

Selected Indicators of Financial Stability

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1. Introduction

The stability of the financial system, as evidenced by markets that are functioning well, by key institutions that are operating without major difficulty, and by asset prices that are not significantly removed from fundamental values, is vital if an economy is to achieve the objectives of sustained growth and low inflation. A financial system that is stable will also be resilient and will be able to withstand normal fluctuations in asset prices that result from dynamic demand and supply conditions, as well as substantial increases in uncertainty. Financial instability, on the other hand, can impede economic activity and reduce economic welfare. If financial markets become dysfunctional or the condition of key institutions becomes severely strained, the attendant pressures on businesses and households may have adverse effects on the real economy as capital may be prevented from flowing to worthy investments and credit crunches may develop. To the extent that those pressures are judged to be sufficiently acute, policymakers may want to respond by altering the stance of monetary policy. Conversely, economic and monetary policy surprises can trigger financial instability and compromise the effectiveness of the

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monetary policy transmission mechanism. As markets react to the new information, large and sudden price movements may occur that may lead to substantial losses and to heightened uncertainty and unwillingness to take on risk. Because of the interdependency between the financial system, the state of the economy, and monetary policy, monitoring financial markets and appropriately assessing their stability are tasks of great importance to policymakers. Indeed, the staff of the Federal Reserve Board devotes a significant amount of time and resources to assess the overall health of the financial system and, when financial disturbances occur, to judge the implications of those disturbances for the nonfinancial sector.

The rapid pace of financial innovation that has taken place over the course of the last decade has brought about a proliferation of new and increasingly sophisticated financial products, has led to the appearance of new types of institutions, and has created new and expanded roles for existing institutions. Against this backdrop of increased complexity, key goals of the Board's staff are to understand financial markets as well as possible and to be able to identify in a timely fashion the potential consequences of any new developments. In pursuit of those objectives, the staff relies on its expertise and judgment, on market intelligence, and on a broad range of financial indicators. Many of those indicators are measures of financial strength, that is, measures of the ability of households or businesses to weather shocks without greatly contracting their spending. Other measures focus on market participants' assessments of, and appetite for, risk. Individual indicators are also combined into aggregate measures that give a synthetic picture of overall financial conditions and thus summarize the general stability of the financial system. While notable efforts have been made in the academic literature as well as at other institutions to develop indicators that could be predictive of adverse developments, all indicators in use at the Board are contemporaneous in nature and are used purely as tools to help interpret current conditions.¹ And importantly, neither the

¹ Reviews and discussions of the predictive ability of various types of indicators, as applied to different types of crises, are contained, for example, in Berg, A. and Pattillo, C., "Are Currency Crises Predictable? A Test," IMF Staff Papers vol. 46, no. 2, June 1999, and Kumar, M.S. and Persaud, A., "Pure Contagion and Investors' Shifting Risk Appetite: Analytical Issues and Empirical Evidence," IMF Working Paper no. 134, 2001.

individual nor the aggregate measures are used as “black boxes” to determine policy actions; rather, they are just a few among a host of instruments that the Board’s staff draws on to inform policy makers of the current state of financial markets.

The individual measures of financial stability used by the Board’s staff are taken from a variety of sources, and are available at a wide range of frequencies. Some, such as asset prices, are market-based and can be calculated daily, if not even more frequently. Others, such as financial stocks and flows, are aggregated from individual institutions at a weekly, monthly, or quarterly basis. Finally, some measures are based on surveys, both formal and informal, of market participants, and are gathered on an ongoing basis. The Board of Governors is provided updates about financial market developments often (at least weekly and sometimes more frequently). The Federal Open Market Committee, which sets the overnight interbank (federal funds) rate in the United States, is provided with information on financial conditions before each FOMC meeting, although many measures are also provided to Committee members on a more frequent basis. Reports on the functioning of U.S. financial markets are prepared at regular intervals in advance of international meetings on financial stability. Several Divisions at the Federal Reserve Board, including the Divisions of Monetary Affairs, Research and Statistics, International Finance, Bank Supervision and Regulation, and Reserve Bank Operations and Payment Systems, contribute to the compilation and interpretation of this information.

While the focus of this paper is on quantitative gauges of financial stability, we should note that qualitative information also figures prominently in the set of tools Board economists use to assess the state of the financial system. Formal surveys of investors and bank senior loan officers are conducted regularly and provide timely information on the respondents’ views on current developments and their likely future unfolding. More informal contacts with market participants, either direct or through the Open Market Desk of the Federal Reserve Bank of New York, are instrumental in the interpretation of the vast amount of information that is received on any given day. Market contacts are especially valuable when events are unfolding rapidly and there is no time to wait for responses to formal surveys. Of course, qualitative information that is received from

market participants needs to be evaluated, put in context, and possibly filtered, but has nonetheless repeatedly proved useful in the past.

Sections 2 to 6 of this paper summarize some of the individual and aggregate indicators that are monitored by the authors and other members of the Board's staff.² Section 7 briefly discusses how some of those indicators were used to assess the impact of the turmoil in the credit markets in the spring of 2005 that was induced by the credit quality deterioration of two large U.S. automobile manufacturers, and section 8 contains some conclusive thoughts.

2. Measures based on interest rates and asset prices

Asset prices and interest rates are determined by the supplies and demands of forward-looking investors and savers; as such, they react nearly instantaneously to investors' judgments about financial conditions. Because many prices and rates are available virtually instantaneously and continuously, Board staff members monitor a broad range of them for prompt information on market liquidity and market participants' attitudes toward risk.³

Measures of market liquidity provide information on the ability of financial markets to absorb large transactions without large changes in prices, and on the premiums investors are willing to pay to hold more liquid assets. The Board's staff assesses the liquidity of the market for U.S. Treasury securities, in part, by looking at bid-ask spreads and volumes. As an example, the top two panels of exhibit 1 plot these measures for the

² The authors are part of the Monetary and Financial Stability section (MFST) of the Division of Monetary Affairs (MA). MFST is responsible for analyzing a variety of issues related to financial stability and the operation of financial institutions and markets. Key areas of specialization include the collection and evaluation of information on financial institutions, methods for assessing stress in financial markets, and assisting in the formulation and implementation of policies regarding Reserve Banks' credit and risk management. Section economists analyze financial developments for the Board of Governors and the FOMC and engage in a broad range of longer-term research projects. Not all the measures discussed in this paper are produced by MFST or MA.

³ This paper draws, in part, from "Pragmatic Monitoring of Financial Stability," by William R. Nelson and Wayne Passmore, in *Marrying the Macro- and Micro-Prudential Dimensions of Financial Stability*, BIS Papers, No.1, March 2001. That paper contains, among other things, a more detailed description of some of the individual indicators of financial stability in use at the time at the Federal Reserve Board.

ten-year on-the-run Treasury security in April and early May, 2005.⁴ The Treasury market is an over-the-counter (OTC) market, and consequently bid-ask spreads and volume data for Treasury securities are more difficult to obtain than for exchange-traded securities, such as stocks or most futures. The Board's staff currently relies on intraday data collected by electronic brokers, such as BrokerTec for the interdealer market and TradeWeb for the dealer-to-customer market. While those electronic brokers do not represent the whole market, they appear to account for substantial and growing percentages of the total daily trading volumes in Treasury securities.

[Exhibit 1 about here]

Members of the Board's staff also follow liquidity premiums, defined as the yield on a less liquid security minus the yield on a highly liquid but otherwise similar security. Highly liquid securities, generally, can be sold rapidly and at a known price. The amount investors are willing to pay for that comfort, in the form of higher prices or lower yields with respect to less liquid securities, may rise rapidly during periods of financial market difficulties, particularly when the source of such difficulties is heightened investor uncertainty. Because these spreads may react rapidly to financial difficulties, and are available at high frequencies, the Board's staff reviews them often. The middle-left panel of exhibit 1 plots the liquidity premium for the two- and ten-year on-the-run Treasury securities relative to the corresponding first-off-the-run securities in recent months, adjusted for the auction cycle. Yield data on Treasury securities are readily available from a variety of sources.

As suggested by economic theory, expected yields on risky debt instruments and equities relative to those on riskless assets vary with investors' assessments of risk and willingness to bear risk. The spreads between the yields on riskier and less risky securities widen when investors judge their relative risks to have increased, and also

⁴ Corporate credit markets were under stress at that time because of the problems at Ford and General Motors. The Treasury market, however, was functioning properly, as evidenced by the minimal bid-ask spreads and the substantial volumes.

when investors demand a higher premium for a given amount of risk. Thus, these spreads will increase when investor uncertainty increases or financial conditions worsen; a sharp widening of these spreads has often been a component of financial turmoil. Examples of such spreads are the differences between investment-grade and speculative-grade corporate yields and comparable-maturity Treasury yields, plotted in the middle-right panel of exhibit 1. The Federal Reserve Board receives yields on several thousand outstanding corporate bonds every day; those data are then used to compute a variety of indexes, such as those shown in the exhibit. Other spreads over Treasury securities that are regularly monitored are swap spreads, which can provide information on the credit quality of the banking sector as well as market liquidity conditions; agency spreads (also relative to swaps and high-grade corporate debt), which are proxies for the housing government-sponsored enterprises' (or GSEs) cost of funds; and money market spreads, such as commercial paper spreads (an indicator of the costs of short-term corporate funding).

Equity prices vary with changes in investors' appetite for risk; in investors' expectations for, and uncertainty about, future macroeconomic and firm-specific outcomes; and in the clarity of information available to investors. To invest in equities, investors demand a premium over bond yields because the return on bonds is generally more predictable. The Board's staff assesses the equity premium in a number of ways, including by comparing the earnings-price ratio of the S&P 500 to the real level of the ten-year Treasury rate—the lower-left panel in exhibit 1. The earnings-price ratio is calculated using analysts' expectations for earnings during the upcoming year and is adjusted to remove the effect of cyclical changes in earnings. For this purpose, the real ten-year interest rate is calculated by subtracting a survey-based measure of long-term inflation expectations from a nominal long-run Treasury rate. Unfortunately, interpreting changes in this measure of the equity premium is difficult. For example, a decline in the earnings-price ratio relative to the real interest rate may reflect new economic information that raises investors' expectations of future earnings growth; or it may indicate that investors have better information or greater certainty about economic outcomes, or an enhanced appetite for risk. Comparisons of analysts' expectations about

longer-term earnings growth to the staff's forecast of earnings permit some judgments about reasons for changes in the earnings-price ratio, but such analysis embodies a great degree of uncertainty.

The Board's staff uses option prices to measure investors' assessment of the likely volatility of interest rates and equity prices. These measures have proven to be useful and timely indicators of investor uncertainty and can also be used to construct the probability distribution of underlying economic outcomes. For example, options on Eurodollar futures provide a measure of the expected volatility of very short-term rates, which rises when investors become more uncertain about the future path of near-term monetary policy (the black line in the lower-right panel of exhibit 1). Equity options (the red line) provide information on investors' uncertainty about equity prices. Those options can also be used to construct the risk-neutral probability distribution of the returns on underlying contract (such as the S&P 500 index): A distribution with a long left tail would presumably indicate elevated market participants' concerns about, or aversion to the possibility of, large losses before the options' expiration.

