Financial Stress: What Is It, How Can It Be Measured, and Why Does It Matter?

By Craig S. Hakkio and William R. Keeton

The U.S. economy is currently experiencing a period of significant financial stress. This stress has contributed to the downturn in the economy by boosting the cost of credit and making businesses, households, and financial institutions highly cautious. To alleviate the financial stress and counteract its effects on the economy, the Federal Reserve has reduced the federal funds rate target substantially and undertaken unprecedented actions to support the functioning of financial markets. There will come a point, however, when the Federal Reserve needs to remove liquidity from the economy and unwind special lending programs to ensure a return to sustainable growth with low inflation.

In past recoveries, the decision when to tighten policy was based mainly on the strength of business and consumer spending and the degree of upward pressure on prices and wages. An additional element in the current exit strategy will be determining if financial stress is no longer high enough to endanger economic recovery. As financial conditions begin to improve, the various measures of financial stress that the Federal Reserve monitors may give mixed signals. In this situation, policymak-

---

Craig S. Hakkio is senior vice president and special advisor on economic policy and William R. Keeton is an assistant vice president and economist at the Federal Reserve Bank of Kansas City. *Research associates Ross Dillard, Paul Rotilie, and John Seliski helped prepare the article. This article is on the bank's website at* ***www.KansasCityFed.org.***

ers would greatly benefit from having a single, comprehensive index of financial stress. Such an index could also prove valuable further down the road, when the Federal Reserve might again need to decide whether financial stress was serious enough to warrant special attention.

This article presents a new index of financial stress—the Kansas City Financial Stress Index (KCFSI). The article explains how the components of the KCFSI capture key aspects of financial stress and shows that high values of the KCFSI have tended to coincide with known periods of financial stress. The article also shows that the KCFSI provides valuable information about future economic growth.

The first section of the article discusses the key phenomena that economists generally associate with financial stress. The next section describes the set of financial variables selected to represent these features of financial stress and explains how the variables are combined in the KCFSI. The third section examines the behavior of the KCFSI during past episodes of financial stress and explains how the index can be used to determine the severity of financial stress. The fourth section examines the link between the KCFSI and economic activity, including the transmission of financial stress to economic activity through changes in bank lending standards.

I. KEY FEATURES OF FINANCIAL STRESS

In most general terms, financial stress can be thought of as an interruption to the normal functioning of financial markets. Agreeing on a more specific definition is not easy, because no two episodes of financial stress are exactly the same. Still, economists tend to associate certain key phenomena with financial stress. The relative importance of these phenomena may differ from one episode of financial stress to another. However, every episode seems to involve at least one of the phenomena, and often all of them.

Increased uncertainty about fundamental value of assets. One common sign of financial stress is increased uncertainty among lenders and investors about the fundamental values of financial assets. The fundamental value of an asset is the present discounted value of the future cash flows, such as dividends and interest payments. Increased uncertainty about these fundamental values typically translates into greater volatility in the market prices of the assets.

In some cases, increased uncertainty about the fundamental values of assets reflects greater uncertainty about the outlook for the economy as a whole and for specific sectors. The prospective cash flows from stocks, bonds, and loans all depend on future economic conditions. As a result, heightened uncertainty about economic conditions can cause lenders and investors to become less sure of the present discounted values of these cash flows. Uncertainty about the fundamental values of financial assets can also increase when financial innovations make it difficult for lenders and investors to even assign probabilities to different outcomes. This kind of uncertainty, in which risk is viewed as unknown and unmeasurable, is often referred to as Knightian uncertainty. According to some economists, such uncertainty tends to arise when losses are incurred for the first time on a new financial instrument or practice—for example, complex structured products such as collateralized debt obligations (CDOs) in the recent subprime crisis, or program trading in the Long-Term Capital Management (LTCM) crisis of 1998. Lacking any historical experience on which to draw, investors may conclude in such situations that they cannot even form a judgment about the probabilities of returns to the new products.[1]

Increased uncertainty about the fundamental values of assets leads to greater volatility in asset prices by causing investors to react more strongly to new information (Pastor and Veronesi; Hautsch and Hess). Suppose, for example, that the maximum price an investor is willing to pay for a firm's stock depends on his estimate of the firm's long-run profitability. Suppose also that the investor revises this estimate whenever he receives new information about the firm's profit outlook. Then the greater the investor's initial uncertainty about the firm's long-run profitability, the more the investor will revise his estimate of the firm's profitability in response to new information, and thus the more he will change his offer price in response to that information.[2] Thus, increased uncertainty about the fundamental value of stocks will generally lead to increased volatility of the prices of those stocks.

Increased uncertainty about behavior of other investors. Another form of uncertainty that often increases during financial crises and contributes to asset price volatility is uncertainty about the behavior of other investors. For an asset that may need to be sold before maturity, the expected return to an investor can depend as much on the actions of other investors as on the long-run or hold-to-maturity value

of the asset. Keynes made this point by comparing the stock market to a beauty contest in which a prize was rewarded for picking the face that the largest number of other people picked. In such situations, Keynes noted, the incentive of the individual is to anticipate "what average opinion expects average opinion to be." This kind of recursive behavior becomes more prevalent when lenders and investors become more uncertain about the fundamental values of assets. Thus, it tends to arise in the same situations as Knightian uncertainty—when investors discover that their assumptions about a new financial product or practice were incorrect and have little historical experience on which to base their new opinions.[3]

Like uncertainty about fundamentals, uncertainty about the behavior of other investors tends to show up in increased volatility of asset prices. When investors base their decisions on guesses about other investors' decisions, prices of financial assets become less tied to fundamental values. Therefore, prices also become more volatile.

Increased asymmetry of information. A third common sign of financial stress is an increased asymmetry of information between lenders and borrowers or buyers and sellers of financial assets. Asymmetry of information is said to exist when borrowers know more about their true financial condition than lenders, or when sellers know more about the true quality of the assets they hold than buyers. Information gaps of this kind can lead to problems of adverse selection or moral hazard, boosting the average cost of borrowing for firms and households and reducing the average price of assets on secondary markets. Suppose, for example, that investors know the average risk of a group of firms issuing bonds but cannot distinguish the high-quality firms in the group from the low-quality firms. Investors will then require a rate of interest on the bonds appropriate for a firm of average risk. But at such a rate, the higher-quality firms may prefer not to borrow and instead rely on internal funds. If so, an adverse selection problem will arise: The mix of firms selling bonds will worsen, leading investors to demand a still higher rate of return.[4]

Such asymmetries of information might worsen during a period of financial stress for two reasons. First, the variation in the true quality of borrowers or financial assets might increase (Mishkin; Gorton). Suppose, for example, that everyone expects the collateral on a particular

type of loan to increase in value. Then lenders will view all loans of that type as safe, regardless of the borrower's future income or profits. But now suppose everyone expects the value of the collateral to decline—for example, because a real estate bubble has burst. Then loans to low-income borrowers will have greater risk than loans to high-income borrowers, because low-income borrowers will be less able to repay their loans if the value of the collateral falls below the amount due on the loan. Thus, if lenders have difficulty determining borrowers' income, an asymmetry of information will arise—borrowers will differ in their true risk, and each borrower will have a better idea of that risk than lenders.[5] The second way information asymmetries can worsen in a financial crisis is through lenders losing confidence in the accuracy of their information about borrowers (Gorton). Suppose, for example, that the issuer of a bond knows its true risk of default, but that investors must rely on credit ratings by a third party to determine that risk. If investors suddenly come to doubt the objectivity of those ratings, they will become more uncertain as to which bonds are likely to repay and which are likely to default. Once again, an asymmetry of information will arise, with issuers of the bonds knowing more about their true risk than investors.[6]

Decreased willingness to hold risky assets (flight to quality). One common sign of financial stress is a sharply decreased willingness to hold risky financial assets. Such a change in preferences will cause lenders and investors to demand higher expected returns on risky assets and lower returns on safe assets. These shifts in preferences away from risky assets and toward safe assets are often referred to as "flights to quality." The result is to widen the spread between the rates of return on the two types of assets and increase the cost of borrowing for relatively risky borrowers (Caballero and Kurlat).

What could cause lenders and investors to become much less willing to hold risky assets? Some theories of financial crises emphasize the tendency for lenders and investors to underestimate risk during booms and overestimate risk during subsequent busts (Kindleberger; Minsky; Berger and Udell; Guttentag and Herring). According to this view, lenders and investors tend to become complacent during periods of prolonged economic stability and forget their previous losses. During such periods, investors are especially prone to ignore "fat-tail" risks—the non-negligible probability of extreme losses. However, be-

cause such euphoria leads to some bad loans and investments, losses are eventually incurred. When lenders and investors realize that such losses are possible, their euphoria turns to gloom, causing them to swing in the opposite direction and overestimate the risk of loss.

Another, quite different reason why lenders and investors may become less willing to hold risky assets is that their appetite for risk falls. Suppose, for example, that people become more uncertain about the future state of the economy and thus more uncertain about their future wage income. They will then have more reason to worry about suffering losses on risky investments when they can least afford them—that is, when their income and consumption are already low due to a downturn in the economy. In such cases, lenders and investors will require greater compensation for holding risky assets, boosting returns on those assets relative to safe assets.[7]

Decreased willingness to hold illiquid assets (flight to liquidity). A final sign of financial stress is a sharply decreased willingness to hold illiquid assets. An illiquid asset is one that the owner cannot be confident of selling at a price close to its fundamental value if faced with a sudden and unexpected need for cash. In some cases, an asset is illiquid because the secondary market for the asset is thin, so that selling a substantial amount of the asset has a large effect on the price. In other cases, an asset may be illiquid because it is of above-average quality and an asymmetry of information between buyers and sellers prevents the owner from selling the asset at a price close to its fundamental value (for example, the value if the owner could hold it to maturity).[8] During financial crises, investors typically become less willing to hold illiquid assets and more willing to hold liquid assets. The effect of these "flights to liquidity" is to widen the spread between the rates of return on the two types of assets and increase the cost of borrowing for those firms that issue illiquid securities.

A flight to liquidity can occur for two reasons–an increase in the demand for liquidity to protect against unexpected cash needs or a decrease in the perceived liquidity of some assets. To see how the demand for liquidity could increase, recall that one feature of financial stress is an increase in the volatility of asset prices. Such an increase in volatility raises the chances that a leveraged investor will have to liquidate some of his assets to meet margin calls (Brunnermeier and Pederson). An

increase in asset price volatility also increases the chances that financial intermediaries such as hedge funds and mutual funds will have to liquidate assets to meet redemptions.[9] To guard against such events, investors and financial institutions will seek to build up their holdings of liquid assets.

The other possible cause of a flight to liquidity is a reduction in the perceived liquidity of assets. As noted earlier, financial stress is often associated with greater asymmetry of information between buyers and sellers of financial assets. In such circumstances, adverse selection may cause the market values of some assets to fall well below their fundamental, hold-to-maturity values. Investors will view such assets as illiquid because they cannot be sold to raise cash without taking a substantial loss.

