Measuring Financial Stress

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Numerous events over the past decade have been described as "financial crises"—the Mexican crisis of 1994–95, the 1997–98 Southeast Asian crisis, and the Russian debt default and Long-Term Capital Management crisis of 1998 are a few of the better known. How did these events affect the Canadian financial system?

One way of considering this question is to apply the concept of "stress" to the financial system, drawing on analogies from the physical sciences. Stress is often caused by an outside (exogenous) force acting on a system. It leads to changes in the functioning and integrity of the system that, if great enough, can damage the system itself. Such a change can be thought of as a "crisis."

The size and diverse makeup of the financial system, which consists of financial institutions, financial markets, and clearing and settlement systems, suggests there are many potential sources of stress. According to this perspective, stress is always present to a degree somewhere in the financial system and may pass largely unnoticed until it reaches high levels or becomes widespread. Thus, a measure of financial stress should be a continuum, where extreme values represent crises.

Stress rises when one or more of the following increases:

- expected financial loss

- risk (a higher probability of loss)

- uncertainty (reduced confidence about the probability of loss)

Stress results from the impact of a shock on the financial system. The amount of stress present in a system therefore depends on the magnitude of these shocks, the initial conditions present in the system, and the structure of the financial system. For example, a negative shock is more likely to cause a large increase in stress when financial conditions are weak, when cash flows are low, balance sheets are highly leveraged, or lenders are more risk-averse. Shocks may also be propagated through weaknesses in the structure of the financial system, such as market-coordination failures, overloaded computer systems, or highly asymmetric flows of information. The size of the shock and its interaction with weaknesses in the financial system determine the level of stress (Chart 1).

Stress can manifest itself in various ways across the financial system, and disruptions in one market can spill over to others (this is known as contagion). For example, adverse movements in market prices and interest rates can impair the value of financial assets, as is the case during a stock market crash. This can be followed by unusually large deposit withdrawals or interruptions in payment flows that strain banking system liquidity.

How Is Stress Measured?

Although the literature on predicting financial crises in emerging markets is abundant, little attention has been devoted to defining crises or measuring their severity. The standard approach in the empirical literature is to treat stress as a binary variable with either crisis or non-crisis values. Kaminsky and Reinhart (1996, 1999) and Frankel and Rose (1996) are commonly followed examples. Crises are usually defined based on an event study or on the extreme values of one or two variables, such as a sharp

exchange rate depreciation that signifies a foreign exchange crisis.

This approach is popular because it allows the application of binary-choice models to estimate the probability of crises in emerging markets. However, the technique does not distinguish between the severity of different stressful events, and it has not been successfully applied to industrialized economies, where full-blown crises are rare.

As a result, only a few studies have attempted to quantify stress as a continuous variable in the context of well-developed financial systems. Bordo, Dueker, and Wheelock (2000) develop an index for the United States based on bank losses, business failures, real interest rates, and bond-yield spreads.

Several organizations have also created stress indexes. BCA Research publishes a monthly stress index for the United States based on variables similar to those in the Bordo et al. index, as well as on several stock market indicators (McClellan 2001). J.P. Morgan Chase & Co. publishes a global Liquidity, Credit, and Volatility Index (LCVI) based on daily bond, foreign exchange, and stock market indicators (Kantor and Caglayan 2002). The financial stress index (FSI) developed by Illing and Liu (2003), which is the basis of this summary report, is the first such measure for Canada.

A Survey of Financial Stress

To improve the accuracy with which our index reflects stress in the Canadian financial system, it was benchmarked against the results from a Bank of Canada survey. Senior staff members were asked to subjectively rank the severity of 41 different events over the past 25 years in terms of how much stress the Canadian financial system was perceived to be under at the time.

