OFR | OFFICE OF FINANCIAL RESEARCH

Financial Research Advisory Committee Meeting
July 20, 2017

Discussion Topic: The OFR Financial Stress Index

The Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 mandates the OFR to develop and maintain metrics and reporting systems for risks to financial stability and to monitor, investigate, and report on changes in systemwide risk levels and patterns. The OFR Financial Stress Index (FSI) complements existing OFR monitoring products that are designed to fulfill these mandates. The OFR FSI is a daily, market-based snapshot of distress in global financial markets that distills the information embedded in over 30 financial market variables into a summary of global financial stress. The index can be decomposed into five subcategories or three economy types.

The OFR FSI answers the following questions:
- What is the current level of financial stress?
- Which subcategories contribute to the current level of financial stress?

Why an FSI?

Financial stress refers to a breakdown in the normal functioning of financial markets. High levels of financial stress sometimes come before reductions in economic activity. Some of these episodes have been severe. Policymakers need accurate, clear, and timely signals of market strains and dislocations to effectively manage their impact.

Financial stress indexes, such as those developed by the regional Federal Reserve banks, combine indicators of various symptoms of financial stress. These symptoms include increased uncertainty about the fundamental value of assets, increased information asymmetries, and decreased investor willingness to hold risky or illiquid assets. Market variables are chosen for an FSI based on how well they incorporate investors' views about these symptoms.

Why an OFR FSI?

Methodological Features

The OFR FSI incorporates information from a broad swath of markets and variables from around the world. The index recognizes that foreign markets can transmit stress to US markets and takes a dynamic approach that adjusts to new information. No two stress events are exactly the same, and the relative importance of drivers of financial stress varies over time. The OFR's innovative methodology is dynamic yet remains accessible to policymakers.

Components of the OFR FSI

The OFR FSI can be decomposed into stress subcategories and economy types. These stress subcategories are unique to the OFR FSI and include equity valuation, credit, volatility, funding liquidity, and flight to safety. Analysis of the subcategories can reveal the drivers of financial stress, guiding the interpretation of market events by cutting through the clutter of market chatter. Stress is

always occurring somewhere, but how to know where? For example, if we examine the OFR FSI during the 2013 "Taper Tantrum" event, we find the index reveals increased levels of stress in the credit and volatility subcategories.

Empirical Characteristics of the OFR FSI

Using dates of significant government intervention in financial markets as a proxy for financial stress events, statistical analysis shows higher values of the OFR FSI are associated with a greater likelihood of being in a stressful period. Analysis also shows higher values of the OFR FSI help predict decreases in the Chicago Fed National Activity Index (CFNAI), which is a measure of overall economic activity. However, the CFNAI does not help predict the OFR FSI, evidence that high levels of financial stress can lead to reductions in economic activity. (See Appendix C.)

Value of the OFR FSI

The OFR FSI conveys information about the realization of shocks and their effects on stress. In contrast, the OFR Financial Stability Monitor focuses on vulnerabilities that can exacerbate or mitigate stress when market events occur. Vulnerabilities can build during periods of low stress, and they should be separately measured.

Questions for Discussion

1. Global market variables with a daily frequency were chosen for the OFR FSI. These variables are listed in Appendix A. Would you make any changes to our set of variables? In particular, the current list does not include variables related specifically to real estate. Should it? If so, which ones available on a daily frequency are worth monitoring?

2. The OFR FSI uses a dynamic principal components methodology where the covariance matrix is sampled over a rolling window. (See Appendix B for details.) We chose this method instead of more advanced techniques because it can be decomposed, and it is relatively accessible to our stakeholders. Should we consider other techniques?

3. Because of the global nature of the modern financial system, the OFR FSI includes variables from global financial markets, using closing values for the variables in each respective markets. Are there any significant problems or issues induced by the fact that world markets operate on different time schedules and our variables are not observed at precisely the same time? If so, how can such problems be reduced or eliminated?

Appendix A: Variables in the OFR FSI

Stress Category	Category Description	Variable	Economy Type
Credit	In times of stress, credit spreads may widen because of increased default risk, dislocations or valuation pressures in credit markets, or increased information asymmetries.	BaML Corporate Master (IG) (OAS)	US
		BaML High Yield Corporate Master (HY) (OAS)	US
		BaML Euro Area Corp Bond Index (OAS)	AE
		BaML Euro Area High Yield Bond Index (OAS)	AE
		BaML Japan Corporate (OAS)	AE
		JPMorgan CEMBI Strip Spread	EM
		JPMorgan EMBI Global Strip Spread	EM
Equity Valuation	In times of stress, measures of equity valuation may fall during a flight to safety because investors are less willing to hold risky assets.	MSCI Emerging Markets Index (P/B Ratio)	EM
		MSCI Europe Index (P/B Ratio)	AE
		NIKKEI 225 Index (P/B Ratio)	AE
		S&P 500 Index (P/B Ratio)	US
Funding	In times of stress, funding markets can seize, inhibiting financial institutions from fulfilling their roles in maturity transformation and credit intermediation.	2-Year EUR/USD Cross-Currency Swap Spread	US, AE
		2-Year US Swap Spread	US
		2-Year USD/JPY Cross-Currency Swap Spread	US, AE
		3-Month EURIBOR - EONIA	AE
		3-Month Japanese LIBOR - OIS	AE
		3-Month LIBOR - OIS	US
Flight to Safety	Safe assets have reliably stable and predictable cash flows. In times of stress, a decreased willingness to hold risky or illiquid assets can lead to investor migration into these assets.	4-Week US Treasury Bill (yield)	US
		10-Year US Treasury Note (yield)	US
		10-Year German Bond (yield)	AE
		US Term Spread (yield)	US
		US Dollar Index (DXY)	US
		Gold/USD Real Spot Exchange Rate	US, AE, EM
Volatility	In times of stress, increased uncertainty about asset values or investor behavior can precipitate attendant increases in volatility.	CBOE S&P 500 Volatility Index (VIX)	US
		Dow Jones EURO STOXX 50 Volatility Index (V2X)	AE
		ICE Brent Crude Oil Future (realized volatility)	US, AE, EM
		Implied Volatility on 6-Month EUR/USD Options	US, AE
		Implied Volatility on 6-Month USD/JPY Options	US, AE
		JPMorgan Emerging Market Volatility Index	AE
		Merrill Lynch Euro Swaptions Volatility Estimate	AE
		Merrill Lynch US Swaptions Volatility Estimate	US
		NIKKEI Volatility Index	AE