Those described above are but a small sample of the indicators based on interest rates and asset prices that members of the Board's staff regularly monitor. A rough count of the number of the basic, individual indicators in daily (or more frequent) production easily exceeds one hundred. Large amounts of data are necessary to construct those indicators and use them in daily reports. In addition, the data, which are provided by a large number of different sources, in different formats, and often at different frequencies, need to be stored in a convenient and easily-accessible database. Significant resources are devoted to the maintenance of such a database, in terms of software, storage space, network accessibility, and personnel.

3. A financial fragility indicator

The information contained in an array of financial variables such as those described above can be condensed into a financial fragility indicator which estimates the probability that the U.S. financial system is currently under severe stress. In our view, two episodes

in recent U.S. financial history can unambiguously be called financial crises—the weeks surrounding the Russian default and the recapitalization of Long Term Capital Management in the fall of 1998, and the aftermath of September 11, 2001. While the causes of those crises were entirely different, several key financial variables behaved in a very similar way during both of those episodes. In particular, risk, liquidity, and term spreads and implied volatilities all moved significantly higher at those times; moreover, they did so at a rapid pace and largely at the same time. Based on these observations, the construction of the indicator follows a two-step process. First, the information contained in the twelve individual variables listed in the top panel of exhibit 2 is reduced to three summary statistics that capture their level, their rate of change, and their correlation.⁵ And second, a logit model is estimated to obtain the probability that, at any given time and based on the three summary statistics, the behavior of financial markets is analogous to that of the fall of 1998, and the aftermath of the terrorist attacks of 2001.

[Exhibit 2 about here]

Perhaps the most straightforward summary statistic, plotted in the middle-left panel, is an arithmetic average of the values of the individual indicators, normalized by their standard deviations, over the entire sample period from 1994 to the present. As noted by the gray-shaded regions, the index is quite elevated during times of acute stress.⁶ As shown in the middle-center panel, the percentage change in the level indicator computed over rolling eight-week intervals gives a sense of the speed of the movements in the underlying financial market variables. One might expect that financial markets would be more “fragile” during episodes when risk spreads, liquidity premiums, and volatility indicators are moving sharply higher. Conversely, even when the level of those indicators remains high, sharp declines in many or all of them might signal the end of a period of acute financial distress. This rate-of-change indicator again singles out the fall

⁵ Those indicators are quoted so that higher values would be associated with greater market strains.

⁶ A third episode during which financial markets were under heavy strain, in addition to the two noted earlier, was the summer and fall of 2002, when risk spreads widened sharply in response to corporate scandals and credit quality problems at several large institutions.

of 1998, the weeks following the terrorist attacks, and the late summer of 2002 as particularly noteworthy periods.

As shown in the middle-right panel, a time-varying measure of the comovement in the individual stress variables can be defined as the percentage of the total variation of the individual variables that can be explained by a single, common factor. This measure was highest at the time of the global financial crisis of 1998, but the months in the run-up to Y2K and following the September 11th attacks were also characterized by elevated correlation among the key financial variables. The shaded region corresponding to the late summer and fall of 2002 does not stand out as a period of high comovement. Even though risk spreads widened dramatically at that time, changes in other measures of market stress were mixed.

The three summary statistics discussed above can be combined into a single measure of financial fragility and used to model the probability that, at any given time, the U.S. financial system is in a situation similar to that of the periods identified as crises. This can be accomplished by fitting a logit model with the three statistics as explanatory variables and a binary variable which identifies crises on the left-hand-side:

$$p_t = L(\beta_0 + \beta_1\lambda_t + \beta_2\delta_t + \beta_3\rho_t)$$

In the formula above λ denotes the level indicator, δ represents the rate-of-change indicator, and ρ is the comovement indicator.

The model is estimated using weekly data from June 1994 to June 2002, with the episodes of 1998 and 2001 defined as crises, and then extended “out-of-sample” until the present.⁷ The fitted probability of being in a crisis at each date in the sample is shown in the bottom panel of exhibit 2. As expected, the period of August to October 1998 emerges as the most severe episode of financial fragility in the recent past. The model does show an increase in the probability of crisis or financial fragility at other points in time that were not defined as crises. For example, there is a notable uptick in early 1999

⁷ The summer and fall of 2002 seems to have been, in retrospect, a time of less virulent strain in U.S. markets, and thus was not classified as a crisis period and was not included in the estimation. A robustness check showed that results would be qualitatively similar if it had been defined as a period of crisis and if the estimation period had been extended to the end of 2002.

coincident with market concerns about developments in Brazil. The summer and fall of 2002 also stand out, although not at levels as high as the two major crises. The last notable—but minor—peak occurred in the spring of 2004, when there was some unease in financial markets about the onset of monetary policy tightening and uncertainty about the pace at which it would proceed after it was started. The measure has remained at quite low levels in the spring of 2005, suggesting that the turmoil in credit markets that was sparked by credit problems at the large automobile manufacturers has not affected other markets to a significant extent.

4. Mortgage market indicators

In recent years, the U.S. mortgage market has grown rapidly. At the end of 2004, the total value of mortgages outstanding exceeded \$10 trillion, of which \$8 trillion were single-family residential mortgages; of those mortgages, about \$4.5 trillion were pooled into MBS, or mortgage-backed securities. The MBS market is larger than the Treasury market, the nonfinancial corporate bond market, and the agency market. Virtually all mortgages pooled into U.S. MBS can be prepaid with no penalty; the prepayment option induces what is known as “negative convexity,” which implies that duration decreases when yields decrease and increases when yields increase. Because of the size of the market, MBS investors who desire to hedge the prepayment risk of those securities are now, in the aggregate, required to buy or sell substantial amounts of other financial instruments; the volumes involved have the potential to reinforce existing market trends. Such effects can arise under a variety of hedging strategies, but they are perhaps best understood in a simple example of dynamic hedging. A decline in market interest rates, say, causes an increase in prepayment risk that reduces the duration of outstanding MBS. Holders of those securities who wish to maintain the duration of their portfolios at a constant target would then have to purchase other longer-term fixed-income securities to add duration, potentially causing yields to fall further. Similar effects tend to amplify increases in market interest rates as well. Thus, mortgage-related hedging flows have the potential, at least for a while, to push interest rates significantly above or below the level

that would be justified by macroeconomic conditions and expectations, and to increase the volatility of fixed-income markets. Quantifying the extent to which interest rates may at times be misaligned with economic fundamentals is thus important both from a financial stability and from a monetary policy perspective.

Several indicators are useful to monitor the impact that mortgage market conditions have on long-term interest rates. One is the average duration of all fixed-rate mortgages included in outstanding MBS securities, plotted in the top-left panel of exhibit 3. Periods of time when duration is increasing or decreasing rapidly could be associated with large hedging flows, as investors buy or sell other fixed-income securities in order to maintain an approximately constant duration target for their portfolios. A rough estimate of the size of those flows can be obtained by assuming that investors have a duration target of 4.5 years and that all MBS investors hedge in the same way.⁸ The amount of ten-year equivalent securities that investors would need to hold in their portfolio to achieve their hypothetical target is plotted in the top-right panel of the exhibit. A rapid increase or decrease in the amount plotted indicates a corresponding potential increase in the demand or the supply of ten-year equivalent securities. For example, in July and early August of 2003, when long-term rates rose rapidly as investors sensed that the Federal Reserve's easing cycle had ended, up to \$2 trillion of ten-year equivalent securities may have been sold in the market, likely amplifying the upward move in rates that was already taking place.⁹

[Exhibit 3 about here]

Perhaps more interesting than duration is convexity (which can be interpreted roughly as the amount by which duration would change following a 100 basis points change in yields). MBS convexity depends mostly on how likely mortgage holders are to prepay their mortgage; that likelihood, in turn, depends on the distance between the

⁸ The hypothetical 4.5 years target matches the historical average duration of MBS at times when little refinancing activity was taking place.

⁹ That estimate is conditional on all mortgage investors fully hedging their portfolios, and as such it provides an upper limit to the actual flows.

current mortgage rate and the rates of outstanding mortgages. The middle-left panel of exhibit 3 shows the percentage of mortgages in outstanding MBS that are economically refinaneable at a given mortgage rate.¹⁰ The steeper the cumulative distribution is at the current mortgage rate, the higher (more negative) is the convexity of the MBS market. A time series of convexity itself is plotted at the right; for example, in mid 2005, convexity was as negative as it had been in recent years, suggesting that the potential risk of increased volatility in the Treasury and related markets was high.¹¹

The information contained in MBS duration and convexity can be used to estimate by how much long-term interest rates shocks are likely to be amplified by mortgage-related hedging flows. Following Perli and Sack (2003), the amplification factor can be obtained by fitting a GARCH model to the volatility of interest rates, under the assumption that hedging flows are determined by either the duration, or the convexity, or the actual amount of refinancing activity currently taking place in the market.¹² The amplification factor is plotted in the last panel of the exhibit: According to our estimates, up to 20 percent of the downward move in ten-year yields that took place earlier in 2005 can be attributed to hedging-related flows. While the confidence interval around that point estimate is fairly wide, it is clear that mortgage hedging could have significant effects on the fixed-income markets that should be monitored carefully. It is important to note that hedging activities, at least in our framework, are never the factor that set off moves in interest rates; they can only amplify, albeit substantially, moves that are already in place.

¹⁰ We assume that the current mortgage rate should be 50 basis points below the existing rate to make it worthwhile to refinance a mortgage due to the various fees associated with extinguishing an old mortgage and starting a new one. The data in the chart are as of the end of May 2005.

¹¹ Duration and convexity help inform judgments of the likelihood that substantial mortgage prepayments will take place. It is also useful to monitor the actual pace of refinancing activity; that measure is shown in the bottom-left panel of exhibit 3.

¹² See Perli, R. and Sack, B., "Does Mortgage Hedging Amplify Movements in Long-Term Interest Rates?," *The Journal of Fixed Income*, vol. 13, December 2003, pp. 7-17.

5. Measures of conditions of individual institutions

Banks can act as transmission mechanisms of crises because they may sharply contract credit in response to depositor demands for early and quick redemption of funds. Or, with deposit insurance, depository institution liabilities may rise with heightened demand for safety and liquidity. The Federal Reserve collects weekly data on bank credit and the monetary aggregates which, to some extent, can be used to monitor financial problems. For example, rapid growth in bank business loans may indicate substitution away from unreceptive capital markets. Similarly, the monetary aggregates may grow more rapidly when investors shift funds out of bond and stock mutual funds and into safer and more liquid bank deposits or money funds.

In the past, both aggressive lending practices and the contraction of lending at banks have been cited as the transmission mechanism of financial problems to nonfinancial businesses and households. The Board collects information from commercial banks four times per year—before every other FOMC meeting—on the standards and terms on, and demand for, loans to businesses and households in its Senior Loan Officer Survey on Bank Lending Practices. The Senior Loan Officer Survey poses a broad range of questions to loan officers at approximately sixty large domestic banks and twenty-four U.S. branches of foreign banks. On the topic of banks' tolerance for risk, the survey asks about changes in risk premiums on business loans, and about changes in business loan standards. Although these surveys are not frequent enough to use for monitoring a quickly unfolding financial crisis, the Federal Reserve has authority to conduct up to six surveys a year, and has done special surveys when warranted by financial conditions, most recently in March of 2001.