II. CONSTRUCTING AN OVERALL INDEX OF FINANCIAL STRESS

The goal of this article is to construct an index capturing all the key features of financial stress discussed in the previous section. This section describes the variables included in the index and which features of financial stress are captured by each variable. The section then explains how the variables are combined into an overall index of financial stress.

Variables included in the financial stress index

Several criteria were used in selecting variables for the KCFSI. First, each variable had to represent one or more of the five features of financial stress. Second, each variable had to reflect prices or yields on financial markets, on the grounds that market prices and yields embody the largest amount of information and are the quickest to reflect changes in financial conditions. Third, each variable had to be available on at least a monthly basis, so that a monthly financial stress index could be constructed. And finally, each variable had to be available at least since 1990, in order to assess the ability of the KCFSI to identify past episodes of financial stress. These criteria led to the selection of 11 variables, each of which is explained below. Table 1 summarizes the key features of financial stress captured by the variables. The table also reports the date at which each variable became available and the mean

and standard deviation of the variable from February 1990 through March 2009.

3-month LIBOR/T-Bill spread (TED spread). The 3-month London Interbank Offered Rate (LIBOR) is a measure of the cost to banks of lending to each other over the short term. Each day, a panel of 16 large banks report the rate at which they believe they could borrow unsecured, dollar-denominated funds on the interbank market. This rate could exceed the rate on a Treasury bill of the same maturity for two possible reasons—because lending banks fear the loan may not be repaid (default risk), or because banks worry they will experience an unexpected need for funds before the loan comes due (liquidity risk).[10] If lending banks have difficulty determining which borrowing banks are good risks and which are bad risks, a problem of adverse selection can also arise, further increasing the LIBOR/T-bill spread. Thus, the LIBOR/T-bill spread can capture three distinct aspects of financial stress—flight to quality, flight to liquidity, and asymmetry of information between buyers and sellers of financial assets.[11]

2-year swap spread. In an interest rate swap, one party agrees to pay another party a stream of fixed-rate payments in return for a stream of floating-rate payments. The floating-rate payments are usually based on a short-term LIBOR rate. The fixed rate is often expressed as the yield on a Treasury security of the same maturity plus a spread over that yield. This spread is positive for two reasons (Grinblatt). First, as noted above, the LIBOR rate on which the floating-rate payments are based will generally exceed the comparable short-term Treasury yield, so that interbank lenders are compensated for the default and liquidity risk of interbank loans. As a result, an investor will agree to make floating-rate payments in return for fixed-rate payments only if he earns more than the comparable long-term Treasury yield on the fixed-rate payments. The second reason the swap spread is positive is that the claim to the fixed-rate payments is considerably less liquid than a Treasury security of the same maturity, which can always be sold on short notice on secondary markets. These explanations for the positive spread on interest rate swaps suggest that increases in the 2-year swap spread can reflect two different features of financial stress—flight to quality (fear that increased default risk in the interbank lending market will drive up LIBOR), or flight to liquidity (fear that funds will be needed before the swap expires,

Table 1

VARIABLES INCLUDED IN KANSAS CITY FINANCIAL STRESS INDEX

Variable	Aspects of financial stress represented by variable	First date available	Mean (February1990–March 2009)	Standard deviation (February 1990–March 2009)
3-month LIBOR/3-month T-bill spread (TED)	Flight to quality, flight to liquidity, increased asymmetry of information	January 1986	.58	.39
2-year swap spread	Flight to liquidity, flight to quality	November 1988	.42	.20
Off-the-run/on-the run 10-year Treasury spread	Flight to liquidity	January 1986	.17	.10
Aaa/10-year Treasury spread	Flight to liquidity	April 1953	1.27	.47
Baa/Aaa spread	Flight to quality, increased asymmetry of information	January 1919	.92	.41
High-yield bond/Baa spread	Flight to quality, flight to liquidity, increased asymmetry of information	December 1986	2.99	1.88
Consumer ABS/ 5-year Treasury spread	Flight to quality, increased asymmetry of information	February 1990	.56	1.01
Negative value of correlation between stock and Treasury returns	Flight to quality	February 1988	.01	.38
Implied volatility of overall stock prices (VIX)	Uncertainty about fundamentals and behavior of other investors	January 1990	20.0	8.1
Idiosyncratic volatility (IVOL) of bank stock prices	Uncertainty about fundamentals and behavior of other investors	February 1990	.80	.78
Cross-section dispersion (CSD) of bank stock returns	Increased asymmetry of information	January 1988	.35	.14

Note: All interest rate spreads are expressed in percentage points. The VIX is calculated for monthly percent changes in stock prices expressed at an annual rate. IVOL and CSD are calculated for daily percent changes in stock prices.

or fear that increased liquidity risk in the interbank market will drive up LIBOR).[12]

Off-the-run/on-the-run 10-year Treasury spread. For a particular maturity, the on-the-run Treasury security is the most recently issued security of that maturity. Off-the-run Treasury securities are previously issued securities of the same maturity.[13] The market for an off-the-run Treasury security is generally not as deep as the market for the on-the-run security of the same maturity. As a result, an investor holding the off-the-run security faces more risk of having to sell the security at a discount if he needs cash in a hurry. To compensate for this liquidity risk, the yield on the off-the-run security must exceed the yield on the on-the-run security. The spread between the off-the-run and on-the-run yields tends to increase when investors become more concerned about the risk of an unexpected need for cash. Thus, the spread provides a good measure of the flight to liquidity that often occurs during periods of financial stress.[14]

Aaa/10-year Treasury spread. Although corporate bonds rated Aaa by Moody's are supposed to have little or no default risk, their yields are generally higher than those on Treasury securities of similar maturity. One reason Aaa bond yields can exceed comparable Treasury yields is that many of the bonds are callable, which means that the company that issued the debt can prepay the loan if a decline in interest rates makes refinancing attractive (Duca). However, another important reason for the difference in yields is that even the highest-rated corporate bonds tend to be less liquid than Treasury securities. As a result, increases in the spread between Moody's Aaa bond index and the 10-year Treasury yield provides another measure of the flight to liquidity during periods of financial stress.

Baa/Aaa spread. Baa-rated corporate bonds are the lowest-rated bonds classified by Moody's as investment-grade. During economic expansions, the yield on these bonds may exceed the yield on Aaa bonds by only a small margin, because investors perceive the risk of default to be almost as low on Baa bonds as Aaa bonds. However, if investors become concerned about the state of the economy or the financial health of lower-rated corporations, they will assign a higher probability of default to Baa bonds. In such circumstances, the Baa yield will rise further above the Aaa yield to compensate investors for the higher perceived risk of

Baa bonds. Such an increase in the Baa/Aaa spread need not be a sign of financial stress if investors' changed beliefs about default risk are well founded. But in some cases, the increased pessimism of investors may represent an over-reaction to a prolonged period of excessive optimism. And in other cases, investors may demand a higher yield on Baa bonds, not because of an increase in the perceived risk of Baa bonds, but because of a decreased willingness to bear such risk. Either way, the increase in the Baa/Aaa spread will reflect a flight to quality. During such periods, investors may also start to worry that some Baa bonds are riskier than others. If so, a problem of adverse selection may arise, causing the Baa rate to move even further above the Aaa yield.[15] Thus, the Baa/Aaa spread may also capture increases in information asymmetries.

High-yield bond/Baa spread. High-yield bonds, also known as "junk bonds," are corporate bonds with too low a rating to be considered investment-grade. The difference in default risk between high-yield bonds and Baa bonds is even greater than that between Aaa bonds and Baa bonds. As a result, there should be an even greater tendency for the high-yield/Baa spread to increase in response to a flight to quality or an increase in information asymmetry (Gertler and Lown).[16] The high-yield/Baa spread may also capture flights to liquidity (Kwan 2001). High-yield bonds tend to have thinner markets than investment-grade bonds, partly because they are issued in smaller quantities and partly because institutional investors such as pension funds are prohibited from investing in them. Thus, when investors become more worried about unexpected cash needs, the high-yield bond yield tends to rise further above the Baa yield to compensate investors for holding the less-liquid asset.

Consumer ABS/5-year Treasury spread. Consumer asset-backed securities are securities backed by pools of credit card loans, auto loans, or student loans. Like mortgage-backed securities, these securities are typically issued in tranches, with the senior tranche receiving the highest rating because it has first lien on the underlying loans (Getter; Furletti). During normal times, the senior tranches are considered to have low risk because the underlying loans are geographically diversified and thus unlikely to default at the same time. As a result, the spread over Treasury securities of comparable maturity is low. During flights to quality, however, investors may become more concerned about the risk

of default by consumers and require higher compensation to hold the securities, just as in the case of high-yield bonds. Asset-backed securities are also susceptible to increases in the asymmetry of information between the buyers and sellers of financial assets. Issuers of consumer asset-backed securities have an incentive to securitize only high-quality loans to preserve their long-run reputation (Calomiris and Mason). During periods of financial stress, however, some issuers may be tempted to retain the higher-quality loans on their balance sheets and securitize the lower-quality loans. Suspecting such behavior, investors may demand sharply higher yields on the asset-based securities.

Correlation between returns on stocks and Treasury bonds. In normal times, the returns on stocks and government bonds are either unrelated or move together in response to changes in the risk-free discount rate. In times of financial stress, however, investors may view stocks as much riskier than government bonds. If so, they will shift out of stocks into bonds, causing the returns on the two assets to move in opposite directions. A number of studies, some for the United States and some for other countries, confirm that the correlation between stock returns and government bond returns tends to turn negative during financial crises (Andersson and others; Baur and Lucey; Connolly and others; Gonzalo and Olmo). Thus, the stock-bond correlation provides an additional measure of the flight to quality during periods of financial stress. This correlation is computed over rolling three-month periods using the S&P 500 and a 2-year Treasury bond index. Also, the negative value of the correlation is used in the KCFSI, so that increases in the measure correspond to increases in financial stress.

Implied volatility of overall stock prices (VIX). The CBOE Volatility Index (VIX) is a measure of the expected volatility in the S&P 500 based on the market prices of options. Options to buy or sell a stock are more valuable when the stock's market price is expected to fluctuate widely, because the option has a greater likelihood of ending up "in the money." For options to buy a stock, there will be a greater chance that the market price exceeds the strike price. And for options to sell the stock there will be a greater chance that the market price falls below the strike price. The VIX exploits this relationship between volatility and options prices to compute the expected upward or downward movement in the index over the next month. As a measure of overall volatility in stock

prices, it captures both uncertainty about the fundamental values of assets and uncertainty about the behavior of other investors.

Idiosyncratic volatility of bank stock prices. Commercial banks play a key role in the financial system as sources of credit and liquidity to their customers. Thus, in measuring financial stress, it is useful to take into account volatility in bank stock prices as well as volatility in overall stock prices. The idiosyncratic volatility of bank stock prices is the volatility of the unexpected return to bank stocks—the portion of the return that cannot be explained by movements in the overall stock market. This measure is expressed as the standard deviation of unexpected daily returns during the month and is calculated from a bank stock index and the S&P 500 (Appendix A).[17] The measure is designed to capture the same features of financial stress as the VIX, but for the banking industry rather than the corporate sector as a whole.

