

A Perspective on Liquidity Risk and Horizon Uncertainty

JOANNE M. HILL

JOANNE M. HILL
is head of Investment
Strategy at ProShares ETFs
and Profunds in Bethesda,
MD.
joahill@gmail.com

In this period of the highest equity market volatility experienced in our lifetimes, we are challenged to understand the nature of the episodes of extreme risk comparable to the one we have just encountered. To do this we must consider sources of risk that depart from concepts that have been in place for most of the past 50 years. For decades, the standard deviation of investment returns and beta—the sensitivity of a stock's returns to those of a broad market index—have been the dominant risk metrics and guideposts for building portfolios of risky assets. These risk measures are likely to again be relevant when we return to a more normal market climate; however, they have been of little help in explaining the cross-asset and cross-market volatility that we have experienced since July 2007. This recent period shares features with other brief periods in the twentieth century, periods in which markets and economies experienced severe financial instability and highly correlated negative returns. The years 1907–1908 and 1930–1932, the fourth quarter of 1987, and the early fall of 1998 all shared a common feature—episodes of selling-contagion in financial assets that followed extended periods of very strong returns to holders of equity and credit risk.

This article explores a common source of tail risk, specifically extreme episodes of liquidity risk in the marketplace. The term “tail risk” as used in this article refers to the chance

of experiencing extremely positive or negative returns with a frequency higher than would be indicated by a normal distribution of investment outcomes. During a tail-risk event, the returns of broad equity indices go to extremes as a result of the following three primary forces:

1. The risk of individual stocks rises due to higher fundamental and flow-related risk at the company level.
2. Delevering and de-risking occur simultaneously across large groups of securities introducing higher levels of short-term return correlation.
3. Bid–offer spreads widen and the market impact of trades becomes large as market makers charge higher prices for providing liquidity; this affects all risky assets and further induces correlations to rise.

Selling-contagion arises from fund flows across asset classes that are related to a rapid and large need to reduce both risk and leverage by investors who are on the brink of financial ruin as a result of losses experienced in the earlier stages of a market crisis. During these financial crises, large groups of investors “at the edge” do not act in the usual manner of making choices across risky assets. In normal situations, investors make choices based on projected cash flows and the risk of those cash flows according to the principles and concepts

taught in finance courses. In a financial crisis, these investors need to sell to survive. They are either facing margin calls from their lenders, bankruptcy, and/or calls for funds from clients, or they need to sell in response to an “urgent” need to reduce the risk of the altered market environment.

Liquidity risk is a separate and distinct type of risk compared to the fundamental risk that arises from uncertainty regarding the cash flows and growth prospects of a company, sector, or economy. It is driven by uncertainty regarding the investment horizon or holding period, the correlation across the cash flow demands of market participants, and short-run constraints on market-making capital. It feeds on itself and escalates rather than following a mean-reversion pattern. It can grow as long as there are assets to liquidate and markets open to trade. Liquidity risk is often high after a long period of abundant liquidity, driven by low fundamental volatility, rising economic growth, and trending returns.

The presence of “urgent sellers” can destabilize a market that has limits on the short-run supply of liquidity. Complicating the process is the fact that the first wave of urgent selling can lead to subsequent waves of selling as the price impact of these early waves is broadcast to the broader investment universe, and the mark-to-market values of investor wealth begin to deteriorate. Also a lack of transparency regarding the size of positions can increase the length and depth of the liquidity problem, as it leads to a perceived overhang of pent-up future selling pressure. Investors and traders rush to be the first to the exits, exacerbating the problem and introducing flow-related linkages across financial assets and markets around the world.

When market participants detect the presence of a large number of urgent sellers, the price of liquidity can rise sharply. Natural buyers of assets hold back from supplying liquidity, accentuating the problem and placing a greater burden on market makers and intermediaries. The financial instability that results can contribute to further risk aversion as investors receive information on the value of their wealth from a market driven by urgent selling pressure and as buyers hold back and wait for calmer markets. In essence, the equilibrating mechanism necessary for the normal functioning of capital markets as a part of the economic allocation process becomes dysfunctional, requiring external intervention to prevent a broadening and deepening of the financial malaise.