The Federal Reserve is the umbrella regulator for financial services holding companies, the primary regulator of bank holding companies, U.S. branches of foreign banks, and state-chartered banks that are members of the Federal Reserve System; other institutions have other primary regulators, with whom Federal Reserve regulatory staff maintains close contacts. Through its supervisory role, the Federal Reserve learns about the condition and behavior of commercial banks, and acts to maintain the soundness of these institutions. During periods of financial turmoil, the familiarity with these

intermediaries deepens the Federal Reserve’s understanding of developing conditions. Communication between the regulatory and policy functions occurs regularly and is institutionalized at various levels.

Not all financial institutions are depositories; indeed many large ones, such as insurance companies, the financial subsidiaries of large nonfinancial corporations, the housing GSEs, etc., are not. In addition, many nonfinancial corporations are heavy participants in financial markets—through their commercial paper and bond issuance programs—and often have large lines of credit with banks. While the Federal Reserve does not regulate most nondepository financial and nonfinancial institutions, the Board’s staff does monitor information that bears on financial conditions to be able to assess the impact of difficulties at one or more of those institutions on the financial system. The monitoring takes place primarily through market-based indicators, such as commercial paper, corporate bond, and credit default swap (CDS) spreads.

An example of nonfinancial institutions monitoring is presented in the top two panels of exhibit 4. Two large U.S. automobile manufacturers have experienced some difficulties in the spring of 2005; the top-left panel of the exhibit plots five-year CDS spreads for the two institutions, as well as the average spread for CCC-rated institutions.¹³ While the rating agencies downgraded the obligations of one or both automakers to junk status beginning in early May, judging from the CDS spreads plotted in the charts market participants anticipated the rating action by many months. The chart at the top-right shows the term structure of default probabilities for the two automakers obtained from CDS spreads as of the end of May 2005. The term structure for another large nonfinancial institution is shown for comparison purposes.

[Exhibit 4 about here]

The Board’s staff monitors CDS on a large number of institutions, both financial and nonfinancial. As of this writing, CDS data is available on about a thousand U.S.

¹³ Our data source, Markit, does not report CDS quotes for firms rated below CCC.

firms, of which roughly two-thirds are rated investment-grade and the remainder are rated speculative-grade. With such a large amount of data, it is useful and convenient to calculate indexes. The investment-grade and speculative-grade indexes computed by weighting each individual CDS spread by the outstanding liabilities of the corresponding firm are plotted in the middle panels of exhibit 4. The panels also show the corresponding market-traded indexes, which are constructed as equally-weighted averages of the CDS spreads of the component firms. Those indexes can serve as an alternative to the corporate bond spreads shown in exhibit 1. For several firms CDS are reported to be more liquid than corporate bonds, so CDS indexes may actually be more representative of current market conditions than corporate bond spread indexes.¹⁴

Credit default swaps give an idea of investors' perception of the riskiness of an institution, but the probabilities of default derived from those instruments are risk-neutral probabilities, i.e., they incorporate investors' attitude toward risk. Obtaining good measures of actual default probabilities is not easy. One option is to use KMV Corp.'s expected default frequencies (EDF). Those are derived by first computing distances to default for all publicly traded firms in the U.S. based on Merton's model, and then by mapping those distances to default into actual defaults using a large historical database.¹⁵ Actual default probabilities are typically lower than risk-neutral probabilities since the latter include a risk premium. Indeed, as shown in the bottom-left panel of exhibit 4, the EDF for General Motors, as estimated by KMV, has been substantially lower than the corresponding risk-neutral default probability since 2002; the risk-neutral probability has surged in March and April of 2005 following the much-publicized problems and the consequent credit rating downgrades, while the EDF has only edged up. The difference

¹⁴ This is especially true at times when individual institutions are experiencing difficulties. At those times many investors would want to sell short the trouble institutions' bonds, but those bonds may be hard to obtain in the repo market. Many corporate bonds are typically held by money-managing firms, such as pension funds or mutual funds, that already have plenty of cash and don't need to finance the purchase of the bonds. Those institutions, thus, may not make the bonds available in the repo market, since by doing so they would effectively pay to obtain even more cash. A more detailed analysis of the deviations between CDS and corporate bond spreads is contained in A. Levin, R. Perli, and E. Zakrajšek (2005), "The Determinants of Market Frictions in the Corporate Market," manuscript, Federal Reserve Board.

¹⁵ For the details see R.C. Merton (1973), "A Rational Theory of Option Pricing," *Bell Journal of Economics and Management Science*, 4, pp. 141 – 183 and KMV Corp., "Modeling Default Risk," January 2002, available at www.moodyskmv.com.

between the two provides a rough estimate of the risk premium that investors demand to provide credit protection on General Motors obligations.

Before backing up in coincidence with the problems at Ford and General Motors, credit spreads declined to levels near or below those that prevailed before the crisis of 1998, and some observers have expressed concern that investors' are not pricing risk properly. The difference between risk-neutral probabilities and the EDFs can be taken for all firms for which data are available, and the average or median of that difference across all firms is a measure of the corporate risk premium.¹⁶ This measure is plotted in the bottom-right panel of exhibit 4 for both investment-grade and speculative-grade reference entities. While it is true that the risk premium fell to very low levels (virtually zero, indeed) in the early part of 2005, it backed up noticeably in March and April, especially for speculative-grade credits.

6. Probabilities of multiple defaults

Corporate spreads or credit default swap spreads and KMV's EDF can be used to assess the probability that an individual institution will default within a given time interval. However, from a systemic risk perspective, the likelihood that more than one institution will default within a short time period is arguably more interesting than the probability of an individual default. An estimate of that likelihood can be computed using a Merton/KMV methodology, modified to take into account the correlation among a group of financial institutions. According to Merton's work, an institution's probability of default is a function of three major factors: the market value of the firm's assets (a measure of the present value of the future free cash flows produced by the firm's assets); the asset risk, or asset volatility (which measures the uncertainty surrounding the market value of the firm's assets); and the degree of implied leverage (i.e., the ratio of the book value of liabilities to the market value of assets). A firm's probability of default

¹⁶ See also Berndt, A., Douglas, R., Duffie, D, Ferguson, M., and Schranz, D. (2004), "Measuring Default Risk Premia from Default Swap Rates and EDFs," available at www.orie.cornell.edu/aberndt/papers.html. The authors take the ratio of the two probabilities as a measure of the corporate risk premium.

increases as the value of assets approaches (from above) the value of liabilities; in theory, when the two cross, the firm should be assumed to be in default, as future incoming cash flows will not be sufficient to cover the firm's commitments. At any given time, the probability of multiple simultaneous defaults can be assessed by simulating the market value of assets of a number of firms in a certain sample, based on the volatility of those assets and their correlation. Since market value of assets, asset volatility, and asset correlation are not directly observable, they first have to be estimated from available information.

Estimates of the market value of assets and its volatility can be obtained by using the Black-Scholes methodology and interpreting a firm's market value of equity as a call option on the firm's asset value struck at the book value of liabilities. The asset correlation matrix, which is assumed to be time-varying, can be estimated by using rolling windows or by way of an exponentially-weighted moving average model (EWMA).

Given current estimates for the market value of assets, asset volatility, and asset correlation for a sample of firms, the market value of assets of each firm can be simulated a large number of times for a period of, say, one year, according to a standard Brownian motion model. The probability of multiple defaults among the institutions in the sample can be computed as the relative frequency of the event that the market value of assets will fall below the book value of liabilities for at least two institutions.

That probability, and the probability of at least one default (which is computed similarly), are plotted in exhibit 5 for a group of about 50 large financial institutions that includes banks, broker-dealers, and other financial institutions. Over the time period considered—August 1993 to May 2005—the most stressful periods for the institutions in our sample were, according to those measures, the fall of 1998 and the summer and fall of 2002. The spring of 2000, when the equity bubble began to burst, also stands out prominently, although concerns about the viability of financial institutions at that time appear to have been short-lived. Interestingly, the probabilities of default in the aftermath of September 11, 2001 were not as high as those in the other periods. Evidently, while financial markets were under substantial stress, investors did not

perceive that the solvency of large financial institutions was threatened at the time. The credit problems at large automobile manufacturers in the spring of 2005 generated only a minor uptick in both probabilities, indicating that investors perceived those problems as well contained.

[Exhibit 5 about here]

The probabilities of defaults plotted in exhibit 5 may seem somewhat high, given that there were relatively few actual defaults of financial institutions since 1994. Several factors, though, should be taken into account when interpreting those probabilities:

- The probability of multiple defaults depends on the sample of institutions that is considered, and it may well be larger than the probability that any given institution will default individually. For example, for a sample of 100 firms all independent of each other and with probability of default of 1 percent within a given time period, the probability that two or more of them will default within the same period is 26 percent. For a sample of ten firms, that same probability is just 0.4 percent.
- The default probabilities obtained from Merton's model are risk-neutral probabilities, since it is assumed that the expected return on any firm's asset is the risk-free rate. Risk-neutral probabilities are typically higher than actual default probabilities, and possibly much higher at times of intense risk aversion. No attempt is made to empirically map the risk-neutral default probabilities into actual defaults, as KMV does.
- Actual defaults may not occur as soon as the market value of assets equals the book value of liabilities; indeed, KMV found empirically that the market value of assets dips further below that theoretical threshold before a default actually occurs. If a lower default threshold had been used, the probabilities would have been correspondingly lower.

These observations suggest that the probabilities shown in exhibit 5 may be most informative when looked at in relation to their own values at different points in time. For example, while it could be useful to know that the estimated probability of multiple

defaults was about 5 percent after the terrorist attacks of 2001, it may be preferable to focus on the fact that at that time it was about four times smaller than in the fall of 1998.

7. An example of market monitoring: hedge fund losses induced by difficulties at Ford and General Motors

News reports surfaced in early May 2005 indicating that some hedge funds may have incurred significant losses as a result of the widening of corporate credit spreads that started in mid-March on the heels of the difficulties reported by the two largest U.S. automobile manufacturers. This section presents some data on hedge fund performance over that period and describes two of the trades that allegedly resulted in significant losses. While those trades were quite unprofitable and several funds indeed reported substantial losses in April and May, the impact on financial markets appears to have been contained.

Several funds that were mentioned in press reports publicly denied experiencing particular difficulties. The available data, however, indicate unusually poor hedge fund returns for the month of April, as shown in the top panel of exhibit 6. Quite a few large funds reported losses between 5 and 8 percent in that month, and many other smaller funds performed significantly worse.¹⁷

[Exhibit 6 about here]

The known hedge fund losses, and fears of losses as yet unknown, sparked concerns that some banks and investment banks that have provided prime brokerage services to hedge funds may have large exposures to troubled funds.¹⁸ Most of the major

¹⁷ While hedge funds are not required to publish their performance statistics, many voluntarily choose to do so. The source of our data is Bloomberg, which collects data for several thousands hedge funds and funds of hedge funds with a total of more than \$800 billion of assets under management. However, the very largest funds, including some of those mentioned in press reports, are not well represented in the database.

¹⁸ Prime brokers provide a variety of services to hedge funds, including financing, trade execution, and performance reporting.

prime brokers stated publicly that most or all of their hedge fund exposures were fully collateralized and that their capital positions were strong; still, as shown in the bottom panels, these firms' stock prices dropped, and their credit spreads widened notably in mid May, although from low levels.

