{A.13}$$

yields the expression for P_0^1 in (8).

<u>The necessary condition (19) for offering a market</u>:

In the case where the probability of a systemic liquidity shock, ξ, is non-zero, the total expected market maker revenue in (9) modifies to:

$$R^1 = \frac{(1-\xi)\lambda\sigma_\theta^2(N-1)}{(a\sigma_v^2 + 2\lambda)^2} \tag{A.14}$$

Since market makers have zero expected profits,

$$MC = \frac{(1-\xi)\lambda\sigma_\theta^2(N-1)}{(a\sigma_v^2 + 2\lambda)^2} \tag{A.15}$$

which is quadratic in λ. It is straightforward to show that the condition in (19) must be satisfied in order for this quadratic equation to yield a real non-negative root for λ. If (19) is satisfied, market makers will offer a market. If (19) is not satisfied, there is no real non-negative value for λ at which market makers can expect to generate sufficient revenue to recover their set up costs.

REFERENCES

Allen, Franklin, and Douglas Gale, 2000, "Bubbles and crises," *Economic Journal* 110, 236-255.

Amihud, Yakov and Haim Mendelson, 1986, "Asset pricing and the bid-ask spread," *Journal of Financial Economics* 17, 223-249.

Amihud, Yakov and Haim Mendelson, 1991, "Liquidity, maturity, and the yields on U.S. treasury securities," *Journal of Finance* 46, 1411-1425.

Banerjee, Abhijit, 1992, "A simple model of herd behavior," *Quarterly Journal of Economics* 107, 797-817.

Bhattacharya, Utpal and Mathew Spiegel, 1991, "Insiders, outsiders and market breakdowns," *Review of Financial Studies* 4, 255-282.

Bikhchandani, Sushil, David Hirshleifer and Ivo Welch, 1992, "A theory of fads, fashion, custom and cultural change as informational cascades," *Journal of Political Economy* 100, 992-1026.

Boudoukh, Jacob and Robert Whitelaw, 1993, "Liquidity as a choice variable: A lesson from the Japanese government bond market," *Review of Financial Studies* 6, 265-292.

Brennan, Michael J. and Avanidhar Subrahmanyam, 1996, "Market microstructure and asset pricing: On the compensation for illiquidity in stock returns," *Journal of Financial Economics* 41, 441-464.

Camerer, Colin, 1989, "Bubbles and fads in asset prices," *Journal of Economic Surveys* 3, 3-41.

Chordia, Tarun, Richard Roll and Avanidhar Subrahmanyam, 2000, "Commonality in liquidity," *Journal of Financial Economics* 56, 3-28.

Comptroller of the Currency, Federal Deposit Insurance Corporation and Federal Reserve Board, 1987, *Joint News Release*, January 8 (U.S. Government Printing Office, Washington, DC).

Dammon, Robert M., Kenneth B. Dunn, and Chester S. Spatt, 1993, "The relative pricing of high-yield debt: The case of RJR Nabisco Holdings Capital Corporation," *American Economic Review* 83, 1090-1111.

Davis, E.P., 1989, "Instability in the euromarkets and the economic theory of financial crisis," Bank of England Discussion Paper No. 43.

DeGroot, Morris H., 1970, *Optimal Statistical Decisions* (McGraw-Hill, New York).

DeLong, Bradford, Andrei Shleifer, Lawrence Summers, and Robert Waldmann, 1990, "Noise trader risk in financial markets," *Journal of Political Economy* 98, 703-738.

Diamond, Douglas W., and Philip H. Dybvig, 1983, "Bank runs, deposit insurance and liquidity," *Journal of Political Economy* 91, 401-419.

Glauber, Robert R., 1997, "Systemic problems in the next market crash," in Hayne E. Leland, Martin Feldstein, Robert R. Glauber, David W. Mullins, and Steven M.H. Wallman, Symposium on Public Policy Issues in Finance, *Journal of Finance* 52, 1181-1198.

Glosten, Lawrence R., 1989, "Insider trading, liquidity and the role of the monopolist specialist," *Journal of Business* 62, 211-235.

Glosten, Lawrence R. and Paul R. Milgrom, 1985, "Bid, ask and transaction prices in a specialist market with heterogeneously informed traders," *Journal of Financial Economics* 13, 71-100.