THE DYNAMICS OF HIGH LIQUIDITY-RISK PERIODS

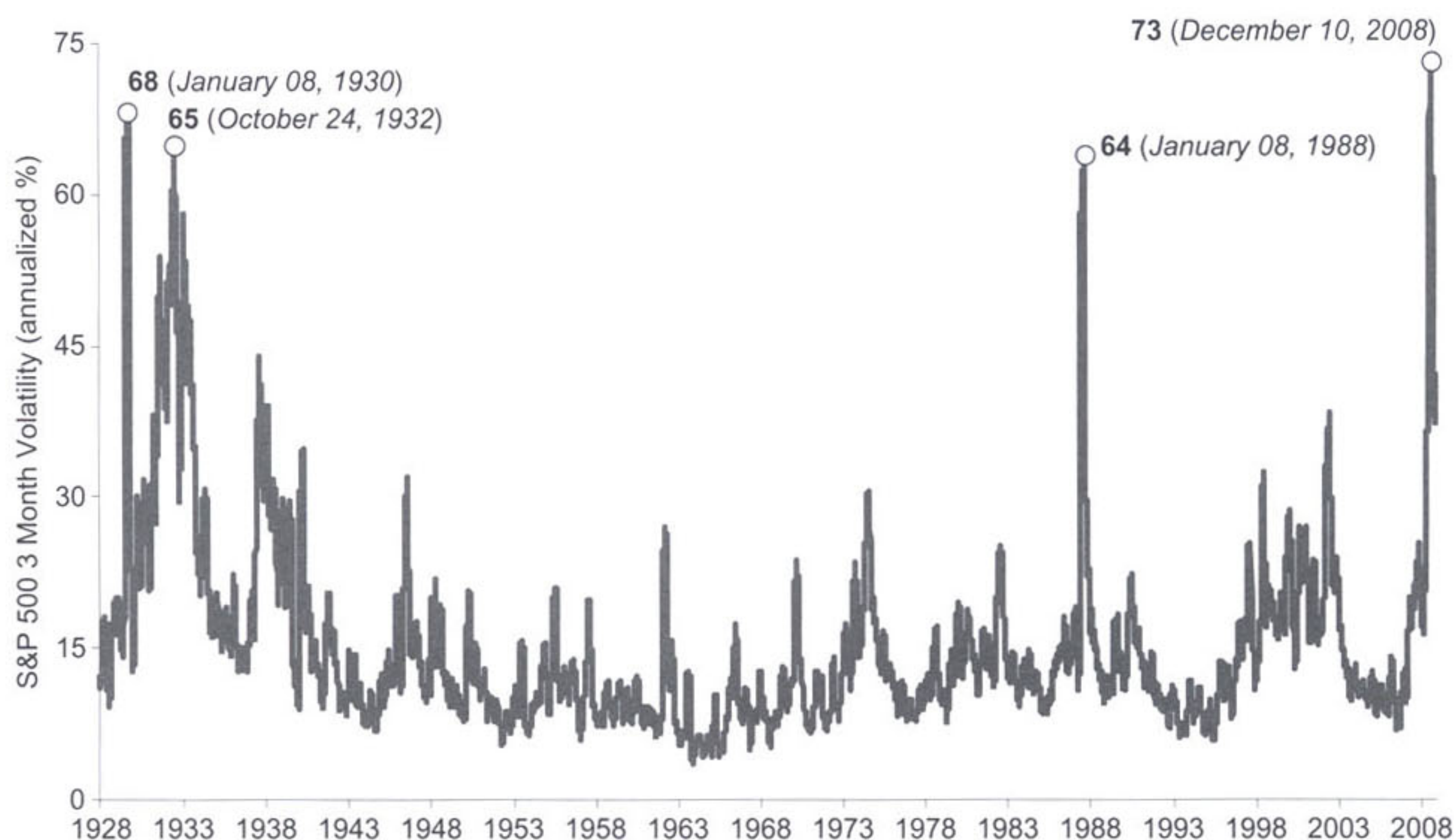
Almost exactly a century ago, the U.S. experienced one of the first severe liquidity-related financial crises that started in the equity market and then sent the broader economy into an extended recession. The recent book, *The Panic of 1907*, by Bruner and Carr [2007] provides a detailed account of the financial instability that was initiated by the failures of trust banks in New York after the equity losses of their partners. The intensity of this financial crisis was reduced by the intervention and leadership of prominent banker J.P. Morgan and by his ability to coordinate with other bankers the extension of credit at a critical juncture. This panic was followed by a period of significant economic weakness and ultimately resulted in the formation of the Federal Reserve System and the FDIC as preventive solutions for runs on banks that would likely lead to bank failures and the associated economic consequences. The authors highlight some of the warning signs of these financial panics, including a prior period of buoyant growth, inadequate safety buffers, system-like architecture, and adverse leadership, followed by an economic shock. Our current Federal Reserve Chairman, Ben Bernanke, specialized during his academic career on research into the causes of the Great Depression, another deep financial crisis. Even though he did not experience the period first hand, he was acutely aware of the connections and pitfalls of a hands-off policy when liquidity demands far outweigh the market's capacity to accommodate them.