While the hedge fund losses that were reported were not dramatic, some of the funds that did not publicly report their performance may have fared significantly worse. To better understand the losses that some funds may have suffered as a consequence of the turmoil in the auto sector, we discuss two types of trades that reportedly were popular among some funds in the months preceding the roiling of credit markets. One such trade involved simply selling protection on auto-sector reference entities in the CDS market. Some funds reportedly believed that Ford and GM spreads already discounted the possibility of a downgrade to junk back in March, before the actual downgrade and even before GM warned about poor earnings on March 16. Indeed, both firms' CDS spreads were already comparable to those of low-quality speculative-grade issuers at that time. GM spreads, however, widened dramatically after its preannouncement and, as shown in the top panel of exhibit 7, a fund that sold five-year protection on a notional amount of \$10 million of GM debt on March 15 would have sustained a mark-to-market loss of more than \$2 million as of the market close on May 15, or more than 20 percent of the notional exposure.¹⁹ Losses would have been comparable if protection of Ford debt had been sold instead.²⁰ Hedge funds, of course, could have exited the trade earlier, but they still would have suffered substantial losses, especially after taking transaction costs into

¹⁹ A trade size of \$10 million is common among investors. Note that a notional exposure of \$10 million does not imply an investment of \$10 million: Usually the amount tied up in the trade, as margin or collateral, is much smaller.

²⁰ Hedge funds would have performed marginally better if they had bought a \$10 million GM bond, since bond spreads widened a bit less than those on CDS; however, funds would have had to finance the bond purchase. Press reports indicated that some funds may have hedged the CDS position by selling GM stock short or by purchasing equity put options. Given that GM's stock price declined only 8 percent since mid-March, that hedge would have been largely ineffective. For example, investing the entire CDS premium in GM at-the-money put options would have reduced the net loss by less than \$0.5 million as of c.o.b. May 15.

account.²¹ Those funds that were willing or able to hold on to their position have seen a partial reversal of their losses, as GM spreads tightened significantly starting in June.

[Exhibit 7 about here]

A second type of trade that is said to have been popular among hedge funds in the months leading to the credit market turmoil involved buying and selling protection in tranches of CDS indexes. Many funds have reportedly sold protection on the equity tranche of the benchmark investment-grade CDS index, and at the same time bought protection on an appropriately-scaled notional amount of the mezzanine tranche of the same index.²² This trade has been dubbed the “correlation trade” because its profitability depends on investors’ assessment of the likelihood that defaults among the components of the index will be clustered in time—the default correlation.²³ As shown in the bottom-left panel of exhibit 7, spreads on the index equity tranche surged in April and May—especially after Standard and Poor’s downgraded Ford’s and General Motors’ debt to junk status—while those on the mezzanine tranche rose only moderately. As a consequence, a correlation trade on a \$10 million notional amount entered into on March 15 would have been somewhat profitable until early May—the bottom-right panel—but would have lost between \$1 and \$2 million after May 7.

²¹ Bid-ask spreads on Ford and GM CDS reportedly widened in March and April.

²² The index is the average of the spreads of 125 CDS of equal notional amount written on large and liquid reference entities. The equity tranche is designed to absorb the first 3 percent of losses generated by defaults of those reference entities, while the mezzanine tranche absorbs subsequent losses up to 7 percent (further losses are absorbed by more senior tranches).

²³ A high default correlation can be interpreted as a sign that investors perceive that the components of the index are vulnerable to systemic shocks. A low default correlation is instead an indication that investors are more concerned about idiosyncratic risk. Default correlation has been low and trending down since the inception of the CDS index in late 2003. The problems and consequent downgrades of Ford and GM evidently exacerbated investors’ concern about idiosyncratic risk, and default correlation dropped sharply in early May. While the mezzanine tranche is relatively insensitive to changes in default correlation, the value of the equity tranche is directly proportional to it. Intuitively, if defaults are clustered together in time—or highly correlated—the likelihood of a few defaults is lower than if defaults are randomly distributed—or uncorrelated. Since a few defaults are all it takes for investors to lose 100 percent of their investment in the equity tranche, the value of that tranche diminishes when default correlation declines.

The trades examined here were clearly unprofitable, but the magnitude of actual hedge fund losses depends on several factors, such as the extent of their involvement in these and similar trades and their degree of leverage. The available data, including readings from many of the indicators mentioned in this paper and conversations with market participants, were instrumental in forming the opinion that the situation, while by no means inconsequential, was not likely to cause major market disruptions and to spread throughout the financial system. While some strains could obviously be noticed in the CDS market, where spreads jumped appreciably and index tranches were repriced sharply, liquidity conditions remained close to normal in most markets throughout the whole episode, implied volatilities stayed low, there were no signs that markets were behaving as if a significant crisis was under way, and key financial and nonfinancial institutions, with the exception of those in the automobile sector, did not show signs of any particular stress. In the event, a number of hedge funds suffered severe losses, a few ceased to exist, presumably some prime brokers' loans to hedge funds became impaired, and dealers posted poor trading results that affected their second-quarter profitability. Overall, however, the financial system proved resilient and absorbed the shock well and conditions in credit markets returned close to normal by June, with the exception that implied default correlation remained low; as a consequence, mark-to-market losses suffered in the correlation trade remain large as of this writing.

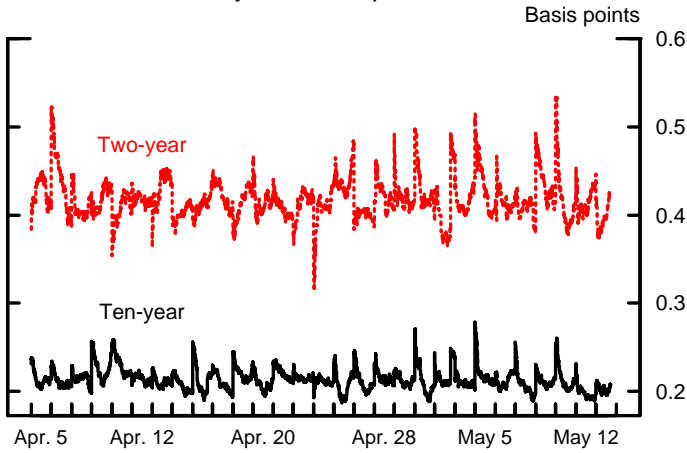
8. Conclusions

We have discussed a number of financial indicators that the Board's staff uses as aids in the interpretation of the conditions of the financial system. Some of those indicators are simple and readily available, while others are more complex in nature and require access to substantial amount of data. None are obviously perfect, in the sense that they are certainly not capable of consistently and correctly gauging the health of financial markets and institutions at any give time. Moreover, the construction of some of them is not solidly grounded in economic or financial theory, and as a consequence they perhaps could be improved. Indeed, all indicators presented here, and certainly their

interpretation, are to be considered as “work in progress.” However, we believe that, when used in conjunction with staff expertise, solid market intelligence, and good judgment, they are valuable tools in assessing the state of financial conditions, in pointing out potential vulnerabilities, and in gauging the severity of crises when they occur.

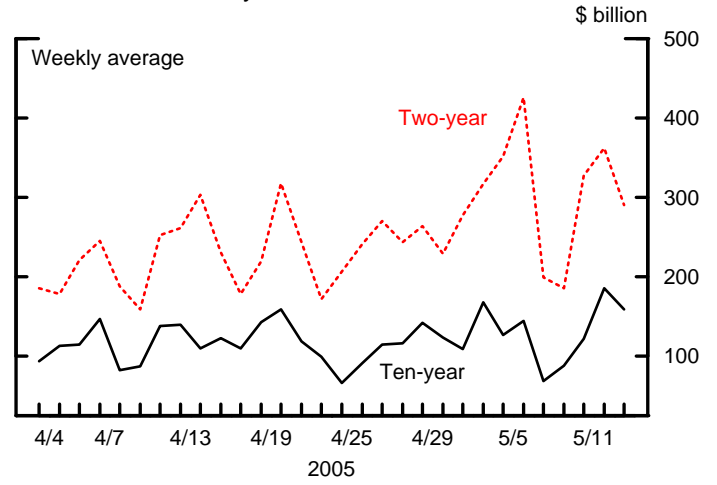
Exhibit 1 Measures Based on Interest Rates and Asset Prices

Interdealer Treasury Bid-Ask Spreads*



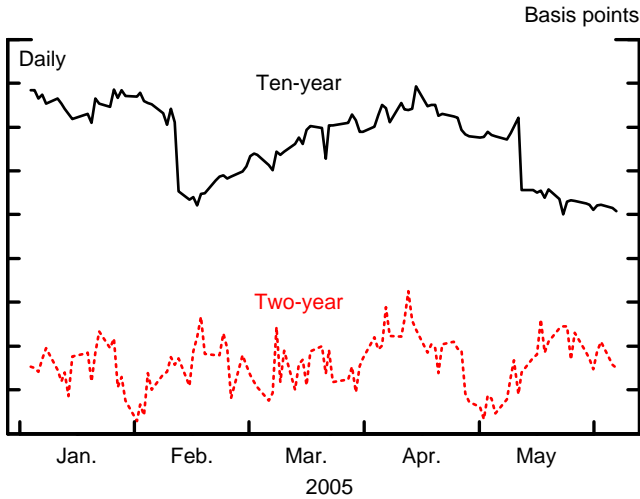
*Intraday four-hour moving average. Source: BrokerTec.

Interdealer Treasury Volumes*



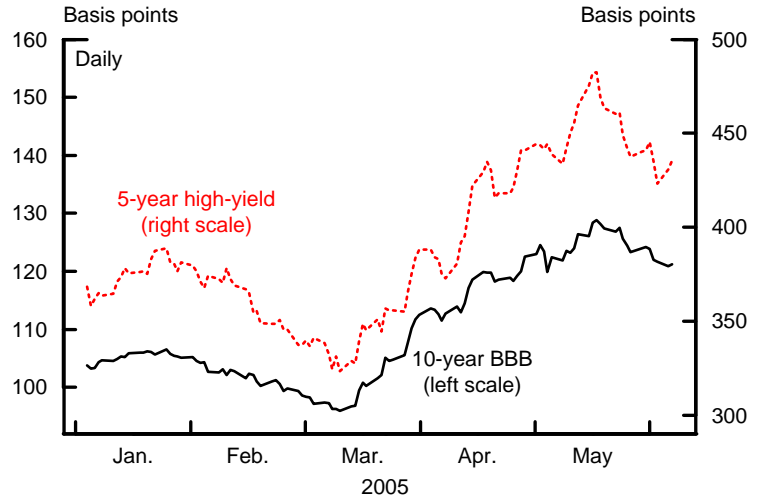
*Source: BrokerTec.

Treasury Liquidity Premiums*



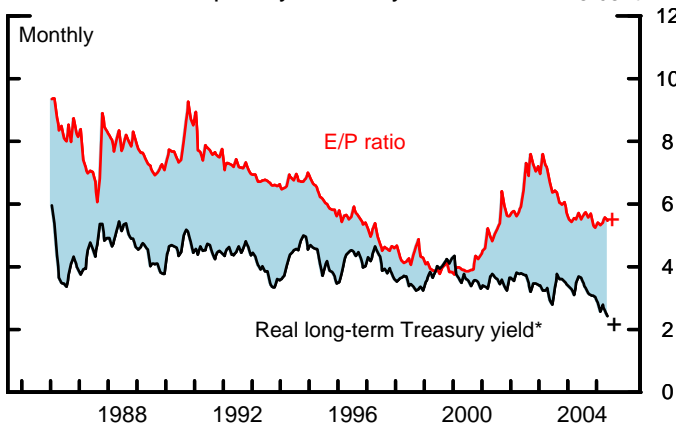
*Computed as the spread of the yield read from an estimated off-the-run yield curve over the on-the-run Treasury yield.