Green, Richard C. and Kristian Rydqvist, 1997, "The valuation of nonsystematic risks, and the pricing of Swedish lottery bonds," *Review of Financial Studies* 10, 447-480.

Guttentag, Jack M. and Herring, Richard J., 1984, "Credit rationing and financial disorder," *Journal of Finance* 39, 1359-1382.

Hasbrouck, Joel and Duane Seppi, 2001. "Common factors in prices, order flows and liquidity," *Journal of Financial Economics* 59, 383-411.

Herring, Richard J. and Robert E. Litan, 1995, *Financial Regulation in the Global Economy* Brookings Institution Press, Washington D.C.

Hong, Harrison and Jeremy C. Stein, 2002, "Differences of opinion, short-sale constraints and market crashes," *Review of Financial Studies* (forthcoming).

International Financing Review, 1987, Special Issue on Perpetual Floating Rate Notes. July.

International Financing Review, various issues.

Kamara, Avraham, 1994, "Liquidity, taxes, and short-term treasury yields," *Journal of Financial and Quantitative Analysis* 29, 403-417.

Kamata, Sawaichiro, 1990, "Measuring 'Herstatt Risk'," *Bank of Japan Monetary and Economic Studies*, 8(2).

Karpoff, J.M., 1986, "A theory of trading volume," *Journal of Finance* 41, 1069-1087.

Kindleberger, Charles P., 1978, *Manias, Panics and Crashes: A History of Financial Crises* Basic Books, New York.

Koeplin, John, Atulya Sarin and Alan C. Shapiro, 2000, "The private company discount," *Journal of Applied Corporate Finance* 12, 94-101.

Krishnamurthy, Arvind, 2002, "The bond/old bond spread," *Journal of Financial Economics*, forthcoming.

Krishnan, Murugappa, 1987, "Rational expectations equilibrium with exact dynamic demand functions," Ph.D. dissertation, The Wharton School, University of Pennsylvania.

Kyle, A.S., 1985, "Continuous auctions and insider trading," *Econometrica* 53, 1315-1336.

Lo, Andrew and Jiang Wang, 2000. "Trading volume: definitions, data analysis, and implications of portfolio theory," *Review of Financial Studies* 13, 257-300.

Longstaff, Francis, 1995, "How much can marketability affect security values?" *Journal of Finance* 50, 1767-1774.

Longstaff, Francis, 2001, "Optimal portfolio choice and the valuation of illiquid securities," *Review of Financial Studies* 14, 407-431.

Meerschwam, David M., 1987, "Schroders' perpetual floating rate note exchange offer," Case 9-288-057, Harvard Business School.

Michaely, R. and J. Vila, 1995, "Trading volume with private valuation: evidence from the ex-dividend day," *Review of Financial Studies* 9, 471-510.

Michaely, R., J. Vila, and J. Wang, 1996, "A model of trading volume with tax-induced heterogeneous valuation and transaction costs," *Journal of Financial Intermediation* 5, 340-371.

Milgrom, Paul and Nancy Stokey, 1982, "Information, trade and common knowledge," *Journal of Economic Theory* 26, 17-27.

Miller, Merton H., 1991, *Financial Innovations and Market Volatility,* (Blackwell Publishers, Cambridge, MA.

Pástor, Lubos, and Robert F. Stambaugh, 2003. "Liquidity risk and expected stock returns," *Journal of Political Economy*, forthcoming.

Pratt, Shannon P., 1989, *Valuing a Business: the Analysis and Appraisal of Closely Held Companies,* Dow Jones-Irwin, Homewood IL.

Romer, David, 1993, "Rational asset price movements without news," *American Economic Review* 83, 1112-1130.

Securities and Exchange Commission, 1971, *Discounts involved in purchases of common stock*, Institutional Investor Study Report, U.S. Government Printing Office, Washington, DC.

Scharfstein, David S. and Jeremy C. Stein, 1990, "Herd behavior and investment," *American Economic Review* 80, 465-79.

Silber, William L., 1991, "Discounts on restricted stock: The impact of illiquidity on stock prices," *Financial Analysts Journal* 47, 60-64.

Wagster, John D., 1996, "Impact of the 1988 Basle Accord on international banks," *Journal of Finance* 51, 1321-1346.