One metric that rises sharply in financial crises is the realized volatility of a broad equity market index, such as the S&P 500, as its level is influenced by both the level of individual stock risk and the correlation across securities. The exhibit shows the history of three-month realized S&P 500 volatility rolling back daily to 1928. Several large spikes associated with extreme liquidity-risk periods in 1929, the 1930s, 1987, and most recently December 2008 are visible; noteworthy is the three-month period ending December 10, 2008, that featured an annualized volatility of 73%, exceeding that of the Depression years and the 1987 stock market crash. In addition, less extreme, but more frequent, periods of high levels of volatility in 1937, 1946, 1962, 1974, 1998, and 2002 were related to liquidity pressures from large-scale risk reduction activity.

Underlying these past episodes of financial crises is the fact that the amount of deposits at banking institutions and the assets of money market funds is typically far in

EXHIBIT

S&P 500 3-Month Realized Volatility, March 30, 1928–March 31, 2009



Source: Goldman Sachs Options Research.

excess of the amount the system is prepared to provide in cash on any business day; similarly, the market value of stocks is far in excess of a typical trading day's trading volume on organized exchanges, which represents only 1%–2% of outstanding equities and derivatives (see Hill [2007]). The financial system is built on the foundation that the distribution of investment horizons or holding periods is normally far longer than the interval over which liquidity is needed. Hence, financial intermediaries lend or hold longer-term, less-liquid assets based on an expectation of the duration of their long-term funding sources, or depositors. Major macroeconomic information that significantly alters the economic and risk outlook as well as investor expectations about future return and risk prospects can dramatically shorten holding periods and trading demands, precipitating a period of market crisis or financial instability. Many investors, corporations, and market makers are unprepared for these periods of market crisis—especially if the crises occur subsequent to a below-normal risk and above-normal return period—if they have used recent history as a guideline for their risk management approach. Consequently, investors often become caught up in the whirlwind

of de-risking, contributing to the intensity of the problem rather than being able to weather the storm.

Brunnermeier and Pedersen [2005] explored how markets and security prices react to large traders whose positions are known by other traders and who are near margin calls. They show that liquidation by a distressed large investor can spawn a withdrawal of liquidity as other traders initially trade in the same direction. In a key article that explored the sources of the Fall 1998 crisis related to the failure of Long Term Capital Management, Brunnermeier and Pedersen [2005] concluded that

... predatory trading can enhance the risk of financial crisis ... predation is profitable if the market is illiquid and if the distressed trader's position is large relative to the buying capacity of other traders (p. 1826).