Corporate Bond Spreads*



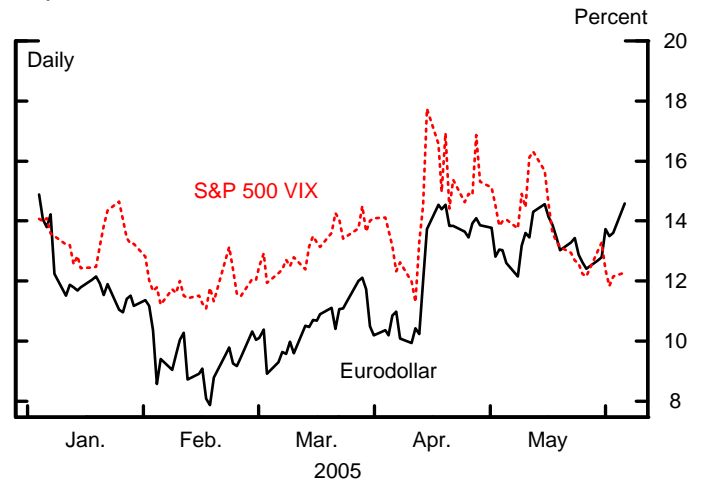
*Based on yield curves estimated using Merrill Lynch bond data.

12-Month Forward Trend Earnings-Price Ratio for S&P 500 and Perpetuity Treasury Yield



* Perpetuity Treasury yield minus Philadelphia Fed 10-year expected inflation.
Note. + Denotes the latest observation using daily interest rates and stock prices and latest earnings data from I/B/E/S.

Implied Volatilities*



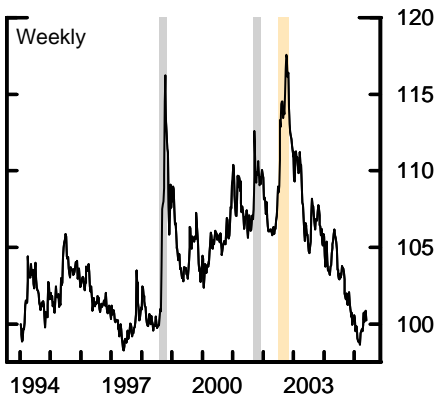
*Calculated from options on the underlying contract.

Exhibit 2 Financial Fragility Indicators

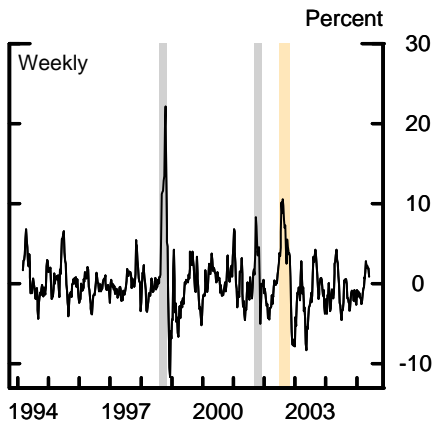
List of Financial Variables Summarized

- | | |
|---|--|
| <ul style="list-style-type: none"> ● 2-year liquidity premium ● 10-year liquidity premium ● BBB risk spreads ● AA risk spreads ● High-yield risk spreads (7-year) ● 3-month Eurodollar confidence interval 1-year ahead | <ul style="list-style-type: none"> ● Long bond implied volatility ● Eurodollar implied volatility ● 10-year Treasury implied volatility ● SP100 implied volatility (VXO) ● Federal funds target - 2-year Treasury ● (12-month ahead earnings/SP500) - (10-year Treasury) |
|---|--|

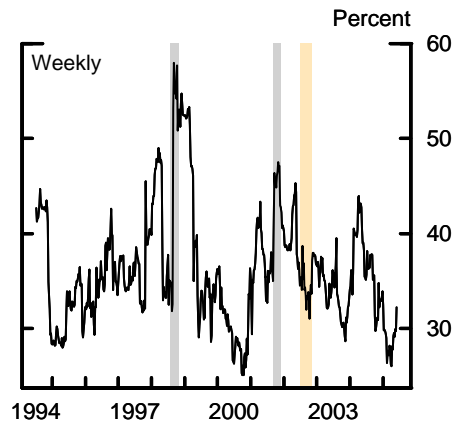
Index of Normalized Variables, January 1994 = 100



Rolling Eight-week Changes, Index of Normalized Variables



Comovement Indicator*



*Percent of total variation in individual stress variables explained by the first factor in a rolling 26-week window.

Financial Fragility Indicator (Probability of Crisis)

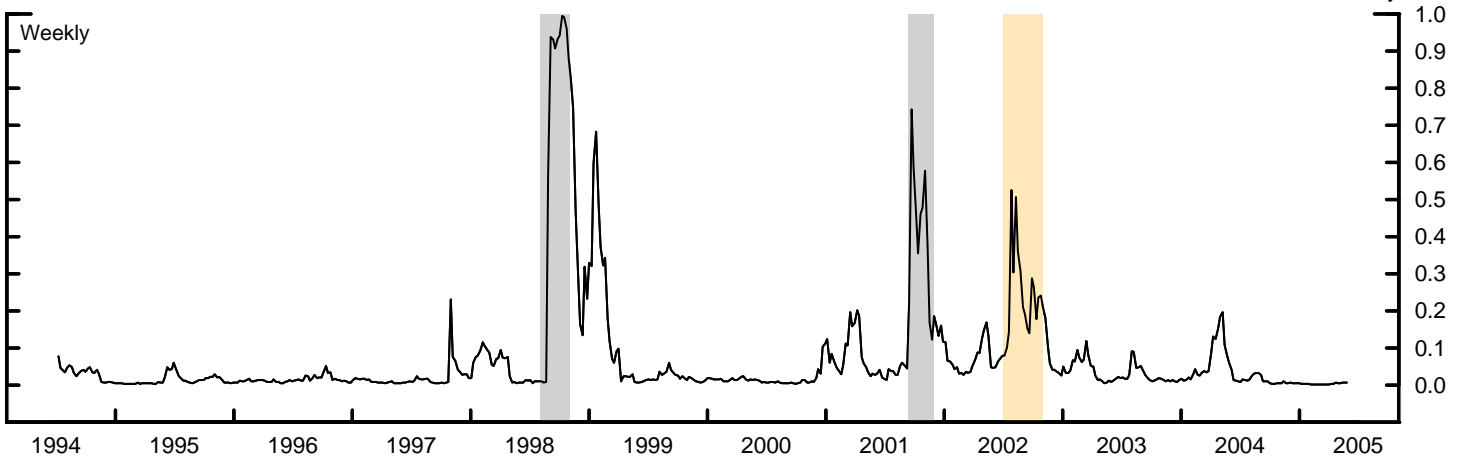
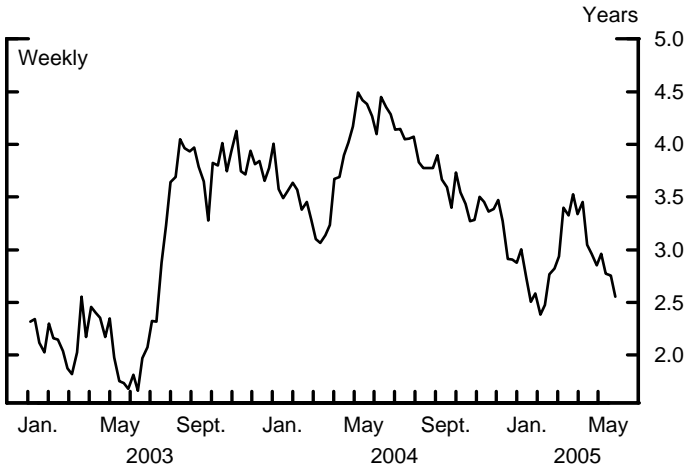


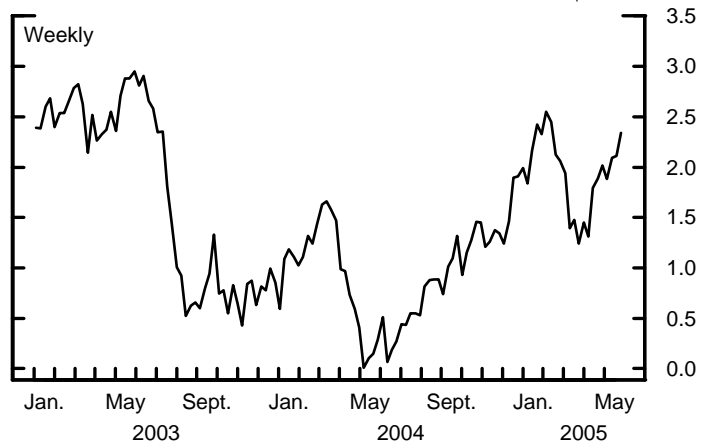
Exhibit 3 Mortgage Market Indicators

Mortgage Duration*



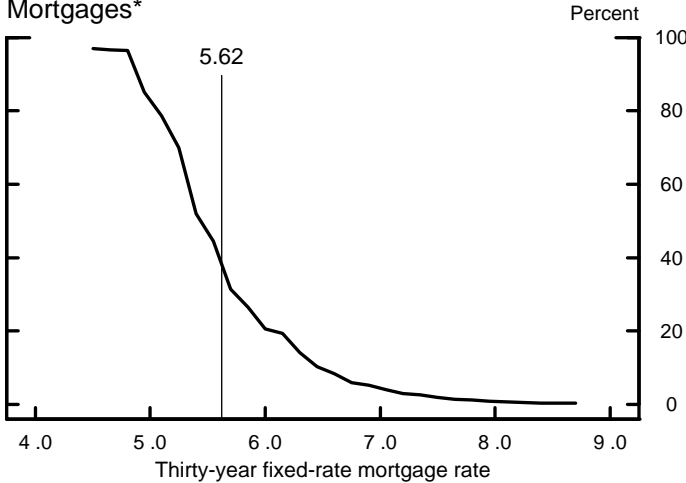
*Based on a large pool of fixed-rate mortgages included in outstanding mortgage-backed securities. Source: Merrill Lynch.

Amount of 10-Year Equivalent Securities Needed to Maintain a Constant Portfolio Duration*



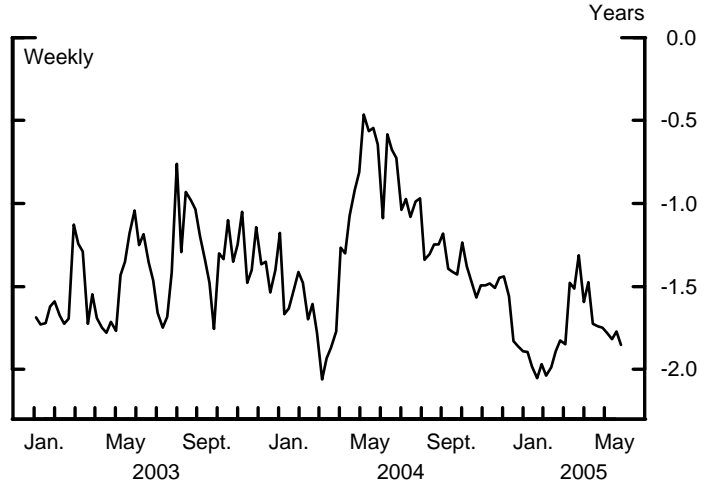
*Staff estimate based on a duration target of 4.5 years.