Warga, Arthur, 1992, "Bond returns, liquidity, and missing data," *Journal of Financial and Quantitative Analysis* 27, 605-617.

Williams, Richard and Michelle Hole, 1987, "Refloating the floating rate note (FRN) market: the view from CSFB," *Journal of International Securities Markets*, Autumn, 5-16.

Zellner, Arnold, 1971, *An Introduction to Bayesian Inference in Econometrics,* Krieger Publishing, Florida.

Table 1
Perpetual Floating Rate Note Issues

This table reports all available data for perpetual floating rate notes issued from March 1980 through January 1987. Descriptive information about each issue is from Bloomberg and Datastream, and price data is from Datastream. Prices are for the last reported transaction, and may not be current.

Issue Date	Issuer	Issue Size (US)	Current status	Recent Price	Index	Credit Rating		Put Features
						S&P	Moody's	
03/29/80	Citicorp Overseas Finance NV	$200	Called	NA	LIBID	NA	NA	Putable quarterly @ 100
04/19/84	National Westminster Finance BV	$500	Called	NA	LIBOR	NA	NA	none
06/01/84	Kingdom of Sweden	$750	Called	NA	NA	NA	NA	none
07/01/84	Kingdom of Belgium	$300	Called	NA	NA	NA	NA	none
07/01/84	Kingdom of Denmark	$600	Called	NA	NA	NA	NA	none
08/10/84	Banque Paribas Series 1984	$150	Priced	80.00	LIMEAN	NA	NA	none
10/16/84	Barclays Overseas Investment Co BV	$600	Priced	86.50	LIBOR	A+	Aa2	none
10/17/84	Den Norske Creditbank A/S	$150	Priced	79.87	LIBOR	NA	NA	none
10/24/84	Genossenschaftliche Zentralbank AG	$100	Called	NA	LIBOR	NA	NA	none
10/24/84	Standard Chartered Finance	$300	Exchanged	NA	LIBOR	NA	NA	none
10/31/84	TSB Hill Samuel Bank Holding plc	$75	Called	NA	LIBOR	NA	NA	none
11/02/84	Allied Irish Banks Limited	$100	Priced	81.13	LIBOR	A-	A1	none
11/26/84	Den Danske Bank of 1817 A/S	$75	Called	NA	LIBOR	NA	NA	none
03/05/85	World Bank/IBRD	$500	Called	NA	91-day T-Bill	NA	NA	Putable quarterly @ 100
03/29/85	National Westminster Bank plc Series A	$500	Priced	84.75	LIMEAN	A	Aa2	none
04/03/85	Compagnie de Saint-Gobain €	$85	Priced	92.50	Euro LIBOR	NA	NA	none
05/14/85	Lloyds Bank plc Series 1	$750	Priced	84.72	LIBOR	A+	Aa1	none
05/24/85	National Westminster Bank plc Series B	$500	Priced	84.88	LIMEAN	A	Aa2	none
05/29/85	Midland Bank plc Series 1M	$750	Priced	79.56	LIBOR	A	Aa3	none
05/31/85	Kleinwort Benson Lonsdale	$100	Priced	77.50	LIBOR	NA	NA	none
06/04/85	Standard Chartered Bank plc £	#REF!	Priced	100.50	Avg of Ref. Bank	NA	Baa1	none
06/11/85	Standard Chartered Bank plc M/M Series 1	$400	Priced	64.88	LIBOR	NA	Baa1	none
06/13/85	Barclays Bank plc Series 1	$600	Priced	85.78	LIBOR	A+	Aa2	none
07/04/85	Allied Irish Banks Limited Capital	$100	Priced	82.00	LIBOR	NA	A1	none
07/24/85	HSBC Series 1H	$400	Priced	86.90	LIBOR	NA	A3	none
08/29/85	Midland Bank plc Series 2M	$500	Priced	79.42	LIBOR	A	Aa3	none
09/27/85	Bank Leumi plc (UK)	$10	Called	NA	LIBOR	NA	NA	none
11/05/85	Bank of Scotland	$250	Priced	82.50	LIMEAN	NA	Aa3	none
11/07/85	Standard Chartered Bank plc M/M Series 2	$300	Priced	66.63	LIBOR	NA	Baa1	none
11/13/85	Lloyds Bank plc Series 2	$500	Priced	83.97	LIBOR	A+	Aa1	none
11/14/85	Standard Chartered Bank plc M/M Series 3	$400	Priced	64.08	LIBID	NA	Baa1	none
11/14/85	National Westminster Bank plc Series C	$500	Priced	84.33	LIBID	A	Aa2	none
11/15/85	Den Norske Creditbank A/S	$280	Priced	79.87	LIBOR	NA	A2	none
11/20/85	Royal Bank of Scotland	$350	Priced	84.41	LIMEAN	NA	Aa3	none
11/27/85	HSBC Series 2H	$400	Priced	85.83	LIMEAN	NA	A3	none
11/29/85	Bank of Ireland	$150	Priced	84.63	LIBOR	A-	A1	none