Cross-section dispersion of bank stock returns. If investors become more uncertain about the relative quality of banks but each bank knows its own quality, the asymmetry of information between investors and banks will increase. One measure of investors' uncertainty about relative quality is the cross-section dispersion in unexpected bank stock returns—the portion of each bank's stock return that cannot be explained by movements in the overall market. The specific measure of dispersion used is the interquartile range of unexpected returns of the 100 largest commercial banks. This measure is calculated using daily data on the S&P 500 and the stock prices of the 100 largest commercial banks (Appendix A).[18]

Combining the variables in an index of financial stress

The variables described above capture one or more features of financial stress. As a result, the variables should have some tendency to move together as the degree of financial stress changes. However, each of the variables can also change for other reasons not directly related to financial stress. For example, even without any flight to quality, the high-yield bond/Baa spread could widen because investors expect a downturn in the economy that will boost default rates. Similarly, the Aaa/Treasury spread could widen, not because of a flight to liquidity, but because of an actual or projected decline in the supply of Treasury securities that depresses Treasury yields. Thus, while financial stress may

cause the variables to move together, other factors unrelated to financial stress may at times cause them to diverge. This possibility is confirmed by Table 2, which reports the correlation coefficient between each pair of variables from February 1990 to March 2009. The average correlation coefficient is 0.57, implying that the 11 variables move together but not in lockstep.

How can the 11 variables be combined into an overall index of financial stress? Financial stress is assumed to be the factor most responsible for the co-movement of the variables. This factor is then identified by the method of principal components. The first step is to express each of the 11 variables in the same units by subtracting the sample mean (the number in the next-to-last column of Table 1) and dividing by the standard deviation (the number in the last column of Table 1). The next step is to calculate the coefficients of these variables in the index. These coefficients are chosen so that the index explains the maximum possible amount of the total variation in the 11 variables. The coefficients are also scaled so that the standard deviation of the index equals one.[19]

Table 3 shows the coefficients obtained by this method using data from February 1990 to March 2009. Since the variables have been standardized, the coefficient on each variable represents the effect on the index of a one-standard-deviation change in that variable. The coefficients range from a low of 0.081 for the stock-bond correlation to 0.130 for the VIX and consumer ABS spread. These differences may seem small, but they are economically important. They imply, for example, that a one-standard-deviation change in VIX has one-and-a-half times as big an effect on the financial stress index as a one-standard-deviation change in the stock-bond correlation. The last row in the table shows that 61.4 percent of the total variation in the 11 variables over the sample period is explained by the index. This number measures the tendency for the 11 variables to move together–a tendency that is assumed to result from each variable capturing a key feature of financial stress.[20] The index itself is plotted in Chart 1. Not surprisingly, it has risen sharply in the current financial crisis. The behavior of the index during this episode and earlier periods of financial stress will be examined in more detail in Section III.

Table 2

CORRELATION COEFFICIENTS FOR VARIABLES IN FINANCIAL STRESS INDEX FEBRUARY 1990-MARCH 2009

	TED spread	Swap spread	Off-the-run/ on-the-run spread	Aaa/Treasury spread	Baa/Aaa spread	High-yield/ Baa spread	Consumer ABS/Treasury spread	Stock-bond correlation	Stock market volatility(VIX)	IVOL,banking industry	CSD, banks
TED spread	1.00										
Swap spread	.72	1.00									
Off-the-run/on the run spread	.23	.40	1.00								
Aaa/Treasury spread	.17	.45	.80	1.00							
Baa/Aaa spread	.45	.54	.58	.56	1.00						
High-yield /Baa spread	.42	.57	.59	.59	.81	1.00					
Consumer ABS/ Treasury spread	.76	.70	.50	.44	.81	.70	1.00				
Stock-bond correlation	.17	.52	.42	.63	.46	.35	.32	1.00			
Stock market volatility (VIX)	.54	.60	.66	.69	.69	.75	.70	.49	1.00		
IVOL, banking industry	.66	.65	.59	.56	.70	.67	.82	.32	.72	1.00	
CSD, banks	.59	.63	.47	.41	.56	.65	.69	.27	.62	.78	1.00

Table 3

ESTIMATED COEFFICIENTS ON KCFSI VARIABLES FEBRUARY 1990 TO MARCH 2009

Variable	Coefficient in KCFSI
TED spread	0.099
2-year swap spread	0.116
Off-the-run/on-the-run-Treasury spread	0.107
Aaa/Treasury spread	0.107
Baa/Aaa spread	0.125
High-yield bond/Baa spread	0.124
Consumer ABS/Treasury spread	0.130
Stock-bond correlation	0.081
Stock market volatility (VIX)	0.129
Idiosyncratic volatility (IVOL) of banking industry	0.130
Cross-section dispersion (CSD) of bank stock returns	0.116
Memo: Percent of total variation of variables explained by KCFSI	61.4

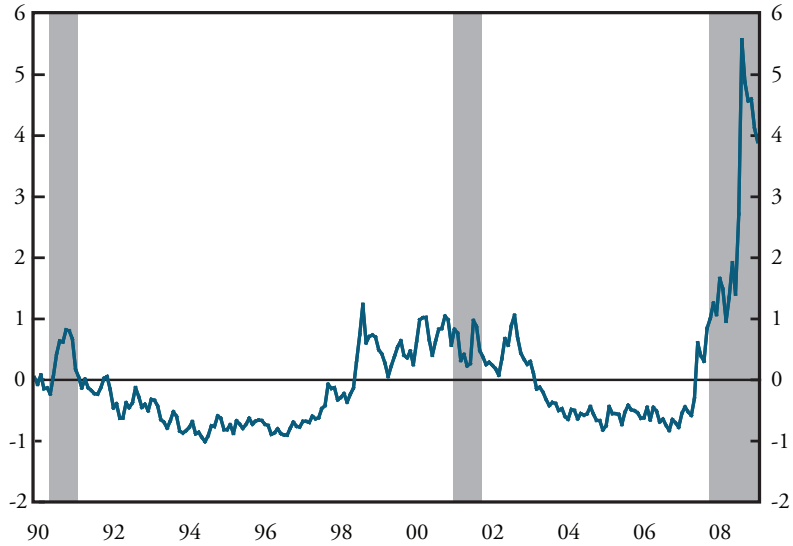
Note: Each coefficient represents the effect of a one-standard-deviation change in the variable on the KCFSI.

Relation to other financial stress indexes

The financial stress index developed in this article is not the first of its kind, so it is important to see how it compares to the others (Table 4). One of the first and most influential composite indexes of financial stress was developed by economists at the Bank of Canada (Illing and Liu). They explored several different ways of combining financial variables into a composite index, one of which was principal components. The Bank of Canada index includes a number of variables like those in the KCFSI, such as a corporate bond spread, a measure of liquidity in the Treasury market (the bid-ask spread), and a measure of volatility in the overall stock market. But the Bank of Canada index differs from the Kansas City Fed index in other important ways: It includes some variables, such as exchange rate volatility, that are more important for a small open economy like Canada's than for the United States. It includes the slope of the yield curve, which likely reveals more about the stance of monetary policy than financial stress.[21] And it fails to include any measures of investor uncertainty about bank stock prices. Most important, the Bank of Canada index is based on Canadian data, making it more useful for detecting financial stress in Canada than the United States.

Chart 1

KANSAS CITY FINANCIAL STRESS INDEX (KCFSI)



Note: Index is calculated using data from February 1990 to March 2009. Shaded areas are recessions.

Another composite index of financial stress that has attracted widespread attention is one developed by economists at the International Monetary Fund (IMF). In contrast to the Kansas City Fed and Bank of Canada indexes, the IMF index does not use principal components to determine the coefficients on the variables. Instead, the variables are standardized and assigned equal weights. The IMF index uses a somewhat smaller set of variables than the Kansas City Fed and Bank of Canada indexes, because the goal of the project was to construct an index that could be used for 17 different countries. Most of the variables in the IMF index closely resemble those in the Bank of Canada index. However, the IMF index differs by including a measure of stress in the interbank lending market and omitting any measure of liquidity in the government securities market. Though useful for international comparisons, the limited number of variables in the IMF index means that it may be less suited than the KCFSI for detecting financial stress in the United States.

Besides the composite indexes described above, a number of indexes have been developed to capture a particular aspect of financial stress.

Table 4
SUMMARY OF OTHER FINANCIAL STRESS INDEXES

Index	Variables	Method of construction of index	Country
Illing and Liu	Rolling beta for banking industry, exchange rate volatility, corporate bond spread, covered Canada-U.S. interest rate differential, stock market volatility, Treasury bid-ask spread, commercial paper/T-bill spread, slope of yield curve	Principal components	Canada
International Monetary Fund	Rolling beta for banking industry, exchange rate volatility, TED spread, corporate bond spread, percent decline in overall stock index, stock market volatility, slope of yield curve	Unweighted average of standardized variables	17 countries

One such index represents changes in investors' risk appetite by changes in the cross-section relationship between risk and return on financial assets (Kumar and Persaud). Another index measures the fragility of the banking system by the average probability of bank failure, using information on the volatility of bank stock prices to estimate the "distance to default" (Carlson and others). Such indexes can be informative. But because they focus on a single aspect of financial stress, they are less useful in assessing the overall level of stress than composite indexes such as the Bank of Canada, IMF, and Kansas City Fed indexes.[22]

III. USING THE INDEX TO IDENTIFY FINANCIAL STRESS

A major objective of a financial stress index is to help policymakers determine whether financial stress is high enough to be a serious concern. This section evaluates the performance of the KCFSI in identifying past episodes of financial stress. The section then discusses how the KCFSI could be used to identify high financial stress in the future.

Ability of the index to identify past episodes of financial stress

The first step in assessing the historical performance of the KCFSI is to see if peaks in the index always occurred in known periods of financial stress. Chart 1 shows that the KCFSI has reached high levels during three separate periods—the 1990-91 recession, the extended period from fall 1998 to fall 2002, and the credit crisis that began in the summer of 2007. Each of these periods will be considered in turn.