Percentage of Economically Refinanceable Mortgages*



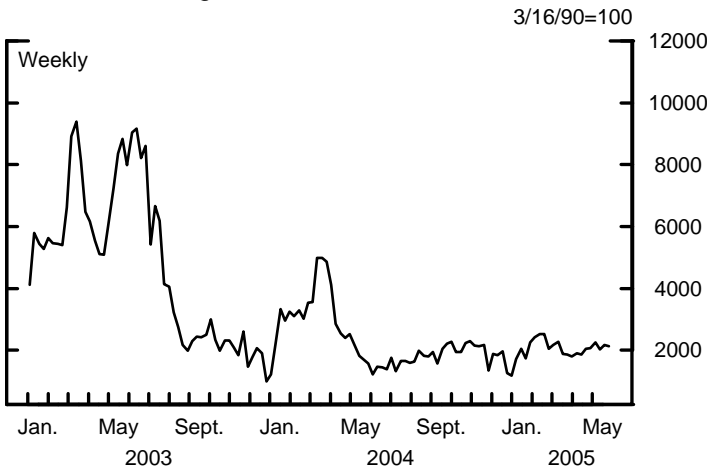
*Cumulative percentage of fixed-rate mortgages included in Fannie Mae's, Freddie Mac's, and Ginnie Mae's outstanding MBS that would be economically refinanceable for any given mortgage rate. Source: Bloomberg.

Mortgage Convexity*



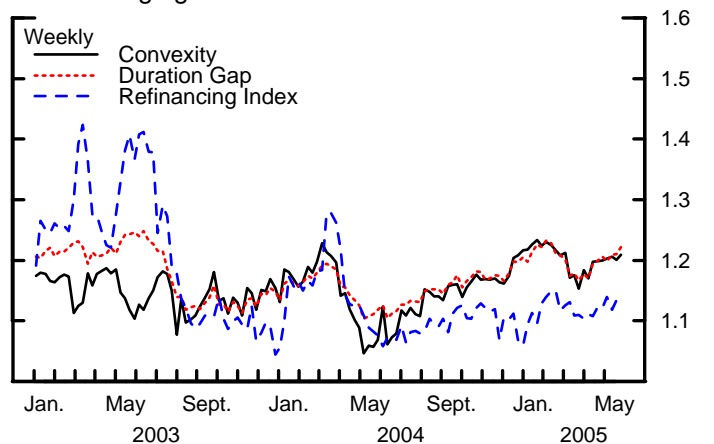
*Based on a large pool of fixed-rate mortgages included in outstanding mortgage-backed securities. Source: Merrill Lynch.

MBA Refinancing Index*



*Source: MBA.

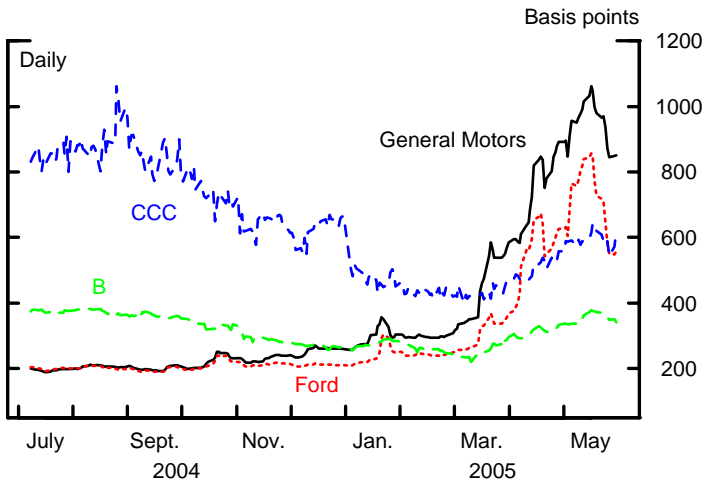
Amplification of Interest Rate Shocks According to Three Hedging Measures*



*Based on Perli and Sack (2003)

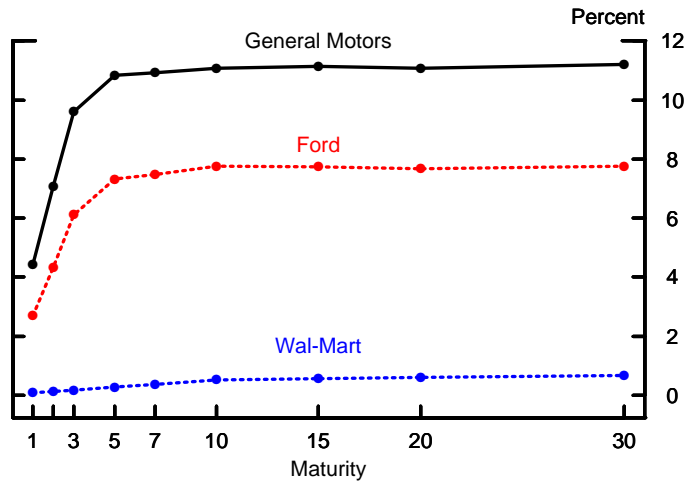
Exhibit 4 Measures of Conditions of Individual Institutions

Credit Default Swap Spreads*



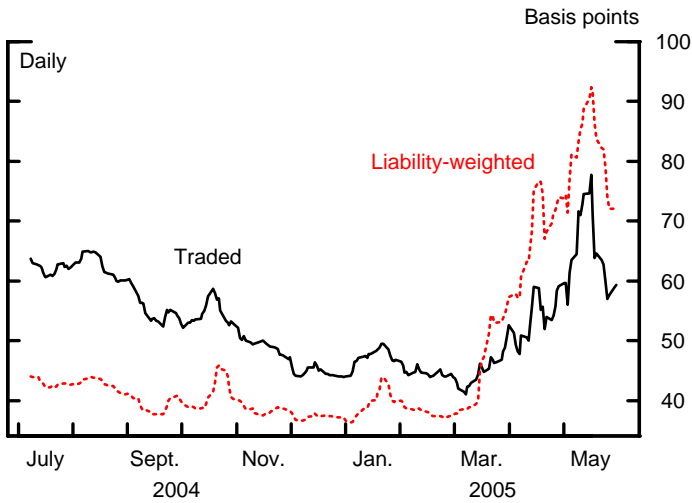
*Source: Markit.

Risk-Neutral Probabilities of Default*



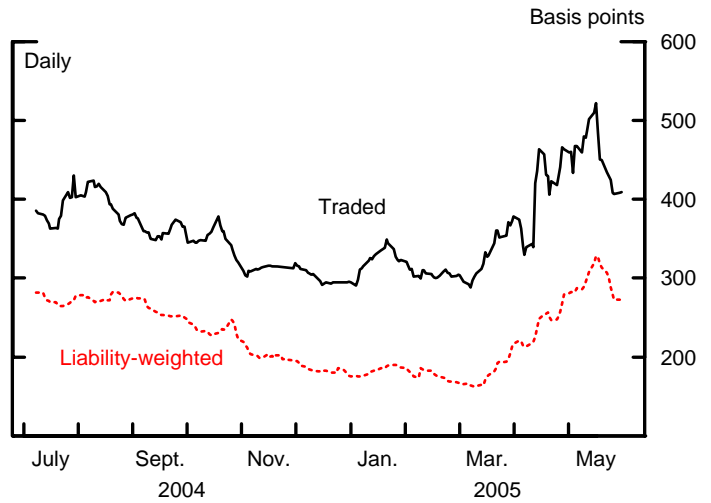
*As of May 31, 2005. Source: MFST staff calculations.

Investment-grade CDS Indexes*



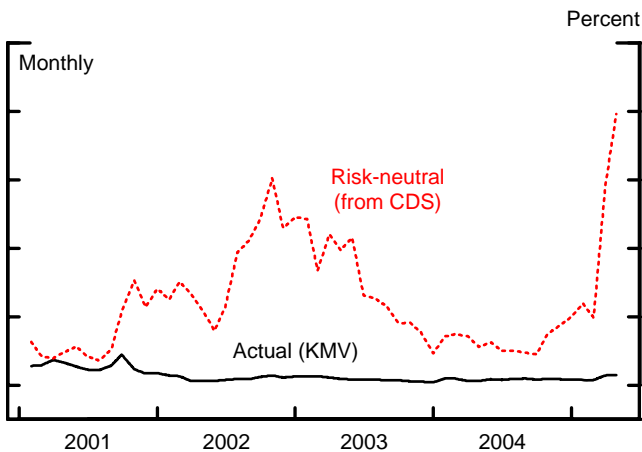
*Source: Markit.

High-yield CDS Indexes*



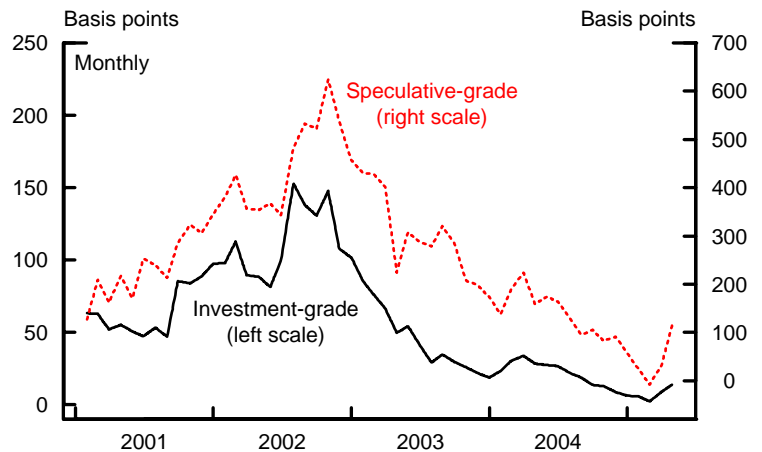
*Source: Markit.

General Motors' One-year Probabilities of Default*



*Source: Moody's KMV and MFST staff calculations.