Table 1 (contd.)

02/06/86	Barclays Bank plc Series 2	$870	Priced	85.03	LIBID	A+	Aa2	none
03/07/86	Financiere CSFB NV	$150	Priced	79.88	LIBID	A+	A2	none
04/24/86	Kleinwort Benson Lonsdale	$125	Priced	77.50	NA	NA	NA	none
05/20/86	DFC Overseas Investment Limited	$100	Exchanged	NA	NA	NA	NA	none
06/27/86	HSBC Series 3H	$400	Priced	75.87	LIMEAN	NA	A3	none
06/30/86	Banque Paribas Series 1986	$350	Priced	82.66	LIBOR	A	NA	none
08/13/86	Den Norske Creditbank A/S Series NEW	$200	Priced	79.88	LIBOR	NA	A2	none
08/14/86	Lloyds Bank plc Series 3	$600	Priced	83.53	LIBOR	A+	Aa1	none
08/18/86	Morgan Grenfell Group plc	$200	Priced	86.00	LIBOR	NA	NA	none
08/19/86	Bergen Bank A/S	$200	Priced	79.88	LIBOR	NA	NA	none
08/28/86	Hydro Quebec Series GL	$400	Priced	88.05	LIBOR	A+	NA	none
09/05/86	Banque Nationale de Paris	$500	Priced	81.38	LIBOR	A	A1	none
09/22/86	Commissioners of State Bank of Victoria	$125	Priced	91.25	LIBOR	NA	Aa2	none
09/22/86	Westpac Banking Corporation	$500	Priced	84.00	LIBOR	A+	A1	none
09/22/86	Rothschild Continuation Finance Limited	$200	Priced	64.41	LIBOR	NA	NA	none
10/01/86	National Australia Bank	$250	Priced	82.13	LIBOR	AA-	A1	none
10/09/86	Australia and New Zealand Banking Group	$300	Priced	81.58	LIBOR	A+	NA	none
10/24/86	Christiania Bank og Kreditkasse	$200	Priced	81.80	LIBOR	NA	NA	none
11/14/86	Societe Generale	$500	Priced	81.33	LIBOR	A	A1	none
11/18/86	Robert Fleming Netherlands BV	$100	Called	NA	LIBOR	NA	NA	none
11/25/86	Citicorp 30-year Put Series BANC	$500	Called	NA	LIBID	NA	NA	Putable @ 100 annually beginning 2016
12/03/86	Midland Bank plc Series 3M	$300	Priced	77.58	LIBOR	A	Aa3	none
12/08/86	Rhone Poulenc 7.875 coupon Series *	$300	Priced	88.50	LIBOR	NA	NA	none
01/05/87	Standard Chartered Bank plc M/M Series 4	$200	Priced	65.10	LIBOR	NA	Baa1	none
01/15/87	Republic of New York Corporation Series BR	$150	Priced	94.50	LIBOR	A	A3	Putable @ 100 semi-annually beginning 2012
	Summary:	Called	12					
		Exchanged	2					
		Priced	47					
		Total Perps	**61**					