Hence, they see large illiquid holdings as dangerous if known to other strategic traders. They further argued that the systemic risk suggested by their predatory trading model implies that sound risk management should take

into consideration other traders' exposures and financial soundness, correlation changes, and fund outflows during a liquidity crisis as well as the discretion involved in marking to market. Recent events suggest their recommendations were not appreciated or incorporated into risk management at financial institutions to any large degree, but may be important in approaches undertaken going forward.

The recent period of financial instability commenced in the summer of 2007 with hedge fund losses on low-quality mortgage debt when these funds received margin calls related to the first wave of reaction to the bursting of the U.S. housing price bubble. We saw the early warning signs as linkages from liquidity demands of the funds dumping toxic mortgage assets spilled over into their quantitative equity strategies and other highly levered fixed-income hedge funds. These strategies were particularly vulnerable because they were among the lowest-risk and most highly levered strategies of investors who were required to mark positions daily by their lenders. As we look back now, those flow effects in the late summer of 2007 that were impacting the performance of quantitative equity managers were more like isolated, severe thunderstorms that preceded the hurricane to follow. Rapid de-risking swept markets like a disastrous flood that showed no mercy in the sweep of its waters—impacting both weak and strong institutions and eventually spilling over into the broader global economy. An analogy drawn from recent financial media commentary is that credit and confidence are like the air that we breathe in the financial markets. We had become dependent on high levels of oxygen, and their sudden removal left all participants withered, needing to cutback on normal activities, and alter their patterns in dramatic ways.

CAPITAL MARKET THEORY: UNDERPINNINGS AND LIMITATIONS

For 50 years, the key concepts of investment theory and practice have been largely based on a single-horizon model and the principle that security prices were the result of the interaction of market participants who were price takers at the margin. Capital market theory—with its normative applications—has its roots in the 1950s portfolio selection research by Markowitz and the simplification of the concepts of factor-based risk models starting with the single-index market model of Sharpe who, along with others, also developed positive implications of portfolio theory in the form of the Capital Asset Pricing Model (CAPM).¹

These risk models were based on concepts of portfolio construction defined in terms of expected return maximization and risk aversion and that assumed a quadratic utility function in which risk was defined as the standard deviation of returns from assets delivering payoffs that generally had normal distributions. Kraus and Litzenberger [1976] extended the CAPM for the case of a cubic utility function and preference for skewness, but at the time the risky assets available for study did not have sufficient skewness to show a meaningful difference from those derived from the mean-variance-based CAPM. Bookstaber and Clarke [1985], Leland [1980, 1999], Sharpe [1987], Sharpe and Perold [1988], and the practitioners Sortino and van der Meer [1991] continued to research third-moment and downside risk measures; however, these efforts were never broadly adopted in mainstream investment practice, largely due to their complexity and the need to specify targets for downside risk.

Optimal models of portfolio choice that are in use today typically assume investors share a common, single horizon that incorporates the information set at the start of the period. Investment choices are anticipated to have the same capacity with respect to the size of the allocation or funds invested. In cases where trading costs are taken into account, the usual process is to reduce the forecasted return or alpha by the expected trading cost given some quantitative model or liquidity rating for the security. Although there are exceptions, the process of building portfolios is not dynamic and adaptive to shifts in volatility or to the cost of trading as the investment decision is implemented. Trading decisions are left up to the expertise of the trading function at the fund management firm. An effective trading function adds value by using quantitative trading tools, expertise, and judgment to achieve the highest value for a portfolio given the potential for short-term alpha versus expected market impact.

The study of liquidity and its cost is a distinct area of the finance academic literature labeled *market microstructure* that considers the factors impacting the cost of trading, the primary concept of which is *implementation shortfall* (i.e., the difference between the price before and after a particular trade). Factors common in trading cost models include bid-offer spreads, short-term volatility, and the volume expected over the anticipated trading horizon (Abrokwah and Sofianos [2007]). Rarely do these execution cost models look, in aggregate, at liquidity demands or at the cost of trading a benchmark asset, or assets, that are closely related to the security or portfolio being traded. Therefore, the

contagion and correlation of liquidity demands, such as those observed in the most recent global financial crisis, are often not taken into account in security risk measures or in the trading cost estimates commonly used by practitioners for building portfolios. (The volatility estimate used in a model input can be adjusted, but anecdotal evidence suggests this is rarely done by model users.)