1990-91 recession. The first peak in the KCFSI occurred in December 1990-January 1991, during the late stages of the 1990-91 recession. The Iraqi invasion of Kuwait in August 1990 had led to a spike in oil prices, increasing uncertainty and decreasing the appetite for risk among investors (Board of Governors 1991, p. 159). As a result, credit spreads widened and volatility in stock prices increased sharply. The beginning of armed conflict between the United States and Iraq in January appeared to resolve much of the uncertainty, and the index quickly subsided.[23]

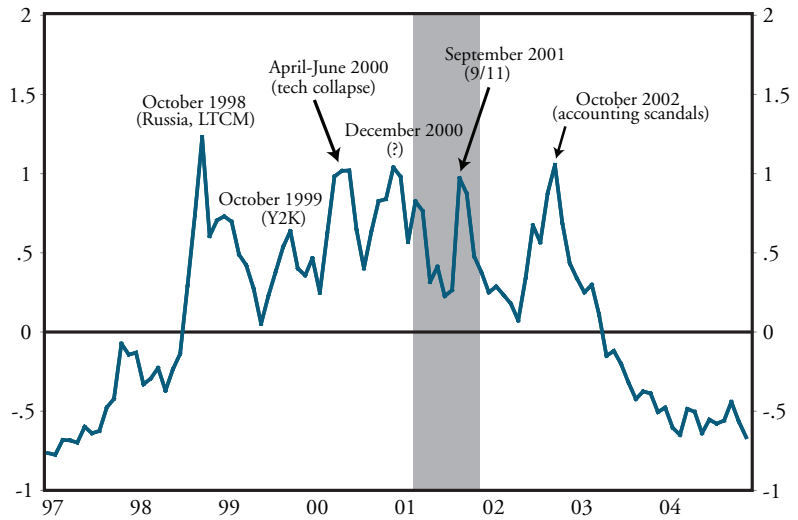
1998-2002. The period from October 1998 to October 2002 was unusual, in that the KCFSI attained six distinct peaks within a relatively short time span. This period is shown separately in Chart 2, so that the peaks can be more clearly distinguished.

The October 1998 peak followed close on the heels of the Russian debt moratorium in August and the bailout of the hedge fund Long-Term Capital Management (LTCM) in September (Board of Governors 1999, pp. 19- 23). The Russian default aroused concerns about other emerging country debt, sparking a flight to quality and liquidity in financial markets throughout the world. Financial stress then intensified in the United States when heavy losses at LTCM prevented the firm from meeting liquidity demands by creditors and counterparties. Quick action by policymakers to resolve the LTCM crisis and assist troubled emerging countries helped calm markets, causing the KCFSI to gradually subside.

The KCFSI next peaked in October 1999, amid intense concern about the approach of Y2K (Board of Governors 2000, p. 18). Most of the increase in the index during this period was due to deterioration in liquidity measures, as credit spreads remained little changed. Concerns about Y2K abated as year-end approached and it became clear that adequate preparations had been made. As a result, the KCFSI turned back downward.

The KCFSI reached two separate peaks in 2000. These increases are perhaps the hardest to explain in terms of financial stress. The first peak in April-June coincided with the bursting of the bubble in technology stocks. But that event had more effect on Nasdaq than on the broader stock market. The second peak was in December 2000, when there were no obvious explanations for increased financial stress other than

Chart 2
KCFSI IN THE LATE 1990s AND EARLY 2000s



Note: Index is calculated using data from February 1990 to March 2009. Shaded area is a recession.

the approach of recession. A factor unrelated to financial stress that may have boosted the KCFSI in 2000 was the expectation that the federal government would run large structural budget surpluses, decreasing the supply of Treasury securities. This expectation put downward pressure on Treasury yields, increasing some of the interest rate spreads in the index (Board of Governors, 2000, p. 20).

The next peak of the KCFSI, in September 2001, is easier to explain because it coincided with the terrorist attacks. High-yield bond spreads had been high all year due to the recession. Immediately following the terrorist attacks, stock price volatility and liquidity premiums also increased, producing the spike in the KCFSI. However, this episode was similar to the one in 1990, in that financial stress subsided quickly once investors realized that the economy would not suffer as much from the attacks as initially feared.

The last peak of the KCFSI during the 1998-2002 period was in October 2002. Financial stress during this period can be attributed to mounting investor concern about the accuracy of corporations' financial statements. This concern began with the failure in December 2001

of the energy trading firm, Enron, which had falsified its accounts to exaggerate its earnings. The concern intensified as the year went on, as other large companies such as WorldCom also admitted overstating their earnings. These revelations increased uncertainty about the financial condition of the corporate sector, leading to greater volatility in stock prices. The revelations also made it harder for investors to distinguish between good and bad companies, increasing the asymmetry of information in debt and equity markets.

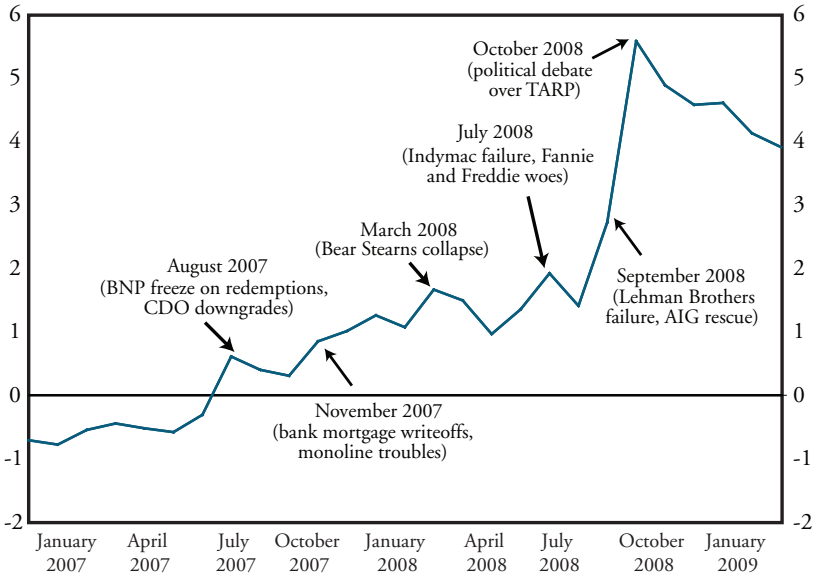
Current crisis. Not surprisingly, the biggest increases in the KCFSI have occurred during the current crisis. While a full discussion of the crisis is beyond the scope of this article, it is instructive to see how the index changed as the crisis progressed.[24] Chart 3 identifies the months in which the largest increases in the KCFSI occurred and lists some well-known events that might have contributed to the increases.[25]

The first signal from the KCFSI of increased financial stress was in August 2007. Investors had already showed concern about the quality of supbrime mortgages. These concerns increased when the rating agencies downgraded a number of structured mortgage products and the French bank BNP Paribas suspended redemptions for several of its investment funds. The next upturn in the KCFSI came in November 2007, when major banks announced writedowns of mortgage products and rating agencies downgraded some of the monoline insurers guaranteeing these products.[26] The KCFSI rose again in March 2008, during the turmoil surrounding the Bear Stearns collapse. The index subsided for awhile but then turned back up in July, when IndyMac Bank failed and Fannie Mae and Freddie Mac showed considerable signs of trouble.

The KCFSI confirms that financial stress took a sharp turn for the worse in the fall of 2008. The index recorded its largest increase ever in the month of September, when Lehman Brothers filed for bankruptcy, AIG was rescued, and two large troubled banks were absorbed by other banks after intervention by regulators. An even bigger increase in the index followed in October, as the previous month's events took their toll and the political stalemate over TARP undermined confidence. The KCFSI has retreated since then. By March 2009, however, the index was still more than three times greater than any of the peaks in the late 1990s and early 2000s, the last period of financial stress.

Chart 3

KCFSI DURING THE 2007-2009 CREDIT CRISIS



Note: Index is calculated using data from February 1990 to March 2009

The above review of the behavior of the KCFSI since 1990 confirms that peaks in the index have almost always occurred during known episodes of financial stress. But another important question is whether there have been any well-recognized periods of financial stress in which the KCFSI has *not* increased. In other words, to be a good measure of financial stress, the KCFSI should not only have few false positives, but also have few false negatives. A careful review of other authors' lists of financial crises in the United States and other developed countries reveal only two episodes that might have been highly stressful but are not captured by the KCFSI—the Mexican peso crisis of late 1994 and the Asian financial crisis in the summer of 1997.[27] During both episodes, the KCFSI remained below zero. However, these crises were mainly international in nature with relatively little spillover to U.S. financial markets. As a result, the crises could be expected to have less effect on financial stress in the United States than in countries more closely tied to international capital markets.

How the index could be used to identify future financial stress

In a period such as the fall of 2008, a financial stress index like the KCFSI may be so high that everyone agrees financial stress is a serious concern. At other times, however, it may not be so obvious whether the index is high enough to be a major concern. There are three possible ways to tackle this problem.

The approach of the Bank of Canada and IMF is to classify financial stress as severe when the index exceeds the historical mean by a certain number of standard deviations. The Bank of Canada uses a relatively high cutoff of two standard deviations above the mean, while the IMF employs a lower cutoff of one standard deviation above the mean.[28] One problem with this approach is that the number of standard deviations by which the index exceeds the mean on a given date can change drastically as observations are added to the sample. As a result, a month could be classified as one of high financial stress before the addition of the new observations, but as a month with low financial stress after the addition of the new observations. Consider, for example, the month of October 1998, when financial stress was very high due to the Russian debt default and the LTCM crisis. When the KCFSI is estimated using only data through June 2007, the index has a value of 2.6 standard deviations in October 1998, putting it well above both the Bank of Canada and IMF thresholds for high financial stress. However, when the KCFSI is estimated using data all the way through March 2009, the index is only 1.2 standard deviations above zero in October 1998, putting it above the IMF cutoff but well below the Bank of Canada cutoff.[29]

A second way to decide if the KCFSI is high enough to be a serious concern is to establish a cutoff in terms of percentiles. For example, the index for a particular month could be classified as high if it fell in the 90th percentile for the entire sample—that is, if the index for that month was greater than or equal to the index in 90 percent of all the months in the sample. An advantage of this approach is the well-known statistical fact that adding extreme observations has much less effect on the 90th percentile of a sample—or any other percentile of the sample—than on the standard deviation of the sample. As a result, the addition of extreme observations is less likely to cause a month to

switch from being classified as high stress to being classified as low stress when the sample is changed.[30]

A final approach is to classify the KCFSI as high whenever it equals or exceeds the value of the index in some benchmark episode, such as the Russian default and LTCM crisis (October 1998) or the Enron/WorldCom accounting scandals (October 2002). This approach has the advantage of being even less affected than the percentile method by the addition of observations with extreme values of the KCFSI to the sample. Suppose, for example, that a particular month has a lower KCFSI than October 1998 using data up to the present. Then that month is likely to still have a lower KCFSI than October 1998 using data available a year from now, no matter how extreme the observations are in the interim.[31] Comparing the KCFSI to some benchmark episode such as the Russian debt default and LTCM crisis also has the advantage of being more intuitive than the other two approaches. Many users of the KCFSI will find it useful to know if the index is higher than in some previous financial crisis with which they are familiar. They are less likely to be interested in how many standard deviations above the mean the index lies, or what percentile of all observations the index represents.

Based on the above discussion, how might the KCFSI be used to assess financial stress in the current crisis? As shown in Chart 1, the KCFSI has fallen considerably from its peak in the fall of 2008. However, the index is still much higher than before the crisis and much higher than in any previous episode of financial stress since 1990. Under a strict standard, financial stress could be judged to no longer be a serious concern once the KCFSI had returned to the same level as in July 2007, before the crisis began. Under a looser standard, financial stress could be judged to no longer be a serious concern once the index had fallen below its level in October 1998 and October 2002, when financial stress was high but the economy still grew briskly. Finally, it is not only the level of the index that matters, but also the length of time over which the index remains at that level. The peaks in the KCFSI in October 1998 and October 2002 were both short-lived. If the KCFSI fell to these levels but then stayed there, there would obviously be more reason for concern than if the index continued to trend downward.