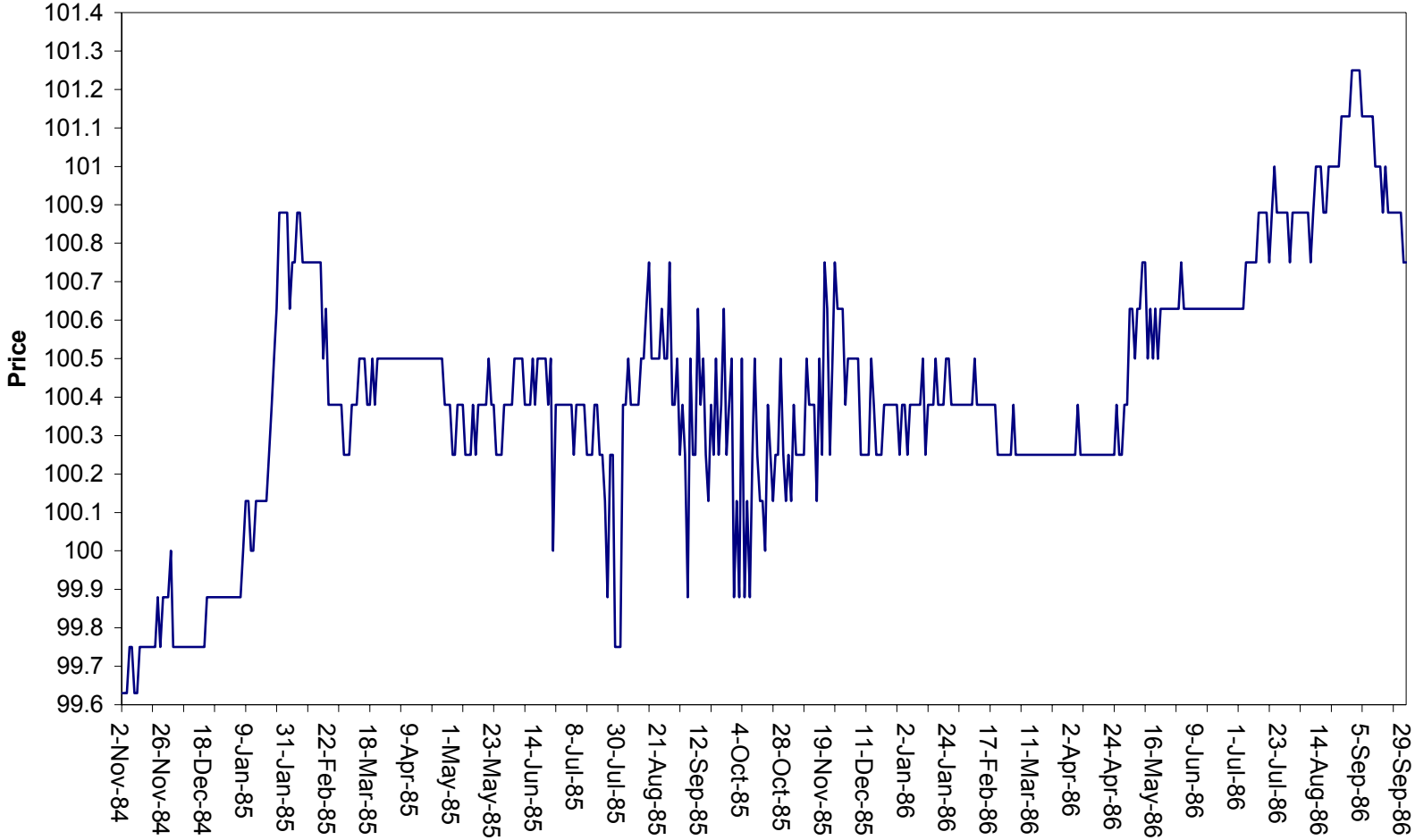

Figure 1: The rising trend in the marketability premium prior to the collapse. This figure captures the declining yield spread over LIBOR (in terms of the corresponding increase in price) for the Barclays Overseas Investment BV perp. As investors grew more confident in the liquidity of the secondary market, their subjective probability of a systemic liquidity shock declined and the marketability premium increased, thus reducing the yield spreads attached to perps.