In the long run, microeconomic and capital market theory posit that price determination for securities, as for goods and services, is based on sloping demand and supply functions driven by fundamentals related to the earnings of the broad economy and the securities being priced based on those earnings. In the short run, however, the supply of liquidity may be highly inelastic such that investors can become urgent sellers, willing to trade at any price to raise cash for the margin calls on other assets. Markets in dysfunction, therefore, can at times depart from basic principles of economic and financial theory and shift to a regime in which prices are determined by the extent of the activity of urgent sellers.² Prices of stocks or other securities that are liquid and performing well may also fall precipitously because they are available for sale while assets with larger losses are not able to be sold because secondary markets are effectively closed or are in dysfunctional states. Note that the presence of an isolated urgent seller will not necessarily impact prices, but given the scarcity of liquidity relative to wealth or to inventories, the presence of several urgent sellers can easily move prices as the information of large imbalances of supply or demand becomes apparent to wide groups of market participants.

The liquidity risk phenomenon is not only present in the *selling* of securities; the counterparty risk occurs when *buyers* have high liquidity demands, often called a “bubble.” The buying frenzy of technology stocks in the late 1990s was the case of a buying bubble, fueled by the desire of investors to own “hot” mutual funds based on historical performance rather than on an assessment of value. The flows into the funds pushed up the prices of technology stocks given the limited amount of outstanding shares; this further boosted performance, attracting more investors, and so forth. Sound familiar? The recent U.S. housing market experience was likely a similar price bubble. With the availability of leverage and the longer-term periods of boom and bust in housing cycles versus stock market cycles, large amounts of household wealth shifted into real estate during the last five years, which followed a bear market in equities and the ample credit from a surge in global liquidity.

When we go through periods of low volatility and trending markets, such as the ones we experienced in the three years prior to mid-2007 and in the mid-1990s, liquidity and leverage are in abundant supply. Periods of severe liquidity scarcity are sufficiently infrequent that it is common for investors who have seen long periods of high returns for risk to believe the conditions of the recent past are predictive of the future. Illiquidity is probably one of the most underappreciated risks and, therefore, carries a very low risk premium, especially as market participants have tended to lose institutional memory of periods of financial instability or have been purged of those who failed during these periods.

Carrying illiquid investments has the following additional disadvantages beyond the tail risk issues:

- Financial markets are dynamic; investors may have to forego great opportunities because of the illiquidity of holdings.
- Liquidity risk often rises when asset prices fall.
- Liquidity risk is not diversifiable as long as capital flows are not constrained across assets or regions of the world's markets.
- Liquidity risk is not a continuous risk, but is subject to large jumps, and depends on aggregate investor behavior, even if the investor functions as a price-taker.

In derivatives pricing theory, liquidity risk is also largely ignored. Futures, swap, and option valuation concepts are based on the idea that equivalent positions can be constructed from stocks, risk-free borrowing, and investing.³ Indirectly, the presumption does exist that there are differences in the operational constraints and access costs across market participants. These differences lead to greater derivatives use by those who can take advantage of the more efficient and lower cost access to risk exposures via derivatives. Also, because derivatives are equivalent to security or index exposures in an economic sense, they are known to expand both liquidity and position-size capacity when they can be created for those participants who have access.

Long option positions are uniquely effective in providing for appreciation in value without the need to source liquidity; their prices and market exposure vary as the underlying security changes in price. One explanation for the rise in index and stock option implied volatility during periods of financial instability in the underlying security (i.e., large gap moves and sizable order imbalances) is that

at these times the benefit of holding options increases in relative value. Options free investors from needing to transact and use liquidity to alter their exposure via transactions. They are particularly effective as tail and liquidity risk hedges because they are able to benefit from changes in value based on moves in the underlying securities and can extract profits from prices falling in reaction to urgent selling.