Key	
AE = Advanced economies, such as Eurozone and Japan	HY = High yield
BaML = Bank of America Merrill Lynch	IG = Investment grade
CBOE = Chicago Board Options Exchange	JPY = Japanese yen
CEMBI = Corporate Emerging Markets Bond Index	LIBOR = London Interbank Offered Rate
EM = Emerging markets	MSCI = Morgan Stanley Capital International
EMBI = Emerging Market Bond Index	OAS = Option-adjusted spread
EONIA = Euro OverNight Index Average	OIS = Overnight indexed swap
EUR = Euro	P/B Ratio = Price-to-book ratio (value-weighted)
EURIBOR = Euro InterBank Offered Rate	USD = U.S. dollar

Appendix B: OFR FSI Methodology

The OFR Financial Stress Index's (FSI's) construction is transparent and methodical, built in two steps:

(1) Variable selection
(2) Variable aggregation

Variable Selection

First, we consulted the academic literature for information about the general symptoms of systemic financial stress. As summarized in Hakkio & Keeton (2009), symptoms include increased uncertainty about the fundamental value of assets or the behavior of investors; increased information asymmetries; and decreased willingness to hold risky or illiquid assets.

Variables for the OFR FSI must reflect one or more of these symptoms of financial stress at the right time. They must also have a daily frequency and a historical time series that goes back to at least 2001. The variables also must be approximately balanced across major asset classes and global market types.

Finally, a marginal variable is subject to a quantitative test for redundant information. A variable with high correlation to another variable already in the set during both crisis times and calm periods is deemed to have failed the test and excluded.

Variable Aggregation

We use a modified principal components analysis (PCA) to determine the weights of the variables in the index. Like other PCA-based stress indexes, we assume that systemic financial stress is the reason for simultaneous co-movement in the set of variables. We extract the first loading vector from a PCA because this gives the rotation of the data that explains the most variation. However, we differ from other PCA-based FSIs in that we estimate this loading vector over a rolling window, which accounts for the fact that the relative importance of drivers of financial stress changes over time.

To estimate today's value of the OFR FSI we:

1. Use the previous 500 trading days of data to estimate the first loading vector from a PCA.
2. Convert the variables to the same units. For each variable, we subtract its historical mean and divide by its historical standard deviation, using the variable's full time series. (The time series of the variables have varying lengths.)
3. The OFR FSI is then the scalar projection (dot product) of today's standardized data onto the first loading vector.

Appendix C: Statistical Analysis of the OFR Financial Stress Index

We performed logistic regression analysis to evaluate the OFR Financial Stress Index's (FSI's) performance in identifying financial stress events. We used dates of significant government intervention in financial markets as a proxy for financial stress events and defined periods of financial stress as encompassing the four weeks before and after these dates. This approach was also used in Carlson et al. (2014).

We then ran a logistic regression of the indicator variable for whether financial stress was occurring on the OFR FSI, using moving block bootstrap standard errors. The coefficient on the OFR FSI was positive and statistically significant with a p-value less than 0.0001, the area under the Receiver Operating Characteristic, or ROC, curve was 0.85, and McFadden's R^2 was 32 percent. Higher values of the OFR FSI are associated with a greater likelihood that the financial system is under stress.

We also examined whether increases in the OFR FSI were useful for predicting reductions in economic activity. We used the Chicago Fed National Activity Index (CFNAI) as a proxy for overall economic activity and performed a Granger noncausality analysis of the OFR FSI and the CFNAI using the method of Toda and Yamamoto (1995). The results confirm that increases in the OFR FSI help predict decreases in the CFNAI (and not vice versa), suggesting that the OFR FSI is useful for predicting reductions in overall economic activity.

References

M. A. Carlson, K. F. Lewis, and W. R. Nelson. "Using Policy Intervention to Identify Financial Stress." *International Journal of Finance and Economics* 19, no. 1 (2014, January): 59-72.

C. Hakkio and W. R. Keeton. "Financial stress: What is it, how can it be measured, and why does it matter?" Federal Reserve Bank of Kansas City Economic Review, Second Quarter 2009.

H. Y. Toda and T. Yamamoto. "Statistical inference in vector autoregressions with possibly integrated processes." *Journal of Econometrics* 66, no. 1-2 (1995, March-April): 225-250.