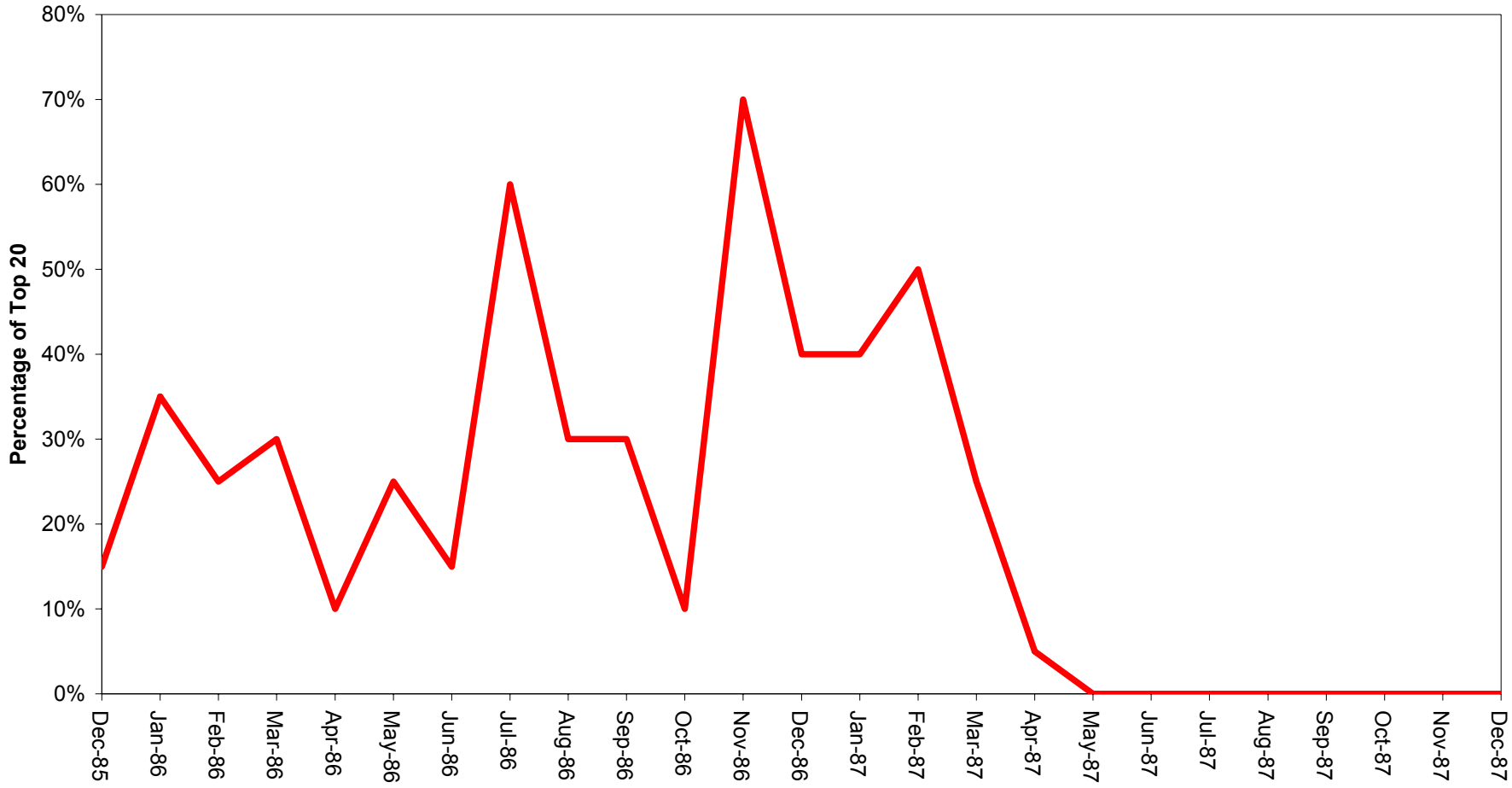

Figure 2: Percentage of perp issues in twenty most actively traded money market issues. This figure provides the number of perp issues in the Euroclear listing of the twenty most actively traded money market issues each month, an indirect indication of trading activity in perps. As shown, perps were among the most actively traded money market instruments through the first quarter in 1987. Average daily volumes of as much as $1 billion were recorded during this period. A dramatic decline in trading activity accompanied the perp collapse.