IV. THE LINK BETWEEN FINANCIAL STRESS AND ECONOMIC ACTIVTY

Previous sections of this article have explained how the KCFSI captures financial stress and how the index can be used to determine if financial stress is high. The implicit assumption was that high levels of financial stress can be harmful to the economy. This section explores the principal basis for such concerns, which is that high financial stress can lead to reductions in economic activity. The section first discusses the various channels through which financial stress can affect economic activity. The section then examines the empirical relationship between the KCFSI and a monthly index of national economic activity to see if increases in financial stress have tended to be followed by decreases in economic growth.

Ways in which financial stress can affect economic activity

An increase in financial stress can lead to a decline in economic activity through three possible channels. The first channel is an increase in uncertainty about the prices of financial assets and the economic outlook in general. Section I noted that financial stress is associated with two kinds of uncertainty—uncertainty about the fundamental value of assets and uncertainty about the behavior of other investors. Both kinds of uncertainty lead to increased volatility in asset prices. Empirical studies have shown that such volatility tends to cause firms to become more cautious, delaying important hiring and investment decisions until the uncertainty is resolved (Bloom). The volatility may also cause households to cut back on spending, as they become more uncertain about their future wealth. To the extent businesses and households do react in this way, real economic activity will fall.

The second channel through which increased financial stress can affect economic activity is through increases in the cost to businesses and households of financing spending. Flight to quality, flight to liquidity, and increased asymmetry of information all have the effect of boosting interest rates on business and consumer debt in the capital markets. In addition, financial stress can make it more expensive for firms to raise funds by issuing new equity. Such increases in the cost of finance may cause businesses and households to cut back on their spending, depressing economic activity still further.

The last way financial stress can lead to a slowing of economic activity is by causing banks to tighten their credit standards. The same factors that cause investors to demand higher returns on debt and equity during periods of financial crisis may make banks less willing to lend. In such situations, banks tend to cut back on lending in two ways. First, they raise the interest rate charged on new loans, making it less attractive to borrowers to take out loans. Such an increase in loan rates should have the same effect on spending by businesses and households as an increase in the cost of credit on capital markets. As a result, this effect can be considered part of the cost-of-credit channel discussed above. Second, banks raise their minimum credit standards, making it harder for borrowers to qualify for loans. Such a tightening of credit standards may lead to an additional decline in spending, beyond that caused by the increase in loan rates (Lown and Morgan). Thus, it constitutes a third channel through which financial stress can affect economic activity—one that may be just as important as increased uncertainty and increased cost of credit.

As noted earlier, the KCFSI is based entirely on interest rates and prices in capital markets. As a result, the index cannot directly capture any tightening of bank credit standards due to increased financial stress. However, independent information on the tightening of bank credit standards is available from the Federal Reserve's quarterly Senior Loan Officer Opinion Survey (SLOOS). As shown in the accompanying box, high values of the KCFSI have tended to either coincide with or precede tighter credit standards over the last 20 years. This evidence suggests that changes in credit standards provide an additional channel through which financial stress may affect economic activity.

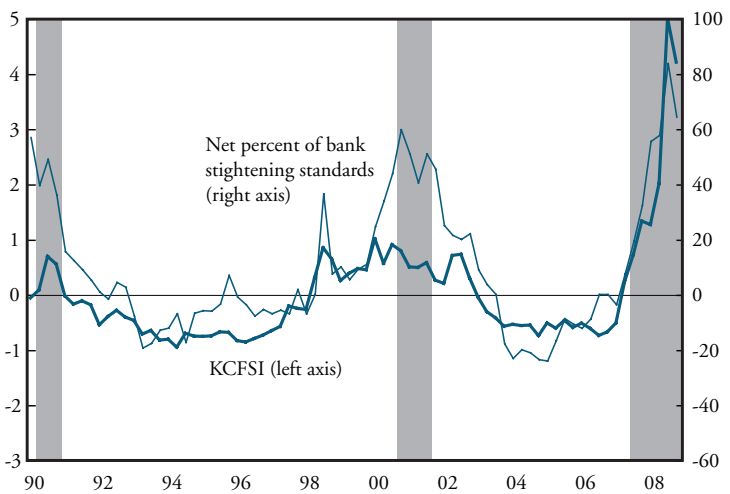
Direct evidence on the link between the KCFSI and economic activity

A useful measure of monthly economic activity is the Chicago Fed's National Activity Index (CFNAI). This index combines a large number of monthly indicators for employment, production, and spending into an overall measure of economic activity in the same way that the KCFSI combines a variety of financial indicators into an overall measure of financial stress. The CFNAI has been shown to have desirable properties as a macroeconomic indicator, including the ability to predict changes in inflation.[32]

FINANCIAL STRESS AND CHANGES IN CREDIT STANDARDS

The chart below compares the KCFSI with a measure of the tightening of credit standards from the Federal Reserve's Senior Loan Officer Opinion Survey (SLOOS). Each quarter, the SLOOS reports the net percentage of banks that said they tightened credit standards over the previous three months. The lighter line in the chart shows this percentage for commercial and industrial (C&I) loans to large firms. The heavy line shows the quarterly average of the KCFSI. The chart suggests that the financial stress index and SLOOS measure have tended to move together since 1990. This tendency is most evident around the three recessions, but it also shows up in late 1998 near the time of the Russian debt default and LTCM collapse. The contemporaneous correlation coefficient between the two measures is 0.80—both for the sample ending in 2009:Q1 and the sample ending in 2008:Q2, before the sharp increase in the KCFSI.

KCFSI VS. CHANGE IN CREDIT STANDARDS ON C&I LOANS



Note: Change in credit standards is for C&I loans to large businesses. Shaded areas are recessions.
Source: Senior Loan Officer Opinion Survey for change in credit standards.

The table below presents standard statistical tests of the lead-lag relationship between the KCFSI and SLOOS measure. In these tests, each variable is regressed on lagged values of itself and lagged values of the other variable. The tests indicate that the KCFSI provides information about future changes in credit standards, but changes in credit standards do not provide information about future levels of the KCFSI. Put another way, the KCFSI tends to lead changes in credit standards, but not the other way around. Taken together, the chart and table confirm that high values of the KCFSI either coincide with or precede tighter credit standards.

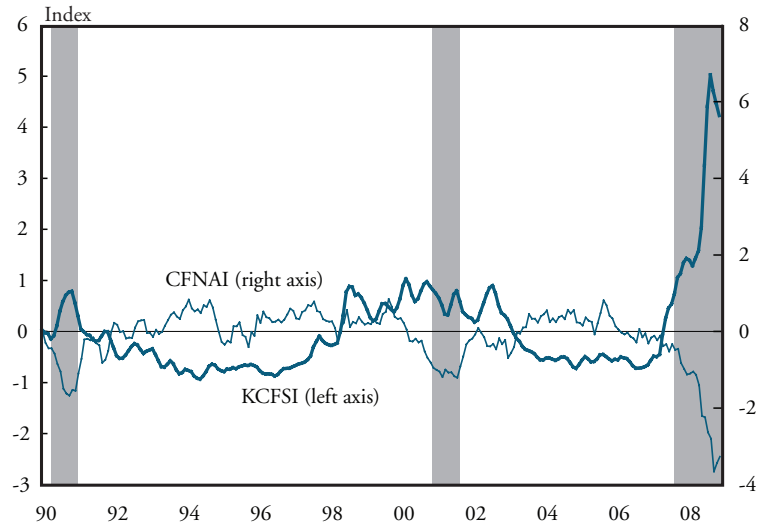
PREDICTION TESTS FOR KCFSI AND CREDIT STANDARDS 1990:Q4 to 2008:Q2

Regression of credit standards on lagged values of credit standards and KCFSI	
Does KCFSI help predict credit standards?	Yes
Sum of coefficients on KCFSI	7.95
p-value for test that sum equals zero	.000
Regression of KCFSI on lagged values of KCFSI and credit standards	
Do credit standards help predict KCFSI?	No
Sum of coefficients on credit standards	-.003
p-value for test that sum equals zero	.460
Memo: Number of lags	1

Note: Quarterly averages are used for the KCFSI, which is calculated with data through 2008:Q2. The number of lags was chosen by the Schwartz criterion. One variable helps predict the other if the p-value for the test that all the coefficients on lagged values of the first variable are equal to zero is less than .01.

Chart 4

KCFSI VS. CHICAGO FED NATIONAL ACTIVITY INDEX (CFNAI)



Note: Both variables are expressed as 3-month moving averages. Shaded areas are recessions.

The KCFSI and CFNAI are plotted in Chart 4 for the period 1990-2009. Because the CFNAI is somewhat choppy on a month-to-month basis, a three-month moving average is used for both indexes. The CFNAI and KCFSI show a strong negative correlation, moving in opposite directions throughout the period. The negative relationship is especially pronounced in late 2008, when financial stress spiked and the recession deepened. Even before then, however, the KCFSI and CFNAI show a strong tendency to move in opposite directions. Specifically, the contemporaneous correlation between KCFSI and CFNAI is -0.52 for the period ending in August 2008, versus -0.72 for the period ending in March 2009.[33]

While there is clearly a negative relationship between KCFSI and CFNAI, it is not easy to tell whether one variable provides information about future values of the other variable. Table 5 provides evidence on this issue. Each variable is regressed on lagged values of itself and lagged values of the other variable. The tests are performed for the period ending in August 2008, so that the results are not influenced by the huge spike in KCFSI and drop in CFNAI in the fall of 2008. The results

Table 5

PREDICTION TESTS FOR KCFSI AND CHICAGO FED NATIONAL ACTIVITY INDEX

April 1990 to August 2008

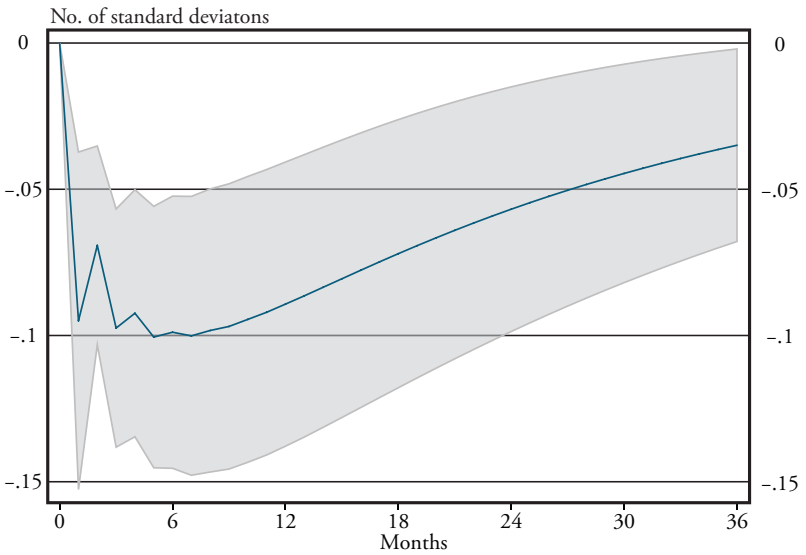
Regression of CFNAI on lagged values of CFNAI and KCFSI	
Does KCFSI help predict CFNAI?	Yes
Sum of coefficients on KCFSI	-.154
p-value for test that sum equals zero	.000
Regression of KCFSI on lagged values of KCFSI and CFNAI	
Does CFNAI help predict KCFSI?	No
Sum of coefficients on CFNAI	-.014
p-value for test that sum equals zero	.763
Memo: Number of lags	2

Note: The number of lags was chosen using the Schwartz criterion. One variable helps predict the other if the p-value for the test that all the coefficients on lagged values of the first variable are equal to zero is less than .01.

indicate that KCFSI helps predict CFNAI, but that CFNAI does not help predict KCFSI. The tests also show that increases in KCFSI tend to lead to decreases in CFNAI, as expected. Specifically, the sum of coefficients on lagged values of KCFSI is negative and statistically significant in the regression for CFNAI. This result contrasts with the regression for KCFSI, in which the sum of coefficients on lagged values of CFNAI is close to zero and statistically insignificant.