The list of events surveyed was drawn from a review of Bank of Canada *Annual Reports* since 1977 and *Monetary Policy Reports* since 1995. Events were included if they were explicitly identified as having had a significant impact on Canadian markets. Ten of these events were ranked as "highly stressful" according to the survey (in chronological order):

- the August 1981 spike in interest rates, when mortgage rates reached almost 22 per cent

Chart 1   Schematic of Financial Stress
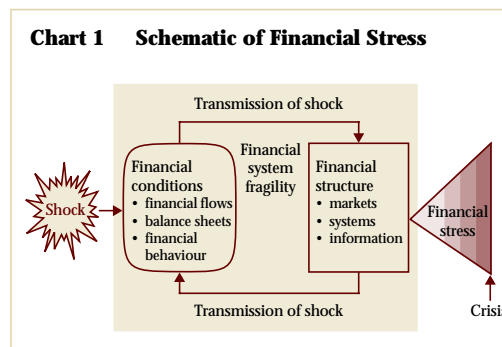
- the less-developed countries (LDC) debt crises of the early 1980s, to which Canadian banks were heavily exposed

- the regional Canadian bank failures of 1985

- the October 1987 stock market crash

- the real estate price collapse, loan losses, and debt defaults of the early 1990s

- the Mexican peso crisis (1995)

- the Southeast Asian crisis (1997–98)

- the Russian/LTCM crisis (1998)

- the high-tech stock market collapse (2000)

- the events of 11 September 2001

Variable Selection

The next step involved determining which variables best reflected the qualitative rankings from the survey and weighting them appropriately.

Over 150 different measures of expected loss, risk, and uncertainty were considered. These were drawn from the financial institutions sector and from the foreign exchange, fixed-income, and equity markets. The rankings from the survey helped to determine which variables were best suited for the index. Several alternative weighting schemes were also tested.

The final results are quite robust to the choice of variables and weighting schemes. The specification of the financial stress index that most closely matches the survey rankings includes the following measures of expected loss, risk, and uncertainty.

Variables that primarily reflect expected loss:

- the spread between the yields on bonds issued by Canadian financial institutions and on government bonds of comparable duration

- similarly, the spread between the yields on Canadian non-financial corporate bonds and on government bonds

- because the capacity to repay debt can be affected by short-term fluctuations in interest rates, the inverted term spread is also included in the index (i.e., the 90-day treasury bill rate minus the yield on 10-year government bonds)

Variables that primarily reflect risk:

- the beta (β) variable derived from the total-return index for Canadian financial institutions (β is a measure of how risky a stock, or group of stocks, is relative to the overall market)

- volatility of the Canadian dollar[1]

- Canadian stock market volatility[2]

Variables that primarily reflect uncertainty:

- the difference between Canadian and U.S. government short-term borrowing rates (the difference is adjusted for exchange rate risk using the covered-interest-parity condition)

- the average bid/ask spread on Canadian treasury bills[3]

- the spread between the rates on 90-day Canadian commercial paper and treasury bills

Weighting Methodology

The daily value of each variable is first weighted by its sample cumulative distribution function. For example, if the value of a variable on a given day exceeds 75 per cent of all previously observed values, then it is given a ranking of 75. Next, each variable is weighted by the relative size of the market to which it pertains. The larger the market's share of total credit in the economy is, the higher the weight.
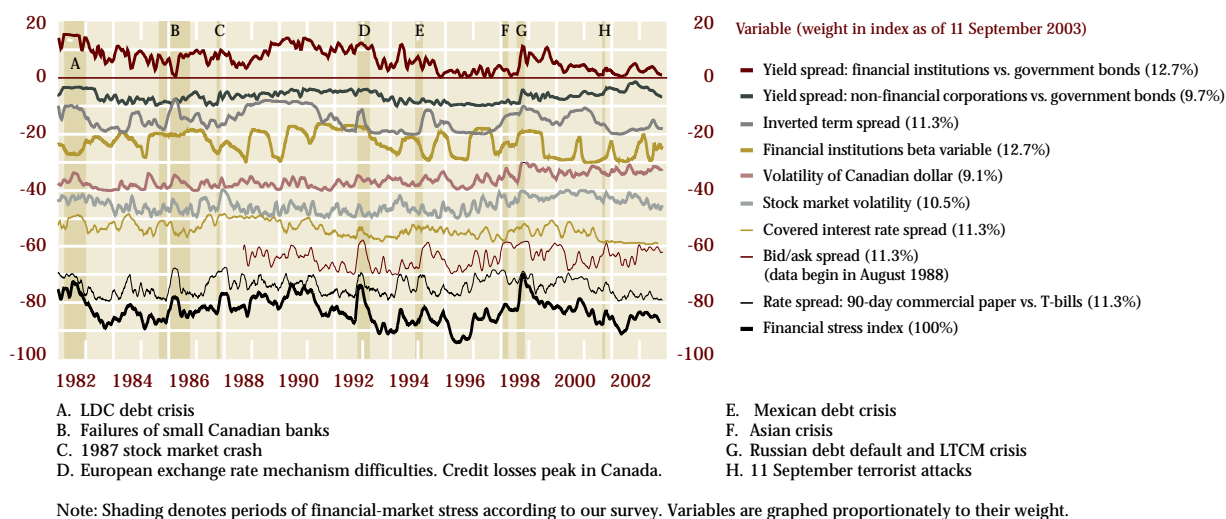
More formally, the index described above can be expressed as