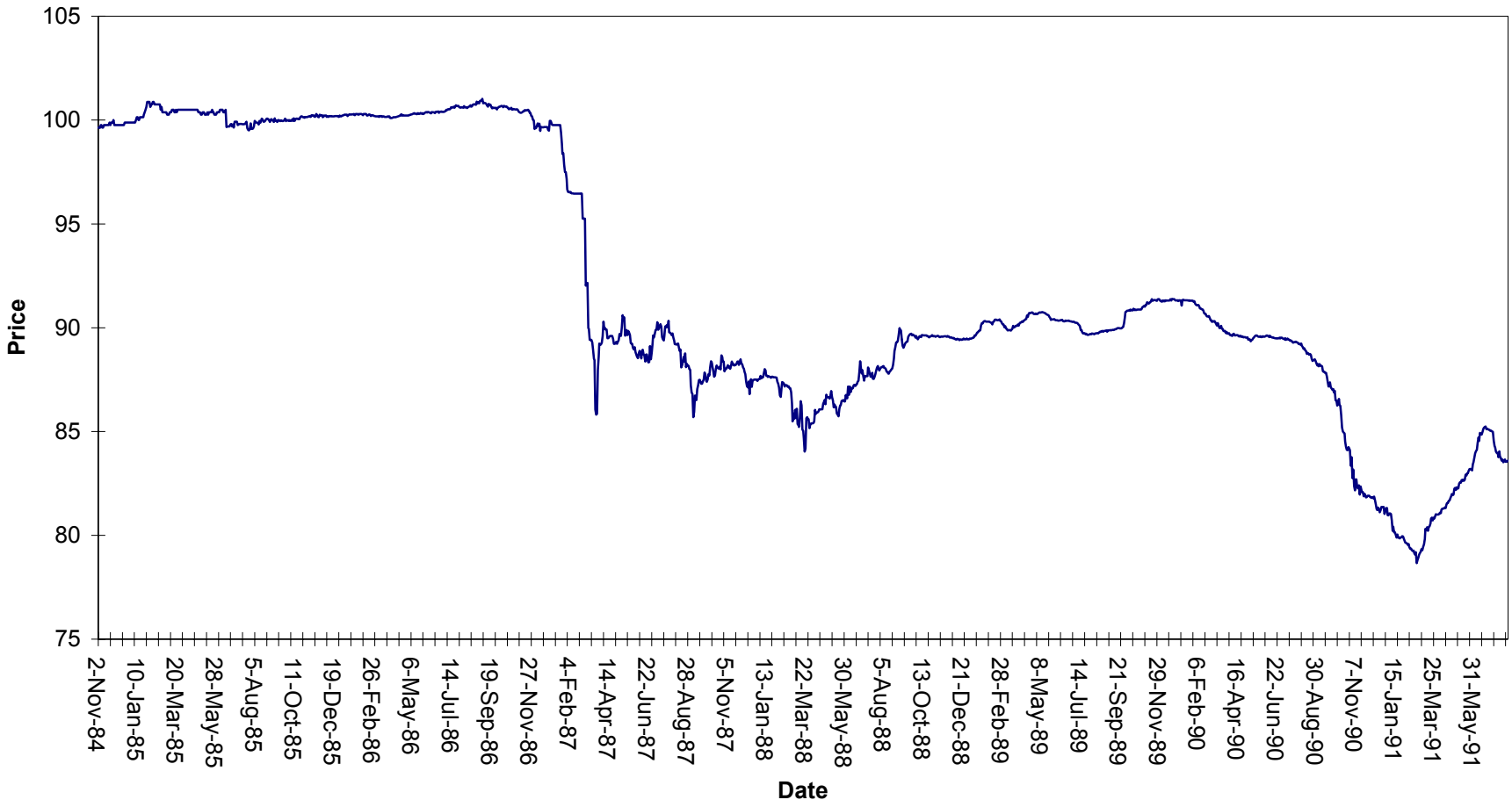

Figure 3: Behavior of perp price index. This figure plots the value from November 1984 through June 1991 of a price index of eleven perps issued by British Clearing Banks. The sudden collapse and lack of recovery of the secondary market is clearly evident. However, prices after the collapse are updated infrequently based on the last reported transaction, and may not be current.