The finding that KCFSI helps predict CFNAI is as expected. It supports the view that financial stress can slow economic activity through some combination of increased uncertainty, increased cost of finance, and tighter credit standards. To provide some idea of the possible magnitude of this effect, Chart 5 shows the impulse response function for a shock to financial stress. The impulse response is the estimated change in CFNAI following a one-standard-deviation shock to KCFSI, based on the regressions for CFNAI and KCFSI in Table 5.[34] The shaded area represents the 95 percent confidence band for the estimate. As indicated by the solid line, the shock to KCFSI leads to a decline in CFNAI of 0.1 standard deviation within the first six months. After that point, CFNAI gradually returns to its initial value. The decline in CFNAI is significantly different from zero, as indicated by the fact that the confidence band lies entirely below zero.

Chart 5
RESPONSE OF CFNAI TO SHOCK TO KCFSI



Note: Assumes a one-standard-deviation shock to KCFSI. The assumed ordering is (CFNAI, KCFSI). KCFSI is calculated using data through August 2008. The shaded area is a 95 percent confidence band constructed from bootstrapped residuals.

Is the impact of financial stress on economic activity shown in Chart 5 large enough to be economically significant? According to the Chicago Fed, recessions typically occur when the CFNAI falls 0.7 standard deviation below its average value of zero. It follows that that the KCFSI would have to rise about seven standard deviations above zero to cause a recession. Such a high level of financial stress may seem too unlikely to worry about. However, the index reached 5.6 standard deviations last October, not too far from the critical level. Furthermore, even if stress is not high enough to cause a recession by itself, it may be more than high enough to do so in combination with other adverse shocks, such as a jump in oil prices or drop in home prices.[35]

V. CONCLUSIONS

The current credit crisis has underscored the importance of understanding and measuring financial stress. This article has introduced a new measure of financial stress—the Kansas City Financial Stress Index

(KCFSI). This measure is a based on 11 financial market variables, each of which captures one or more key features of financial stress. The KCFSI was shown to perform well in identifying widely recognized episodes of financial stress over the last 20 years. The index was also shown to do a good job in this period of anticipating changes in economic activity.

Going forward, these findings suggest that the KCFSI can be a useful tool in the Federal Reserve's exit strategy for the current crisis. The decision when to remove liquidity from the economy and unwind special lending programs will be based in large part on the strength of business and consumer spending and the amount of upward pressure on wages and prices. However, in deciding when to tighten, it will also be useful for policymakers to know if financial stress no longer poses a threat to economic recovery. This article has not tried to define a critical level of the KCFSI above which financial stress is a serious concern and below which it is not. However, the article has suggested that policymakers can still gain insight into the seriousness of financial stress by comparing the current value of the KCFSI to its value in widely recognized episodes of financial stress in the past. In particular, a sustained decline in the index below levels in the LTCM crisis of 1998 or the accounting scandals of 2002 would indicate that policymakers can focus more heavily on traditional indicators of economic activity and inflation.

APPENDIX A

This appendix provides further details on the 11 variables included in the KCFSI. Sources for each variable are given in Table A.1. The second column of the table indicates the primary source, while the third column indicates the source from which the data was obtained. Three of the variables were calculated by the authors as described below.

Correlation between returns on stocks and Treasury bonds. The stock-bond correlations are computed using rolling three-month windows. The Merrill-Lynch total return index for 2-year Treasury notes is used for bonds, and the S&P 500 total return index is used for stocks. In both cases, the daily total return is measured as the log difference in the total return index. For each month, the business day closest to the 15th is selected. The correlation coefficient between daily bond and stock returns is then computed using the 66 business days leading up to and including the chosen day.

Idiosyncratic volatility of the banking industry. For each month, the idiosyncratic volatility of bank stock prices is derived in three steps. The first step is to estimate a Capital Asset Pricing Model (CAPM) regression of the daily return on the bank stock index published by SNL Financial against the daily return on the S&P 500 index, using data for the previous 12 months. For each index, daily returns are measured as the log difference in the total-return index. The second step is to use the estimated coefficients from the CAPM regression and the daily returns on the S&P 500 to calculate the residual return on the SNL bank stock index for each day of the month. The last step is to calculate the standard deviation of these daily residual returns for the current month.

Cross-section dispersion of bank stock returns. The cross-section dispersion of bank stock prices is computed using daily data for the 100 largest commercial banks. For each month, the dispersion measure is calculated in four steps. The first step is to choose the 100 largest commercial banks in terms of market value and estimate a CAPM regression of the daily return on each bank's stock index against the daily return on the S&P 500 index, using data for the previous 12 months. As before, daily returns are measured as the log difference in the total-return index. In the second step, the estimated coefficients from the bank-level CAPM regressions and the daily returns on the S&P 500

are used to calculate the residual return for each bank for each day of the current month. The third step is to add the daily residual returns to obtain the monthly residual return for each bank. The last step is to calculate the interquartile range for these monthly residual returns—the difference between the top and bottom quartiles. The daily stock price data were taken from CRSP for the period through December 2008 and from SNL Financial for the first three months of 2009.

Table A.1

DATA SOURCES FOR VARIABLES IN KANSAS CITY FINANCIAL STRESS INDEX

Variable	Primary source	Source used to obtain data
Spread between 3-month LIBOR rate and 3-month secondary market T-bill yield (TED spread)	British Bankers Association for LIBOR; U.S. Treasury for T-bill rate	Haver for 3-month LIBOR; Federal Reserve H.15 release for T-bill rate
2-year swap spread	Bloomberg	Bloomberg
Spread between off-the-run 10-year Treasury yield and on-the-run 10-year constant maturity Treasury yield	Federal Reserve for off-the-run par yield; U.S. Treasury for on-the-run constant maturity yield	Haver for off-the-run yield; Federal Reserve H.15 release for on-the-run Treasury yield
Spread between Aaa corporate bond yield and 10-year constant maturity Treasury yield	Moody's for Aaa yield, U.S. Treasury for constant maturity Treasury yield	Federal Reserve H.15 release for Aaa yield; see above for Treasury yield
Spread between Baa and Aaa corporate bond yields	Moody's	Federal Reserve H.15 release for Baa yield; see above for Aaa yield
Spread between high-yield bond yield and Baa corporate bond yield	Merrill Lynch cash pay index for high-yield bond yield; Moody's for Baa yield	Haver for high-yield bond yield; see above for Baa yield
Spread between fixed-rate credit card ABS yield and 5-year constant maturity Treasury yield	Citicorp for consumer ABS yield; U.S. Treasury for Treasury yield	Bloomberg for consumer ABS yield; Federal Reserve H.15 release for Treasury yield
Negative value of correlation between total return on S&P 500 and total return on 2-year Treasury bonds	Calculated by authors from S&P 500 total return index and Merrill Lynch total return 2-year Treasury bond index (Bloomberg)	Bloomberg for S&P 500 and 2-year Treasury bond index
Implied volatility of overall stock prices (VIX)	Chicago Board Options Exchange	Haver
Idiosyncratic volatility of bank stock prices	Calculated by authors from S&P 500 total return index and SNL total return banking index	See above for S&P 500; SNL Financial for bank stock index
Cross section dispersion of bank stock returns	Calculated by authors from S&P 500 total return index and stock price data from CRSP and SNL Financial	See above for S&P 500; CRSP and SNL Financial for individual bank stock returns

APPENDIX B

This appendix explores the potential for instability in the KCFSI. As new observations are added to the sample, values of KCFSI in the original sample can change. This kind of instability would be troubling if the changes in KCFSI for past months were big enough to alter the classification of a month as high-stress. This appendix investigates the issue by examining the impact on the KCFSI of a specific sample change—the extension of the sample from June 2007, prior to the start of the current crisis, to March 2009. The appendix concludes from this example that the instability problem can be mitigated by comparing the KCFSI to its value in some benchmark episode of financial stress, as suggested in Section III.

Impact of the sample change on past values of the KCFSI. Chart B.1 shows the effect of the sample change on values of the KCFSI in the original sample. The heavy line shows the index for the sample period February 1990-June 2007, while the lighter line shows the index for the sample period February 1990-March 2009. The main effect of the sample change was to significantly reduce the KCFSI in those months in which the index was initially high. However, the index fell by a similar proportion in these months, leaving the relative position of the months little changed. The other impact of the sample change was to slightly increase the KCFSI in those months in which the index was initially negative and very low.

