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The OFR Financial System Vulnerabilities Monitor

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The OFR Financial System Vulnerabilities Monitor

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Abstract

The Office of Financial Research (OFR) has a mandate to measure and monitor risks to U.S. financial stability. To help fulfill that mandate, the OFR launched the Financial System Vulnerabilities Monitor (FSVM) in 2017. The monitor is a starting point for assessing vulnerabilities in the U.S. financial system. It is constructed as a heat map of 58 quantitative indicators. It is designed to provide early warning signals of potential financial system vulnerabilities that merit investigation. This paper details the monitor's purpose, construction, interpretation, and use.

[1] A predecessor tool, the OFR Financial Stability Monitor, was developed by Rebecca McCaughrin, Adam Minson, and Thomas Piontek. We thank Daniel Barth, Jill Cetina, Greg Feldberg, Dasol Kim, Phillip Monin, Drew Morehead, Stathis Tompaidis, the OFR Financial Research Advisory Committee, the FSOC Systemic Risk Committee, and workshop participants at the Federal Reserve Board of Governors and OFR Research and Analysis Center for highly useful input and feedback. We thank Anthony Deaconn, Andrea Krukowski, and the cross-divisional OFR Monitoring Tools team for indispensable assistance in creating this monitor.

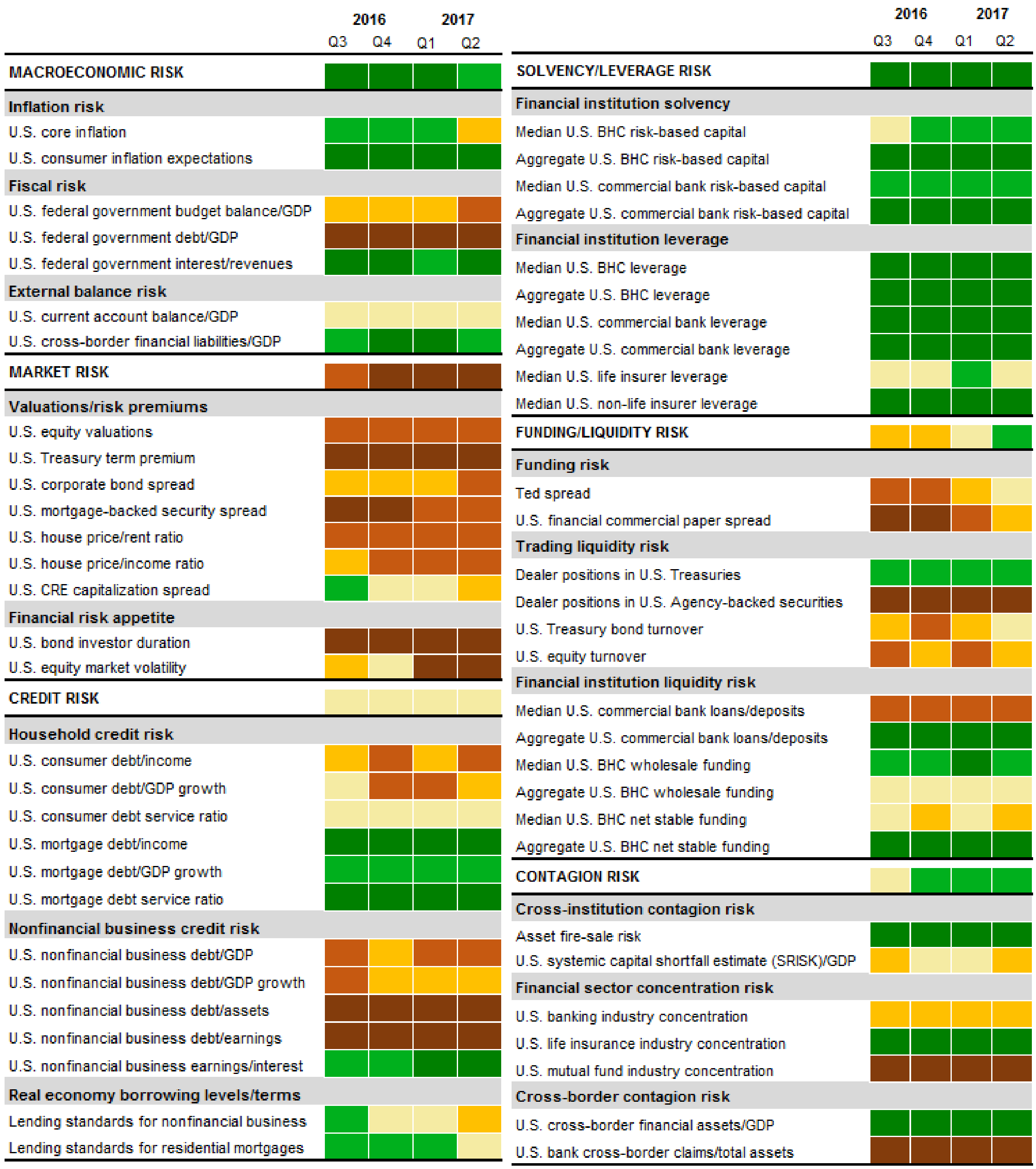
1 Introduction

After the 2007-09 financial crisis, there was a broad realization that official monitoring of the financial system had been inadequate. The creation of the OFR was intended to be part of the solution. The OFR is mandated to monitor risks across the entire financial system — including areas outside formal supervisory oversight — and to create tools to improve the measurement and monitoring of such risks. The OFR focuses on risks that could threaten U.S. financial stability. We define financial stability as the ability of the financial system to provide its basic functions even under stress.

Monitoring financial stability requires tracking both *vulnerabilities* and *stress*. The OFR Financial System Vulnerabilities Monitor identifies potential financial system vulnerabilities. Vulnerabilities are factors that can originate, amplify, or transmit disruptions in the financial system. For example, the reliance of Lehman Brothers and other broker-dealers on unstable funding was a vulnerability that allowed runs on those firms in 2008. The OFR has also developed the Financial Stress