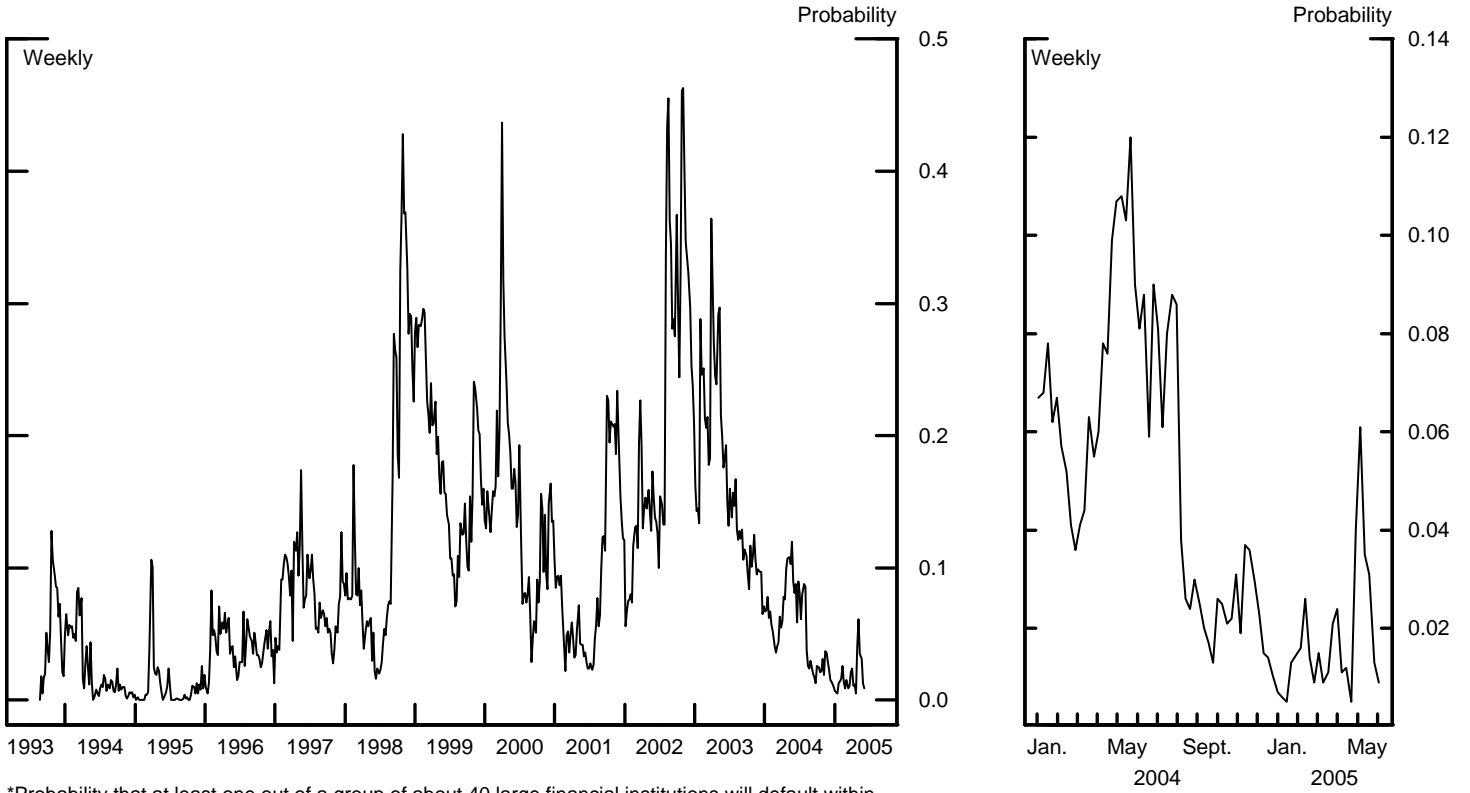
Corporate Risk Premium*



*Source: MFST staff calculations.

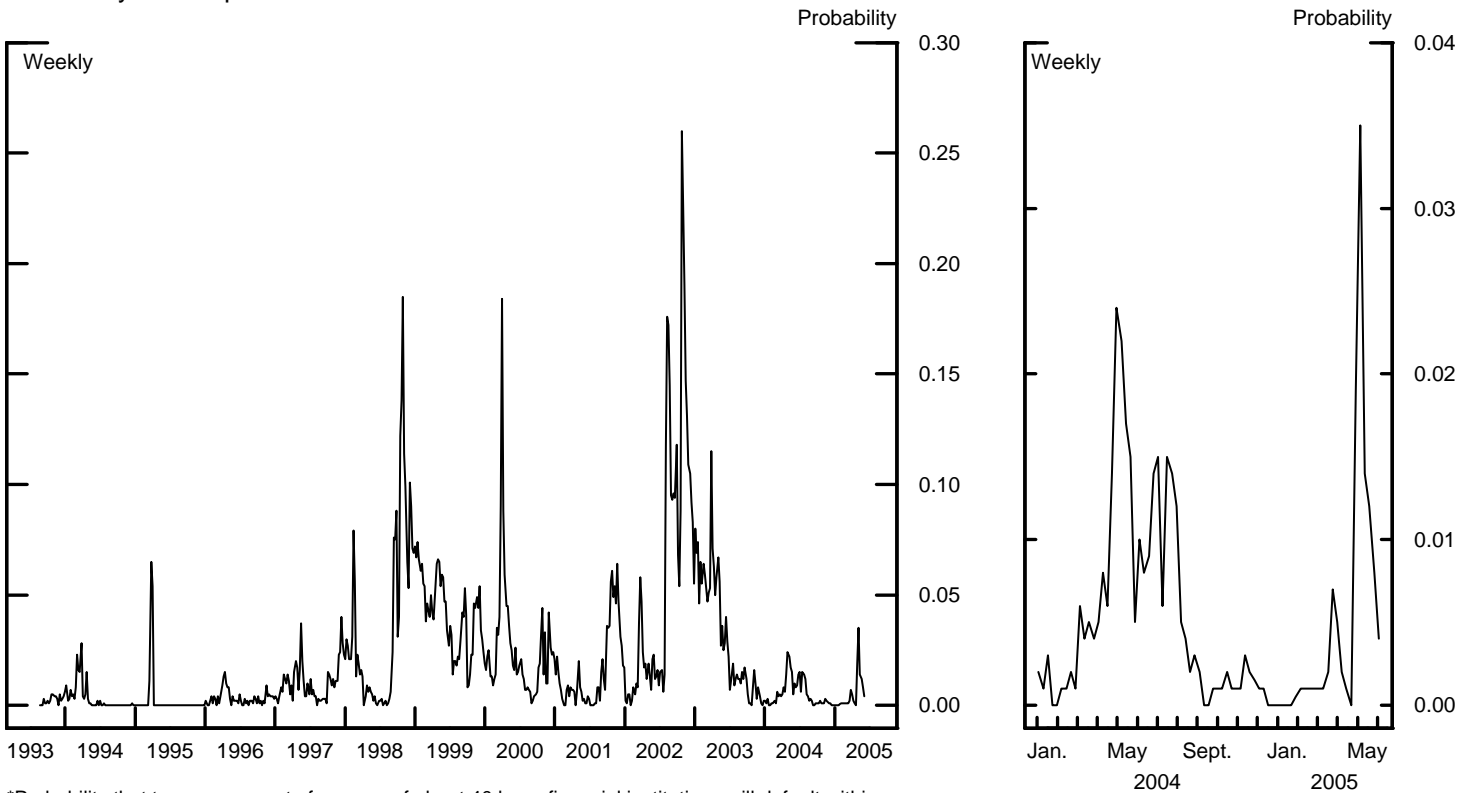
Exhibit 5 Probabilities of Default of Financial Institutions

Probability of at Least One Default of Financial Institutions*



*Probability that at least one out of a group of about 40 large financial institutions will default within one year. Source: MFST staff calculations.

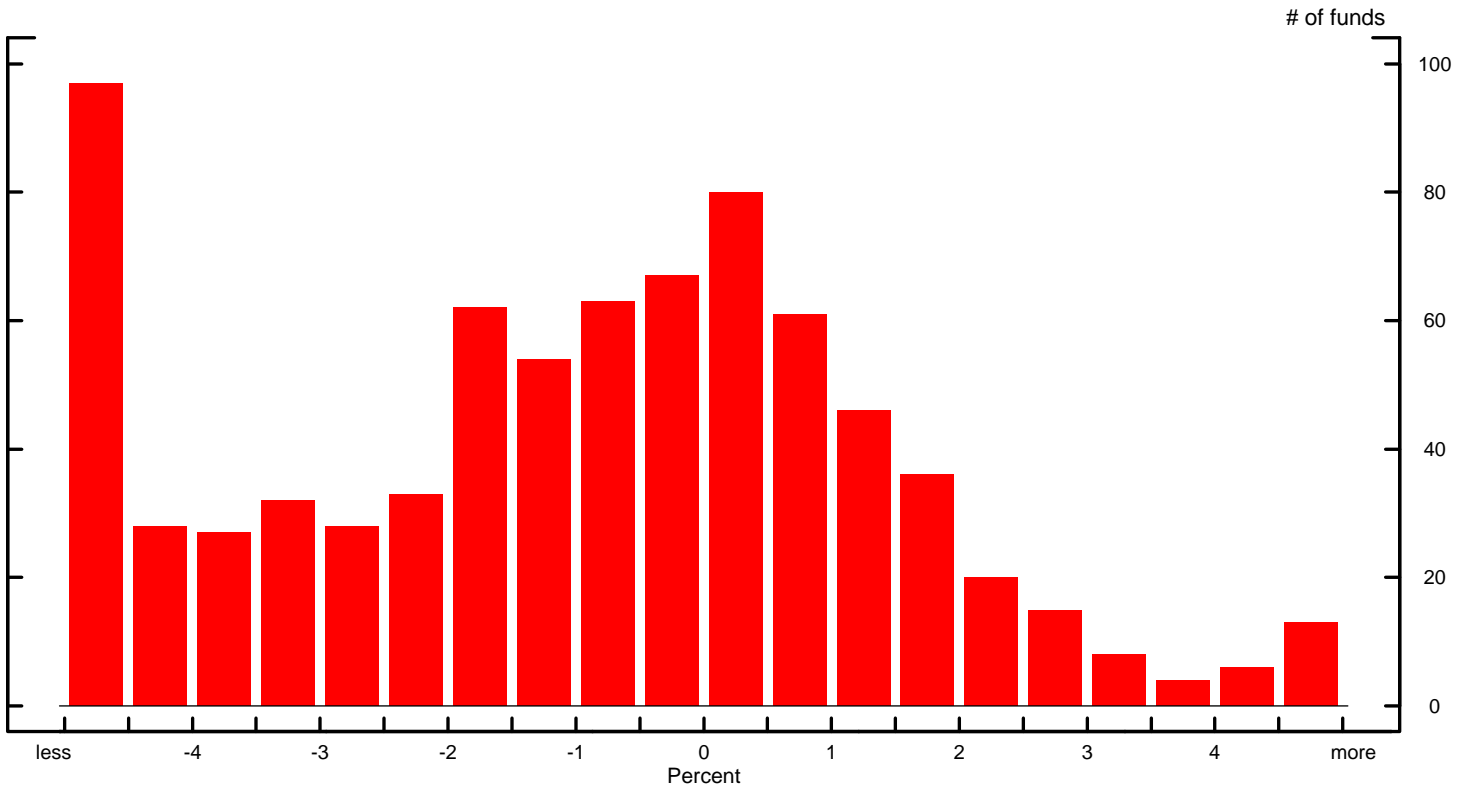
Probability of Multiple Defaults of Financial Institutions*



*Probability that two or more out of a group of about 40 large financial institutions will default within one year. Source: MFST staff calculations.