HORIZON UNCERTAINTY AND LIQUIDITY

Liquidity issues are most pronounced when an investor's horizon differs from that of the security being held. As noted previously, price gaps and overreaction to liquidity demands become a problem when one or more market participants becomes an urgent seller (i.e., an investor with an extremely short horizon) and their security sales establish a price that other investors who hold the security must now accept to value their own positions. This dysfunction from a wide disparity in investor horizons in illiquid assets can introduce correlation and contagion to more liquid assets as investors seek to find liquidity where they can, often by selling the more liquid and better performing assets. Eventually, if the market crisis broadens and lasts, the illiquid assets may need to be disposed of, which can lead to large systemic shock as investors who are permitted to carry the illiquid assets at book value have to adjust to the new "traded" price.⁴

Stocks have infinite horizons and trade in a transparent market where liquidity is a key consideration in attracting equityholders. Equity wealth is consistently based on exchange prices because of the uncertainty associated with independently valuing corporations as an infinite stream of future cash flows to equity owners. Equities are considered to be one of the most liquid financial assets as demonstrated by price quotes flashing across electronic media throughout the trading day. Nevertheless, research shows that over the 1997–2006 period between 0.3% and 0.6% of equity market capitalization traded on exchanges in a typical day (Hill [2007]). When the dollar volume of exchange-traded equity derivatives is added to share volume, the percentage of market capitalization traded daily rises to around 2%, but many derivatives trades are offsetting or are hedges to stock trades. Given this narrow "pipe" of daily liquidity for stocks, it is not hard to see how an information event or regime shift could significantly increase the demand for liquidity given the size of the investment holdings relative to typical trading flows. These events also are often

accompanied by much larger flow imbalances to the sell side than are seen on a normal trading day.

For debt securities, the horizon issue is very connected to the problems of leverage and financial instability. Most companies and public entities have numerous debt issues outstanding, both negotiated privately and traded in the dealer markets. The basis for extending credit and for the debt ratings process is focused on the assumption that security buyers will hold these securities to term. Credit quality evaluation is based on an assessment of the ability of cash flow to support the interest payments and repayment of principal. The assessment can be modified depending on market conditions, but is usually modified only when the ratings agency has a high conviction that a change is warranted. A modification occurs most often subsequent to periods of price weakness, rather than ahead of them. Ratings and political risk assessment of government debt do not normally take liquidity risk into account.

For financial institutions and investors holding debt, and for derivatives on this debt, ratings are based on the cash flow risk to coupon and principal payments. Prior to the current market crisis and over the last five years, ratings became the basis for a massive explosion of credit extensions. Because many structured and derivative debt securities were acquired with leverage or held on corporate balance sheets subject to GAAP accounting, owners of debt were subject to monitoring based on the market values of the debt as determined in the dealer markets. A contraction in the availability of credit sent a shock to the system as large groups of investors could not hold debt to maturity and needed to sell based on interim market prices from dealers making secondary markets. In this situation, prices were driven by liquidity demands rather than by ratings and the ability of issuers to pay cash obligations of the security.

For private equity, a major risk is the uncertainty of the term of the investment horizon because commitments are typically for 10 years or more. Investors with an infinite, or very long, horizon for a large portion of their cash flows are very appropriate holders of illiquid assets, such as private equity, and can thereby capture the risk premium for liquidity.⁵ The expected high returns are, in part, compensation for taking on this liquidity risk, but market-based risk measures are of little value for private equity due to the arbitrariness of interim marks. Since many holders value these assets at book value rather than market value, the value discrepancy between short- and long-horizon prices can become quite large, creating

controversy as to where the appropriate valuation lies. Also, changes to value occur with a lag because it takes time to find buyers or to restructure balance sheets when the economy weakens. A hidden opportunity cost that comes with the liquidity risk of private equity is the risk of capital calls that may require liquidation of other holdings or of foregone investment opportunities in areas of the portfolio with higher near-term return expectations.