Reasons for the change in past values of the KCFSI. In general, a sample change can alter values of the index in the original sample either by changing the coefficients on the variables in the index or by changing the values of the variables in the original sample. The change in the coefficients can be due either to a change in their overall magnitude or to a change in their relative magnitudes. The change in the values of the variables in the original sample is due to the fact that each variable is standardized in the principal components procedure—the sample mean is subtracted from the raw value of the variable and the result is then divided by the sample standard deviation. As new months are added to the sample, the sample mean and sample standard deviation of a variable can change, especially if the new observations are extreme, as in the case of the credit crisis. But if the sample mean and sample standard

deviation of a variable change, so too will the standardized values of the variables in the original sample.[36]

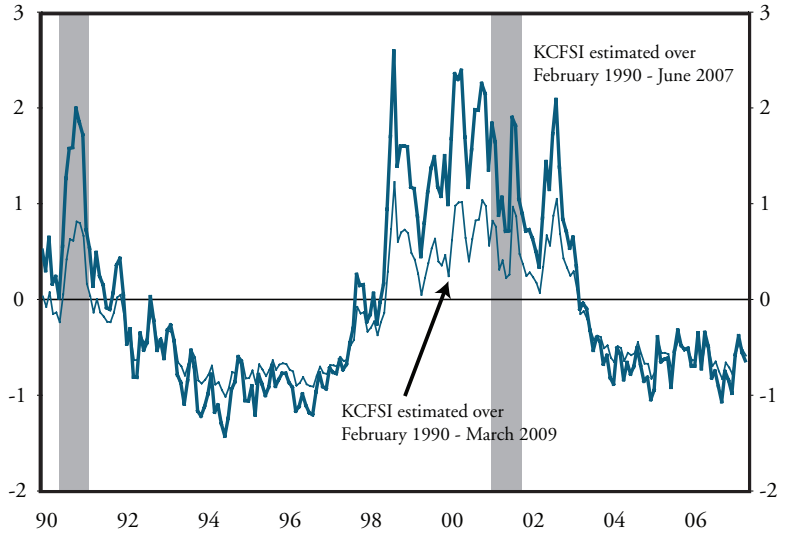
For the specific sample change under consideration—the addition of the 18 months from July 2007 to March 2009—the most important source of change in past values of KCFSI was changes in the standardized values of the variables.[37] This change was due to unusually high levels of most of the variables during the credit crisis. These high levels raised both the sample means and sample standard deviation of the variables, decreasing their standardized values in those months in the original sample when the variables were initially positive and high. These decreases in the standardized values of the variables led in turn to the decreases in KCFSI shown in Chart B.1. The next most important source of change in past values of the KCFSI was a change in the overall magnitude of the coefficients. Not surprisingly, the variables making up the KCFSI had a much greater tendency to move together during the credit crisis: The KCFSI explains 61.4 percent of the total variation in the variables in the new sample period, versus 42.6 percent in the original sample. In the principal components procedure, such an increase in the proportion of total variation explained by the index requires a scaling down of all the coefficients of the variables in order to keep the standard deviation of the index equal to one.[38] The least important source of change in past values of KCFSI was changes in the relative magnitudes of the coefficients. The sample change raised the coefficients on the TED, Baa/Aaa, and consumer ABS spreads relative to the coefficients on the other variables. On the whole, however, these changes had much less impact on the KCFSI than changes in the standardized values of the variables or changes in the overall magnitude of the coefficients.[39]

Implications for the interpretation of the KCFSI. The above findings on the effects of extending the sample from June 2007 to March 2009 support the use of benchmark episodes in determining whether financial stress is high in a particular month. If the standard deviation approach were used, the downward shift in the KCFSI shown in Chart B.1 for months with high values of KCFSI could cause some months to be reclassified from high-stress to low-stress. For example, if the cutoff were one standard deviation above the mean, the months December 1990 and October 1999 would no longer be considered high-stress

months. The percentile method would be less subject to this problem. However, because most of the months added to the sample have very high values of KCFSI, using a percentile cutoff could also result in the reclassification of previous months from high-stress to low-stress. But suppose that the degree of stress in a particular month is determined by comparing that month to some benchmark month such as October 1998, when financial stress is known to have been high because of the Russian debt default and LTCM crisis. Then the classification of a month as high-stress would be less likely to change, because the KCFSI shifts down by similar amounts in all months in which the index was initially high.

Chart B.1

EFFECT OF SAMPLE CHANGE ON VALUES OF KCFSI IN ORIGINAL SAMPLE



Shaded areas are recessions.

ENDNOTES

[1]See Caballero and Krishnamurthy and Easley and O'Hara for examples of this view of financial crises.

[2]In terms of Bayesian decision theory, the investor will revise his estimate of firm profitability by a greater amount, the higher is the signal-to-noise ratio—the higher is the precision of the signal relative to the precision of prior information about firm profitability. The precision of signals may decrease during a financial crisis—e.g., because changes in accounting practices make earnings announcements harder to interpret. However, the precision of prior information is likely to decrease even more, causing signals to have a greater impact on stock prices.

[3]Asset markets in which investors base their actions on their expectations of other investors' expectations have been modeled in two ways by economists. The first approach is to assume that each investor receives some private information about the fundamental value of the asset (Allen and others). The second approach is to assume that investors have common information but different beliefs (Kurz).

[4]A similar result would occur if the firms issuing the bonds were identical but investors could not observe how the firms were using the borrowed funds–the case of moral hazard. In this situation, each firm might have an incentive to use the funds in ways that benefited the firm's shareholders or managers at the expense of the bondholders. For example, the firm might make risky investments that mainly benefit shareholders if successful, but mainly hurt bondholders if unsuccessful. Realizing that firms have this incentive, bondholders would require a higher rate of interest on the bonds than if they could commit the firm to investing the funds in safer projects.

[5]Besides creating adverse selection, declines in collateral values can lead to moral hazard by giving borrowers more incentive to make risky investments or abscond with the funds.

[6]Another way lenders and investors could lose confidence in the accuracy of their information about firms is through accounting scandals or relaxations in accounting standards.

[7]In consumption-based asset pricing models, the compensation for bearing risk is referred to as the "price of risk." In such models, two factors can cause the price of risk to rise: an increase in the rate at which marginal utility declines with consumption or a belief that future consumption growth has become more volatile (Cochrane). Some economists argue that the second factor is a more likely source of large and sudden shifts in the price of risk than the first factor (Gai and Vause, pp. 6-8, and Coudert and Gex, pp. 10-14).

[8]In extreme cases of adverse selection, the market for an asset category can even break down completely, in which case even lower-quality assets cannot be sold to meet unexpected cash needs.

[9]For example, in the event of liquidation, fund managers may be paid a fee that is proportional to the liquidation value of the fund. The higher is the volatility of asset prices, the greater is the chance that the value of the fund's assets will fall below the threshold at which it has to be liquidated, and thus the more important it will be to the funds' managers to have highly liquid assets on hand (Vayanos).

[10]Default risk in the LIBOR market is often referred to as counterparty risk. For discussions of the relative roles of default risk and liquidity risk in boosting the LIBOR rate in the current crisis, see Kwan 2009 and Taylor and Williams.

[11]Some observers have questioned the accuracy of LIBOR on the grounds that banks in the panel could have an incentive to misreport their cost of borrowing on the interbank market (Mollenkamp and Whitehouse). However, none of the results in this article are changed if the 3-month LIBOR rate is replaced in the KCFSI by the 3-month Eurodollar deposit rate, a rate that is very highly correlated with LIBOR but reflects actual transactions.

[12]Another source of risk is the possibility of default by a counterparty, but this risk exists on both sides of the swap, making the effect on the swap spread ambiguous.

[13]Most longer-term Treasury securities are issued once a quarter.

[14]The measure used for the off-the-run yield is the 10-year par yield from the off-the-run yield curve estimated by Gurkaynak and others.

[15]Bernanke and Gertler refer to the part of the yield spread due to information asymmetry as the external finance premium.

[16]Recessions tend to cause much bigger increases in defaults on high-yield bonds than on Baa bonds. Thus, as in the case of the Baa/Aaa spread, an increase in the spread could in some cases reflect a well-founded change in investor expectations about the economy rather than a flight to quality.

[17]The methodology is essentially the same as in Smirlock and Haq and Heaney.

[18]The interquartile range is the difference between the top and bottom quartiles. As a measure of dispersion, it has the advantage over the standard deviation of reducing the influence of extreme outliers. Apart from the use of the interquartile range, the calculation of dispersion in unexpected stock returns is similar to that in Cutler.

[19]The procedure may be described formally as follows. Let X_{it} be the value of the i^{th} standardized variable in month t; let $a_1....a_{11}$ be a set of coefficients for the 11 variables; let FSI_t be the value of the financial stress index in month t; and let T be the number of months. The values $\{FSI_t\}$and the coefficients $\{a_K\}$ are chosen to minimize the sum of squared errors, $SSE = \sum_K \sum_t (X_{Kt} - a_K FSI_t)^2$, subject to the constraint $\sum_t FSI_t^2 /(T-1) = 1$. As shown in Theil, the values of $a_1....a_{11}$ solving this problem are the elements of the first eigenvector of the sample correlation matrix of the 11 variables (Table 2). Also, $FSI_t = (a_1/\lambda)X_{1t} +....+ (a_{11}/\lambda)X_{11t}$ for all t, where

λ is the first eigenvalue for the sample correlation matrix. The coefficients in this expression are the ones reported in Table 3.

[20]In terms of the previous endnote, the number in the last row of Table 3 is 1– SSE/SST, where SST is the total sum of squares, $\sum_K \sum_t X_{Kt}^2$. When the coefficients are chosen as described in the previous endnote, this number equals the first eigenvalue of the sample correlation matrix divided by the number of variables in the index. See Theil for further details.

[21]According to the expectations theory, the long-term Treasury yield should equal the average of expected future short-term yields. A tightening of monetary policy relative to long-run expectations tends to push the current short-term yield above expected future short-term yields. As a result, it also tends to increase the spread of the current short-term yield over the current long-term yield.

[22]See Illing and Aaron for a more detailed review and assessment of the two kinds of financial stress indexes.

[23]Other events contributing to financial stress in 1990 included the failure of the investment bank, Drexel, Burnham, Lambert, a major player in the junk bond market, and commercial real estate losses at large regional banks such as the Bank of New England (Wolfson, pp. 127-137).

[24]For a more detailed review of the events of the crisis through the end of 2008, see Brunnermeier.

[25]These events are listed mainly to place the changes in KCFSI in context. With so many factors contributing to financial stress in the period, it is not possible to identify the precise causes of each monthly change in the index.

[26]Monoline insurers are companies that specialize in guaranteeing the timely repayment of bonds.

[27]Lists of episodes of financial stress can be found in Bloom, Bordo, and Illing and Liu. The last authors presented their colleagues at the Bank of Canada with a long list of episodes and asked them to rank them according to how stressful they were for Canada. Given the high degree of integration of the U.S. and Canadian economies, one would expect many of the events that were stressful for Canada to also be stressful for the U.S.

[28]The IMF also treats episodes that are two or fewer quarters apart as the same episode.

[29]The source of the problem is that the sample standard deviation of a variable is very sensitive to the addition of extreme values to the sample. As a result, more moderate values of the variable will represent fewer standard deviations from the mean in the new sample than in the original sample.

[30]For example, the KCFSI for October 1998 falls in the 90th percentile whether only data through June 2007 is used to calculate the index or data through March 2009 is used. It should be noted, however, that with the percentile method, it is still possible for the classification of a month as stressful to change as the sample grows. Consider, for example, the month of December 1990, during the late

stages of the 1990-1991 recession. The index for that month is well above the 90th percentile using data through June 2007 but somewhat below the 90th percentile using data through March 2009.

[31]Another problem posed by sample changes is that the addition of new observations can alter past values of the index by changing either the estimated coefficients on the variables or the standardized values of the variables. Appendix B presents evidence from the change in sample after June 2007 suggesting that such instability need not interfere with the use of the index to assess financial stress, as long as the benchmark method is used rather than the standard-deviation or percentile approach.

[32]A detailed explanation of the CFNAI can be found on the Chicago Fed's website. The index is constructed using principal components and draws on extensive research by James Stock and Mark Watson on the forecasting properties of such indexes.

[33]These correlations are for the monthly KCFSI and CFNAI rather than the 3-month moving averages shown in the chart.