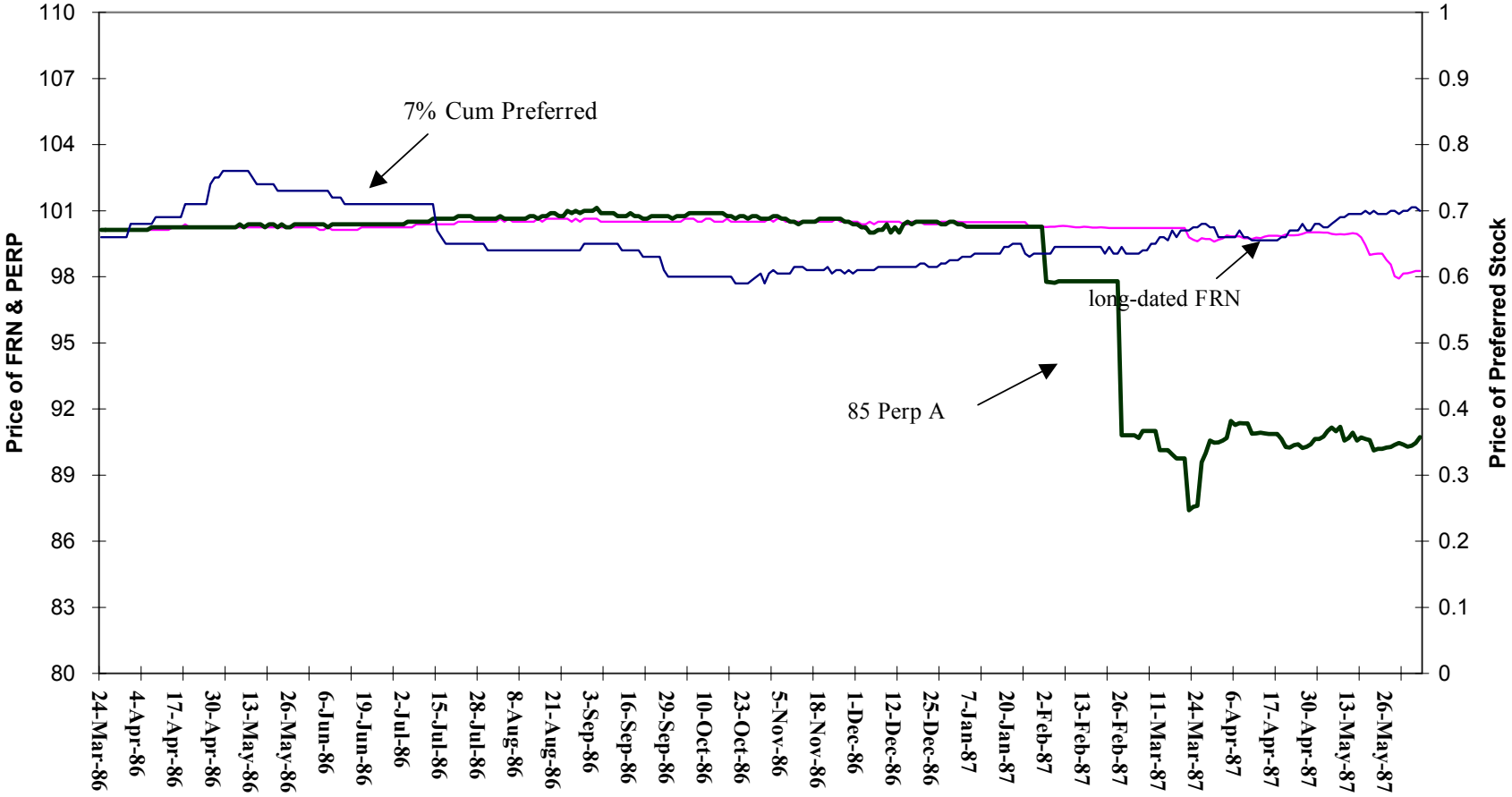

Figure 4: The price behavior of 3 NatWest financial securities. This figure shows the prices of three obligations—a perpetual floating rate note, preference shares (which were subordinate to the perp), and a long-dated floating rate note (FRN)—of the National Westminster Bank (NatWest), a major U.K. clearing bank. After trading steadily at its par value, the price of the NatWest perp shows a sudden decline, which coincided with the collapse of the perp market. Clearly, this collapse cannot be attributed to a decline in the creditworthiness of NatWest since the prices of its long-dated FRNs and preference shares held steady while the prices of its perps dropped.