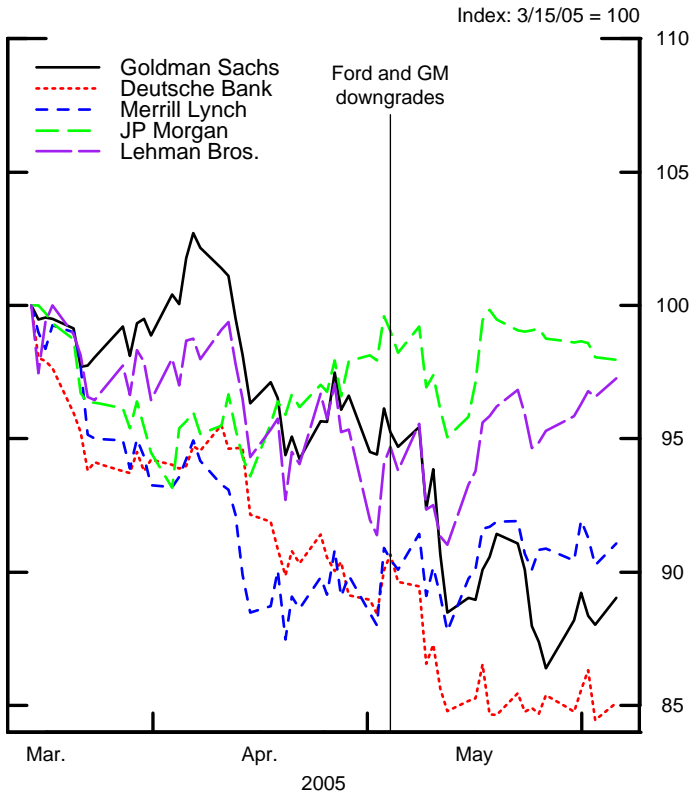
Exhibit 6 Hedge Fund Performance

Distribution of Hedge Fund Returns for April 2005*

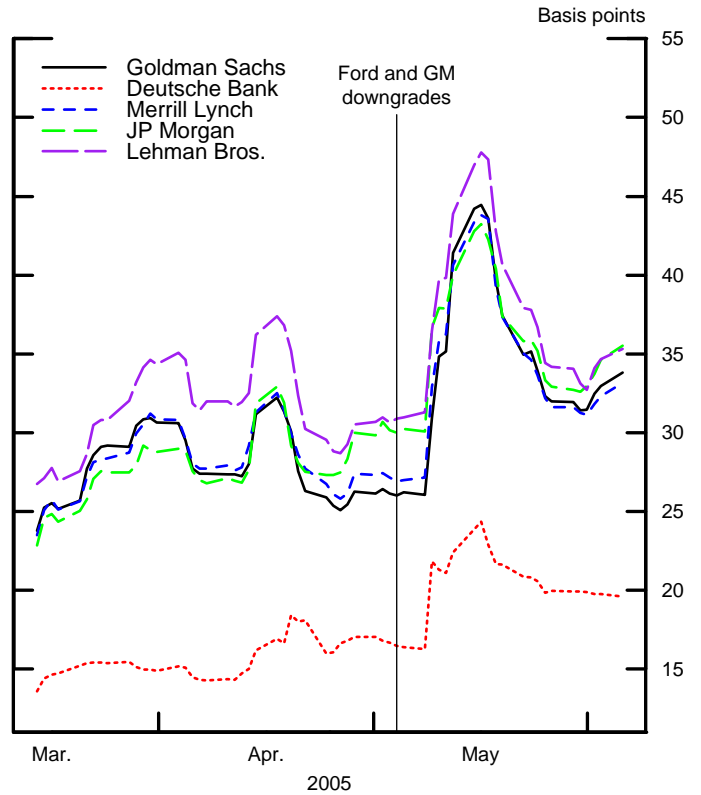


*Includes only funds with assets in excess of \$50 million. Source: Bloomberg.

Prime Broker Stock Prices



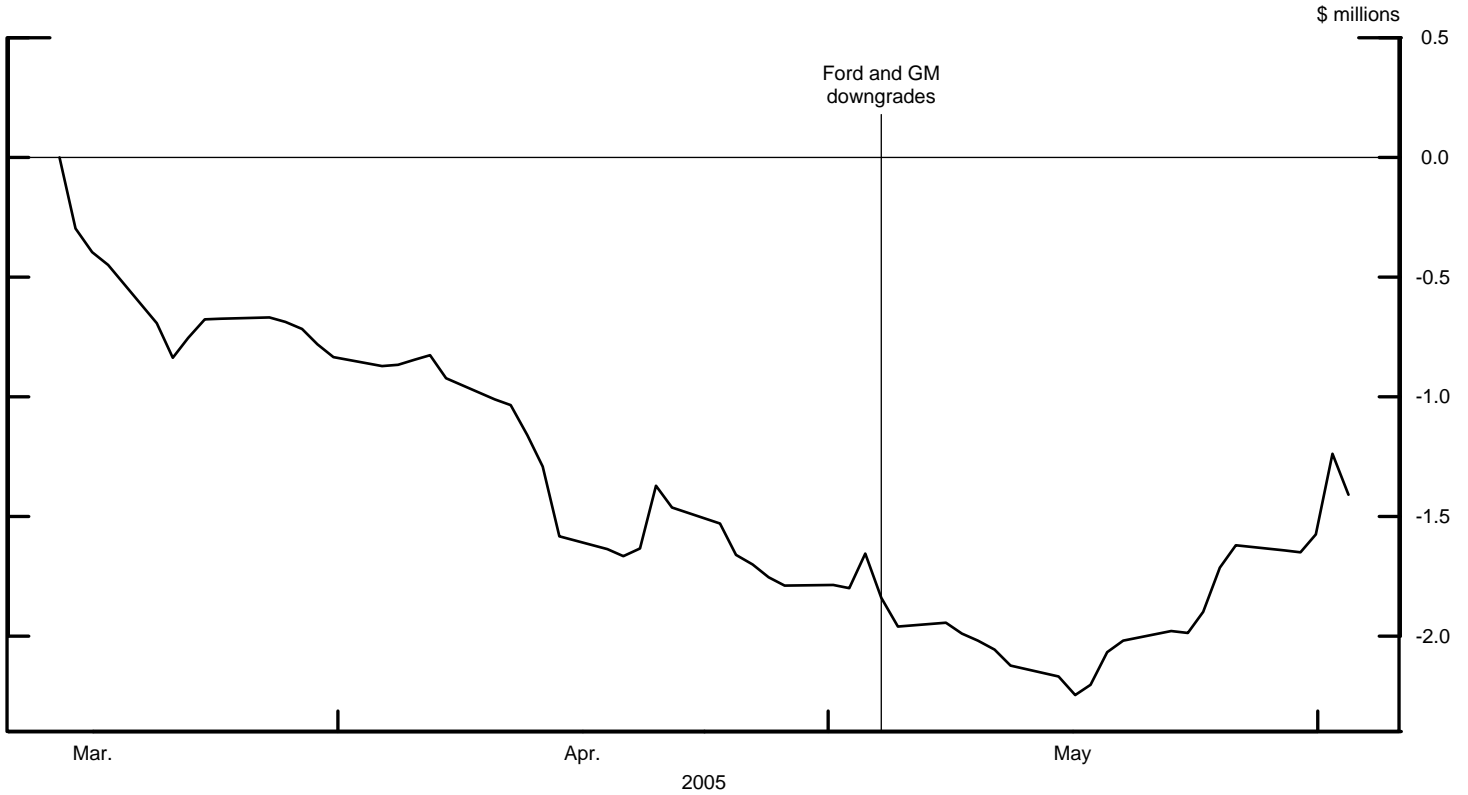
Prime Broker Credit Default Swap Spreads*



*Source: Markit.

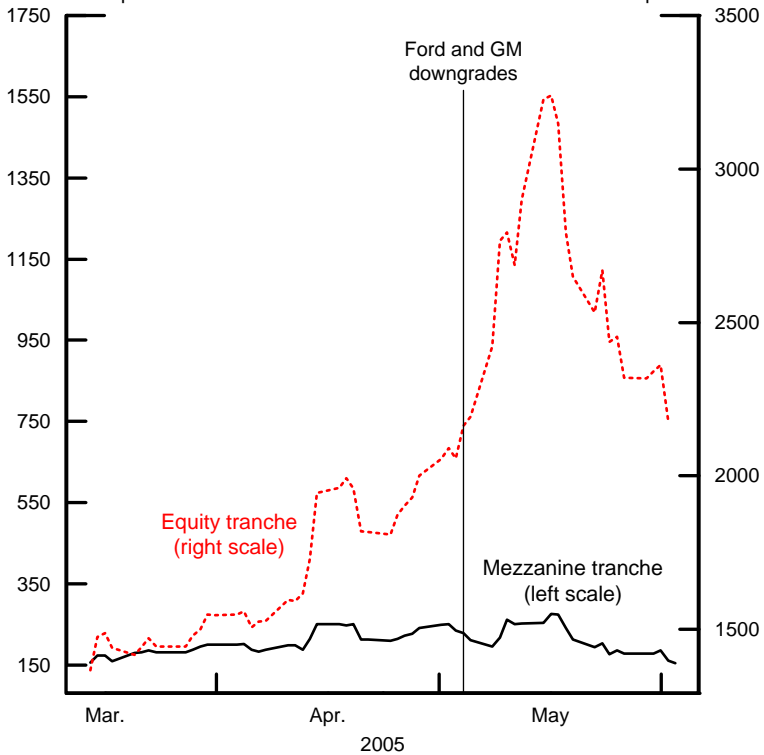
Exhibit 7 Trade Analysis

Profit/Loss from Selling CDS Protection on GM on March 15*



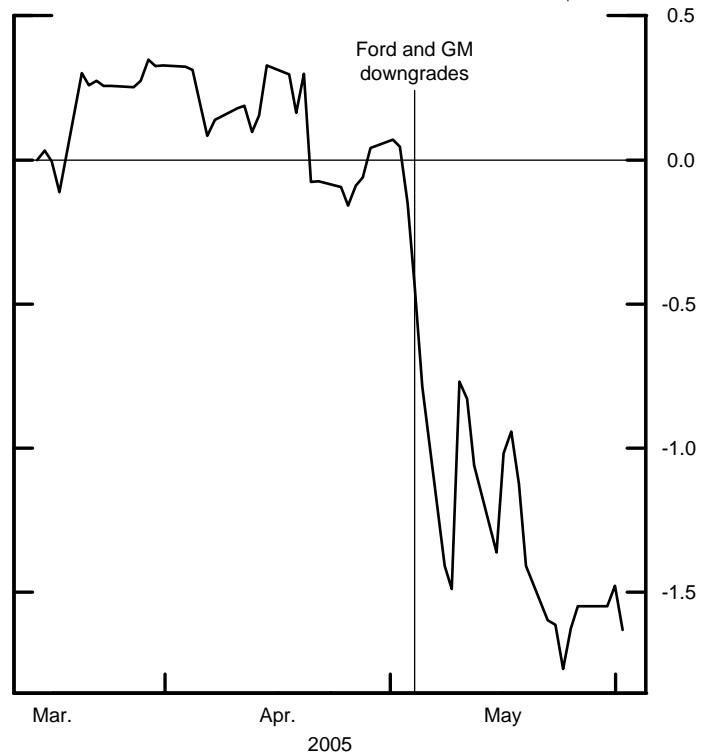
*Based on \$10 million notional amount.

Equity and Mezzanine CDS Index Tranche Spreads*
Basis points



*Equity tranche spread converted from upfront payment to running spread.

Profit/Loss from "Correlation Trade" Entered on March 15*



*Based on selling equity tranche protection on \$10 million notional amount and buying mezzanine tranche protection on \$42.5 million notional amount (optimal hedge ratio).