[34]To compute the impulse response, some assumptions must be made about the contemporaneous relationship between KCFSI and CFNAI. Chart 5 assumes that within any month, a shock to CFNAI affects KSFSI, but a shock to KCFSI has no effect on CFNAI. While this ordering of the two variables seemed most plausible, the impulse response looks essentially the same when the ordering is reversed.

[35]Another way to assess the ability of the KCFSI to predict the CFNAI is by comparing the out-of-sample forecast errors from models using only lagged values of CFNAI to a model using both lagged values of KCFSI and lagged values of CFNAI. Preliminary analysis suggests that using information on KCFSI improves out-of-sample forecasts of CFNAI at some horizons but not others.

[36]The sources of change in the KCFSI can be formally identified by rewriting the expression for the FSI in endnote 19 as $FSI_t = (b_1X_{1t} + ...+ b_{11}X_{11t})/\lambda^{1/2}$, where $b_K = a_K/\lambda^{1/2}$ for all k. The parameters $\{b_K\}$ can be shown to satisfy $\sum b_{Kt}^2 = 1$, which is equivalent to the eigenvector $(b_1 \ldots. b_{11})$ having a length of one (Theil). Changes in $\lambda^{1/2}$, the square root of the eigenvalue, correspond to changes in the overall magnitude of the coefficients on the variables. Changes in the unit-length eigenvector $(b_1 \ldots. b_{11})$ correspond to changes in the relative magnitudes of these coefficients. Finally, changes in the standardized values of the variables correspond to changes in $\{X_{Kt}\}$.

[37]The relative importance of the different sources of change in KCFSI was determined by doing a shift-share type decomposition of the change in the index for each month in the original sample.

[38]In terms of endnote 36, the scale factor $\lambda^{1/2}$ increases from 2.16 in the original sample to 2.60 in the new sample, multiplying all the coefficients (and thus all the values of KCFSI in the original sample) by the factor .83.

[39]For non-overlapping periods of sufficient length, it is possible to test if differences in either the eigenvalues or the unit-length eigenvectors of a principal components model are statistically significant. See Perignon and Villa, who draw on earlier research by Flury. The period July 2007-March 2009 is too short to conduct such a test, but the test could be conducted by splitting the entire sample period into two parts, one of which includes the credit crisis.

REFERENCES

Allen, Franklin, Stephen Morris, and Hyun Song Shin. 2006, "Beauty Contests and Iterated Expectations in Asset Markets," *The Review of Financial Studies*, Vol. 19, No. 3, October.

Andersson, Magnus, Elizaveta Krylova, and Sami Vahamaa. 2008. "Why Does the Correlation between Stock and Bond Returns Vary over Time," *Applied Financial Economics*, Vol. 18, No. 2, January.

Baur, Dick G., and Brian M. Lucey. 2008. "Flights and Contagion–An Empirical Analysis of Stock-Bond Correlations," working paper, July.

Berger, Allen B., and Gregory F. Udell. 2004. "The Institutional Memory Hypothesis and the Procyclicality of Bank Lending Behavior," *Journal of Financial Intermediation*, Vol. 13.

Bernanke, Ben S., and Mark Gertler. 1995. "The Credit Channel of Monetary Policy Transmission," *Journal of Economic Perspectives*, Vol. 9, No. 4, Autumn.

Bloom, Nicholas. 2007. "The Impact of Uncertainty Shocks," National Bureau of Economic Research, Working Paper 13385, September.

Board of Governors, *Monetary Policy Report to Congress*, various issues.

Bordo, Michael D. 2007. "The Crisis of 2007: The Same Old Story, Only the Players Have Changed," working paper, September.

Brunnermeier, Markus K. 2009. "Deciphering the Liquidity and Credit Crunch 2007-2008," *Journal of Economic Perspectives*, Vol. 23, No. 1, Winter.

Brunnermeier, Markus K., and Lasse H. Pedersen. 2009. "Market Liquidity and Funding Liquidity," *Review of Financial Studies*, Vol. 22, No. 6, June.

Caballero, Ricardo J. and Arvind Krishnamurthy. 2007. "Collective Risk Management in a Flight to Quality Episode," NBER Working Paper 12896. February.

_____. 2008. "Musical Chairs: A Comment on the Credit Crisis." Banque de France, *Financial Stability Review*, February.

Caballero, Ricardo J., and Pablo Kurlat. 2008. "Flight to Quality and Bailouts: Policy Remarks and Literature Review," working paper, October.

Calomoris, Charles W., and Joseph R. Mason. 2004. "Credit Card Securitization and Regulatory Arbitrage," *Journal of Financial Services Research*, Vol. 26, No. 1, August.

Carlson, Mark A., Thomas B. King, and Kurt F. Lewis. 2008. "Distress in the Financial Sector and Economic Activity," Federal Reserve Board, Finance and Economics Discussion Series No. 2008-43, August.

Cochrane, John. 2005. *Asset Pricing*, rev. ed., Princeton, N.J.: Princeton University Press.

Connolly, Robert, Chris Stivers, and Licheng Sun. 2005. "Stock Market Uncertainty and the Stock-Bond Relation," *Journal of Financial and Quantitative Analysis*, Vol. 40, No. 1, March.

Coudert, Virginie, and Mathieu Gex,. 2006. "Does Risk Aversion Drive Financial Crises? Testing the Predictive Power of Empirical Indicators," CEPII Working Paper No. 2007-02, January.

Cutler, David M. 1989. "Stock Market Volatility, Cross-Section Volatility, and Stock Returns," working paper, MIT.

Duca, John V. 1999. "What Credit Market Indicators Tell Us," Federal Reserve Bank of Dallas, *Economic and Financial Review*, Third Quarter.

Easley, David, and Maureen O'Hara. 2008. "Liquidity and Valuation in an Uncertain World," working paper, September.

Flury, Bernhard N. 1988. *Common Principal Components and Related Multivariate Models*, New York: John Wiley & Sons.

Furletti, Mark. 2002. "An Overview of Credit Card Asset-Backed Securities," Federal Reserve Bank of Philadelphia, Payment Cards Center Discussion Paper, December.

Gai, Prasanna, and Nicholas Vause. 2005. "Measuring Investors' Risk Appetite," Bank of England, Working Paper No. 283.

Gertler, Mark, and Cara S. Lown. 1999. "The Information in the High-Yield Bond Spread for the Business Cycle: Evidence and Some Implications, *Oxford Review of Economic Policy*, Vol. 15, No. 3.

Getter, Darryl E. 2008. "The Credit Card Market: Recent Trends, Funding Cost Issues, and Repricing Practices," CRS Report for Congress, No. RL34393, February 27.

Gonzalo, Jesus, and Jose Olmo. 2005. "Contagion versus Flight to Quality in Financial Markets," Universidad Carlos III de Madrid, Working Paper No. 05-18, April.

Gorton, Gary B. 2008. "The Panic of 2007," in Federal Reserve Bank of Kansas City, Proceedings of Jackson Hole Conference, *Maintaining Stability in a Changing Financial System*.

Grinblatt, Mark. 2002. "An Analytic Solution for Interest Swap Spreads," Yale ICF Working Paper No. 02-02. January.

Gurkaynak, Refet S., Brian Sack, and Johnathan H. Wright. 2007. "The U.S. Treasury Yield Curve: 1961 to the Present," *Journal of Monetary Economics*, Vol. 54, No. 8, November.

Guttentag, Jack M., and Richard J. Herring. 1986. *Disaster Myopia in International Banking*, Princeton University Essays in International Finance, No. 164. September.

Haq, Mamiza, and Richard Heaney. 2009. "European Bank Equity Risk: 1995-2006", *Journal of International Financial Markets, Institutions, and Money*, Vol. 19.

Hautsch, Nikolas, and Dieter Hess. 2007. "Bayesian Learning in Financial Markets: Testing for the Relevance of Information in Price Discovery," *Journal of Financial and Qualitative Analysis*, Vol. 42, No. 1, March.

Illing, Mark, and Ying Liu. 2006. "Measuring Financial Stress in a Developed Country: An Application to Canada," *Journal of Financial Stability*, Vol. 2, No. 3, October.

Illing, Mark, and Meyer Aaron. 2005. "A Brief Survey of Risk Appetite Indexes," Bank of Canada, *Financial System Review*.

International Monetary Fund. 2008. *World Economic Outlook*, October.

Kindleberger, Charles P. 1978. *Manias, Panics, and Crashes*. London: Macmillan.

Kurz, Mordecai. 2008. "Beauty Contests under Private Information and Diverse Beliefs: How Different?" *Journal of Mathematical Economics*, Vol. 44, Nos. 7-8, July.

Kumar, Manmohan S., and Avinash Persaud. 2001. "Pure Contagion and Investors' Shifting Risk Appetite: Analytical Issues and Empirical Evidence," IMF Working Paper No. 01-134, September.

Kwan, Simon. 2001. "Rising Junk Bond Yields: Liquidity or Credit Concerns?" Federal Reserve Bank of San Francisco, *Economic Letter*, No. 2001-33, November 16.

_____. 2009. "Behavior of Libor in the Current Financial Crisis," Federal Reserve Bank of San Francisco, *Economic Letter*, No. 2009-04, January 23.

Lown, Cara S., and Donald P. Morgan. 2006. "The Credit Cycle and the Business Cycle," *Journal of Money, Credit, and Banking*, Vol. 38, No. 6, September.

Minsky, Hyman P. 1972. "Financial Stability Revisited: The Economics of Disaster," in Board of Governors, *Reappraisal of the Federal Reserve Discount Mechanism*, Vol. 42, No. 3, July.

Mishkin, Frederic S. 1991. "Asymmetric Information and Financial Crises: A Historical Perspective," in R.G. Hubbard, ed., *Financial Markets and Financial Crises*. Chicago: University of Chicago Press.

Mollenkamp, Carrick, and Mark Whitehouse. 2008. "Study Casts Doubt on Key Rate," *Wall Street Journal*, May 29.

Pastor, Lubos, and Pietro Veronesi. 2008. "Learning in Financial Markets," University of Chicago Business School, Working Paper No. 08-28.

Perignon, Christophe, and Christophe Villa. 2006. "Sources of Time Variation in the Covariance Matrix of Interest Rates," *Journal of Business*, Vol. 79, No. 3.

Smirlock, Michael. 1984 "An Analysis of Bank Risk and Deposit Rate Ceilings," *Journal of Monetary Economics*, Vol. 13, No. 2, March.

Taylor, John B., and John C. Williams. 2008. "A Black Swan in the Money Market," Federal Reserve Bank of San Francisco, Working Paper No. 2008-04.

Theil, Henri. 1971. *Principles of Econometrics*, New York: John Wiley & Sons.

Vayanos, Dimitri. 2004. "Flight to Quality, Flight to Liquidity, and the Pricing of Risk," NBER Working Paper 10327.

Wolfson, Martin H. 1994. *Financial Crises: Understanding the Postwar U.S. Experience*, 2nd ed., Armonk, N.Y.: M.E. Sharpe.