$$FSI_t = \sum_j \left[w_{jt} \cdot \int_{-\infty}^{x_j} f(x_{jt}) dx_{jt} \right] \cdot 100,$$

where x_{jt} is the value of the jth variable (from the nine variables listed above) on day t, and w_{jt} is the credit weight. The integrated term is the estimated cumulative distribution function for x_j based on the historical sample.

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1. We use a trade-weighted average of the dollar versus the currencies of Canada's six largest trading partners and apply a general autoregressive conditional heteroscedastic (GARCH) model to measure the volatility.
2. We use the S&P TSX index and apply a GARCH model to measure the volatility.
3. The "bid" and "ask" rates are those at which securities dealers, acting as market middlemen, will sell and buy treasury bills.

Chart 2   Financial Stress Index: Component Breakdown

Variable (weight in index as of 11 September 2003)

- Yield spread: financial institutions vs. government bonds (12.7%)
- Yield spread: non-financial corporations vs. government bonds (9.7%)
- Inverted term spread (11.3%)
- Financial institutions beta variable (12.7%)
- Volatility of Canadian dollar (9.1%)
- Stock market volatility (10.5%)
- Covered interest rate spread (11.3%)
- Bid/ask spread (11.3%)
  (data begin in August 1988)
- Rate spread: 90-day commercial paper vs. T-bills (11.3%)
- Financial stress index (100%)

A. LDC debt crisis
B. Failures of small Canadian banks
C. 1987 stock market crash
D. European exchange rate mechanism difficulties. Credit losses peak in Canada.

E. Mexican debt crisis
F. Asian crisis
G. Russian debt default and LTCM crisis
H. 11 September terrorist attacks

Note: Shading denotes periods of financial-market stress according to our survey. Variables are graphed proportionately to their weight.

The individual historical contribution of each component to past movements in the FSI is shown in Chart 2.

Alternative Measures of Stress

Alternative measures of stress were constructed using Canadian data and the various methods employed in other empirical studies. These included the straightforward binary measures of stress commonly used in studies of financial stability in emerging markets, as well as the more comprehensive measures of stress for industrialized countries discussed earlier. The last measures were far more successful at matching the survey rankings, while the former frequently identified tranquil periods as being crises. Overall, however, the FSI provided the closest match.

Charts 3 and 4 illustrate four different measures of financial stress for Canada. Although the BCA Research (BCA) and Bordo, Dueker, and Wheelock (BDW) indexes were originally developed for the United States, we apply their respective methodologies to Canadian data. On the other hand, the J.P. Morgan LCVI is based on global data.[4] Interestingly, movements in the FSI, which is based entirely on Canadian data, and the LVCI are quite similar (the correlation coefficient between the two indexes is 0.63).