DERIVATIVES AND LIQUIDITY RISK: CAUSE, SOLUTION, OR A BIT OF BOTH

A key component of the portfolio-building process going forward will be the balance of illiquid (i.e., long-horizon) to short-horizon assets. If fundamental volatility rises, liquidity risk premiums are likely to rise as well because intermediaries will demand more compensation for carrying interim positions. Index products or derivatives that are traded actively by a diverse group of market participants can provide some critical access to liquidity during periods of financial stress. These tools, however, should be used with restraint and not as vehicles for excess leverage that can backfire in high-volatility regimes; derivatives can reduce liquidity risk, but can lead investors to take on more horizon uncertainty and counterparty risk. Their use as hedges for less-liquid assets must be undertaken only after considering the potential basis risk from long and short positions that differ in their liquidity properties.

Derivatives are tradable forms of payoffs that are based on the price movement of an underlying security, index, or real asset. The economic justification for derivatives is an improvement in the allocation of capital. These tools are said to serve as a means of allocating risk across market participants in a more efficient way than would occur if this risk were bundled within the security itself. Derivatives and leverage go hand in hand because market participants divide across two classic types—those who hold the underlying security and are reducing risk, and those who do not hold the security but want the synthetic exposure while the capital is deployed elsewhere. The latter group can replicate the risk of the underlying security by investing in risk-free assets in an amount based on the expected settlement or term value of the derivative, net of the risk-free interest earned.

The clearinghouse or counterparties to derivatives trades normally monitor leverage and control their risk by requiring daily marking to market, as on futures exchanges, or by placing collateral and interim cash flow requirements

on counterparties based on their creditworthiness. Thus, for creditworthy investors, derivatives embed leverage and allow for more flexible portfolio building, including alpha-beta separation, tactical overlay trading, buying convexity, and classic leverage of the risky asset underlying the derivative.

Well-functioning derivatives markets depend on the evaluation of counterparty risk, the assessment of the cash requirements given market volatility. Episodes of financial instability affect derivatives (and other forms of leverage) in several ways. First, the wide swings in value are likely to place higher cash demands on the borrower or derivatives holder; these margin calls can be destabilizing if they are larger than anticipated and require the derivatives owner or issuer to begin liquidating positions due to not receiving funds from the counterparty. Second, standardized measures of credit risk, such as ratings, are commonly used to set criteria for credit extension. When markets become stressed, default rates often move higher, more ratings downgrades occur, and—as we saw in this particular crisis—the ratings themselves may lose credibility. The contraction in credit extension and higher credit standards reduce liquidity and the number of market participants in derivatives, making it difficult for those with open positions to unwind their exposure.

The supply and demand for risk transfer drives derivatives activity. Normally, the demand for risk transfer increases in high-volatility regimes, and such periods coincide with high levels of derivatives activity. What was unusual about the 2003–2007 period was the rapid growth in demand for risk transfer in a declining and low-risk environment. In a low-risk-premium environment, the standard means for institutional investors to deliver their desired returns is by increasing risk through leverage and through the use of derivatives. In a similar fashion, providers of credit must extend the supply of credit to improve their profits as the cost of credit falls. This often excessive use of derivatives for leverage during low-volatility regimes can help plant the seeds for a high degree of disruption when the period changes to a credit crisis. In the recent crisis, there was a frenzy to reduce explicit credit risks as well as the supply of risk-transfer from the embedded credit in derivative securities. Just at a time of high demand for derivatives in order to reduce risk, the natural sellers of derivatives already had high levels of exposure and had no more capacity to assume risk from market participants who wanted to hedge.