The Evolution of Stress

The FSI, BCA, and BDW indexes all reached their highest values during the recession of the early 1990s. This coincided with a collapse of real estate prices in Canada, particularly for commercial properties. Business and personal bankruptcies also rose sharply, as did mortgage and credit card arrears, commercial and industrial loan losses, and bond defaults. The end of this period also witnessed heightened foreign exchange and interest rate volatility resulting from the difficulties of the European exchange rate mechanism in late 1992.

The level of stress generally trended downwards over the 1994–97 period. It rose suddenly in August of 1998, following Russia's debt default. The subsequent collapse of the world's largest hedge fund, Long-Term Capital Management (LTCM), marked a period of extreme movements in market prices and rates. The BCA and BDW indexes rose sharply during this period, although they were well below the levels of stress indicated by the FSI and the LCVI.

4.   Data for the LCVI begin in October 1997.

Chart 3 Monthly Measures of Financial Stress
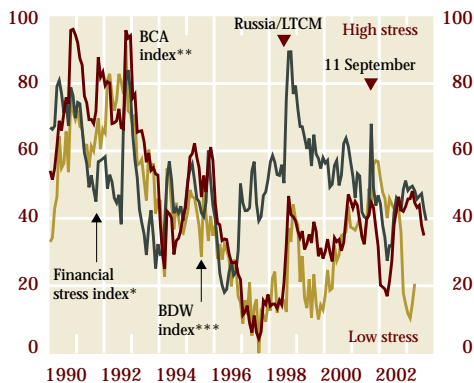
* Source: Illing and Liu (2003)
** Using McClellan (2001) methodology applied to Canadian data
*** Using Bordo, Dueker, and Wheelock (2000) methodology applied to Canadian data

Chart 4 Daily Measures of Financial Stress
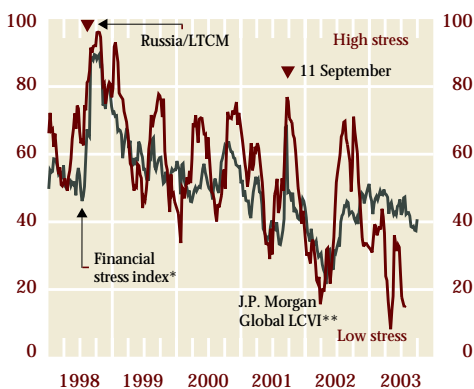
* Source: Illing and Liu (2003)
** Source: J.P. Morgan Chase & Co.

Financial stress also rose sharply following the terrorist attacks of 11 September 2001. Many stock markets were temporarily closed, and bond market trading was widely curtailed. However, the financial system was more robust than it had been during previous shocks, and the effects dissipated quickly. In particular, no serious problems materialized at major banks, securities dealers, or insurance and reinsurance firms.

Recently, financial stress appears to be in the moderate-to-low range. The resiliency of the Canadian financial system to numerous shocks over the past two years has been remarkable. Low and stable inflation has enabled interest rates to remain low, thereby limiting financial pressures on debtors. The balance sheets of financial institutions and non-financial firms are also in a much stronger position than they were a decade ago.

Interpretation and Summary

The financial stress index complements the many other tools used at the Bank of Canada to assess whether financial conditions are improving or deteriorating. The specific level of the index has no implications for policy, and in no sense should the index be seen as a target.

The FSI is an ordinal measure of stress in the financial system, meaning that it is a ranking of the current situation relative to history. A change in the level of the index may not correspond to the same change in actual stress, however.

The weighting of the components by their shares in credit involves a certain arbitrariness. Thus, one cannot claim that this index has the optimal weights for measuring stress. It should be noted, however, that the weights are approximately equal across the components, and thus it is not just one or two components that are driving the behaviour of the index.

The FSI should prove useful for future research on financial stability. In particular, one might find certain threshold levels of the index at which financial pressures spill over into the real economy.

The FSI is intended to capture the contemporaneous level of stress in the system and is not designed to have strong predictive power for future stress. The FSI could therefore be used as a

dependent variable in econometric models to identify and test leading indicators of stress. These models could then form the basis of early-warning indicators of potential instability in the financial system or in the broader economy.

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