OPTIONS AS HEDGES FOR PERIODS OF FINANCIAL STRESS AND TAIL RISKS

Long option positions provide a natural hedge for liquidity risk. Profits and losses accrue without any need to trade or to seek liquidity, a feature that can be of significant value in periods of extreme volatility and scarce liquidity. For this reason, many highly levered traders at financial institutions and hedge funds use options as their primary vehicle for hedging tail risk and/or liquidity risk. (Option pricing tends to be most attractive for hedging liquidity risk during periods of normal or below-normal volatility, as these conditions are commonly reflected in the option volatility risk premium.) Even more importantly, pressures on the underlying security price from imbalances in liquidity demands may benefit an option owner. These liquidity pressures often lead to large and volatile price moves that raise the value of the option, both from the price change as well as from a higher volatility premium being reflected in the option value. Short option positions have negative convexity and can have sizable losses in rising volatility markets if the security is moving below the strike price (for puts) and reflecting the greater risk of even more-severe moves.

The purchase of out-of-the-money put options or long positions in volatility (VIX futures) are one of the few hedges that are effective during market disruptions (Gregory [2008]). (The VIX is now commonly accepted as a measure of market fear and instability.) In normal market periods, equity index put options typically trade at a premium to recent index volatility due to the value of these options during periods of market disruptions, especially when those periods occur after long intervals of financial stability (Grant, Gregory, and Liu [2007]). For risk-averse investors, this strategy is deserving of consideration as a hedge against financial ruin or large losses because of its ability to avoid liquidity risk and to profit from moves to extreme volatility that are typical of these periods.

CONCLUSION

In periods when the markets are not operating at high enough risk levels to deliver the returns investors seek, investors have historically tended to increase risk in an attempt to achieve higher rewards. The means for actively increasing risk include leverage, moving into riskier and less-liquid asset classes, and reducing holdings of lower-risk and

more-liquid assets. Examples of each of these tactics were readily apparent among institutional investors in the five years preceding mid-year 2007. During this five-year period, financial market innovation facilitated the growth of new products that benefited investors by allowing cheaper or more efficient access to markets (e.g., algorithmic trading, more offerings of futures, ETFs, options, and so forth).

Innovation also brought over-the-counter fixed-income products with embedded, hidden risks that only emerged during highly volatile periods, in effect incorporating short option exposure. Some structured products were advocated as an improved method of intermediating risk. They allowed consumers who previously did not have access to credit to borrow with the ability to pool or package risks in more efficient ways. Unfortunately, like portfolio insurance after the 1987 stock market crash, these innovations often contribute to, and are the first victims of, the period of financial instability that follows.

A return to normal markets should bring a return to investment processes based on well-proven techniques of risk management, such as diversification and hedging; however, we should never again let the liquidity risk issue move to the background. Given the potential for correlated and urgent fund flows in well-developed financial markets, we can never easily foresee when periods of market chaos will arrive and liquidity risk will become front and center again. These periods have surprised investors before and they will again; we, therefore, need to have contingency plans or—ideally—positions that protect us in such scenarios, that provide explicit or implicit sources of liquidity. One step in the right direction is more research on how option-based derivatives with long volatility exposure can be of help as tail risk hedges for investors with a low tolerance for short-horizon and liquidity risks.

ENDNOTES

This article was written while the author was employed by Goldman Sachs & Co. The views expressed are solely those of the author.

¹See Markowitz [1952] and Sharpe [1963, 1964].

²A similar situation can be seen in the retail sector where high discounts are offered to liquidate inventory for stores on the verge of bankruptcy due to credit scarcity.

³One of the few attempts to incorporate liquidity and trading cost issues into derivatives pricing and strategies came in the late 1980s as portfolio insurance strategies were being

formulated and explored. Work by Leland [1985] showed higher trading costs added to option prices just like an increase in volatility. An article by Hill and Jain [1988] discussed how changes in volatility and futures mispricing affected the cost of portfolio insurance with the conclusion that volatility surges had a much larger impact than futures mispricing.

⁴This is largely what happened to the highly rated tranches of CDOs containing subprime mortgages and to AIG's position in credit default swaps. As cash requirements led to a need to liquidate, book and market values needed to be aligned at the same time large amounts of supply were brought into the dealer markets.

⁵Many large endowments and foundations with long investment horizons reaped the rewards of this risk premium as they allocated significant portions of their funds to private equity.

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