Index to identify the magnitude and sources of stress (see Monin, 2017). Stress is a disruption in the normal functioning of the financial system. Stress can be minor, as seen in a brief period of uncertainty and price volatility in the equity market. Or it can be major, like the stress precipitated by the runs on Lehman and other broker-dealers in 2008. High or rising vulnerabilities indicate a high or rising risk of disruptions in the future. A high level of stress indicates a disruption today.

The FSVM is a heat map of 58 indicators of potential vulnerabilities in the U.S. financial system. Indicators are organized in six categories: macroeconomic, market, credit, solvency and leverage, funding and liquidity, and contagion (see **Figure 1**). The heat map color-codes indicators based on their positions within a long-term range. Scores closer to red signal higher potential vulnerability. Scores closer to green signal lower potential vulnerability. The scores are calculated and updated quarterly.

Figure 1. Financial System Vulnerabilities Monitor (Excerpt)



Note: This figure is excerpted from the OFR Financial System Vulnerabilities Monitor. The full monitor is available at https://www.financialresearch.gov. See Appendix A for a list of data sources and notes on the indicators. The figure reports FSVM colors as of October 2017. The colors for these quarters are subject to change as future data change the scoring distributions for the indicators.

The FSVM is designed to provide early-warning signals of potential U.S. financial system vulnerabilities that merit investigation. For example, it shows rising potential vulnerabilities in the years leading up to the 2007-09 financial crisis. However, it does not provide conclusions about financial stability. Such conclusions require expert assessment, and should incorporate a broader set of quantitative and qualitative information than can be included in this monitor. The OFR continually monitors this broader set of information and provides an overall assessment of U.S. financial stability in its *Financial Stability Report* and *Annual Report.*

Section 2 of this paper describes our motivation for creating a heat map, and compares it to other financial stability heat maps. Section 3 describes how the heat map is constructed. Specifically, it explains how indicators are selected and scored, and then explains how those indicator scores are combined to create aggregate scores for each of the six risk categories. Section 4 describes the performance of the heat map. The FSVM shows elevated levels of key vulnerabilities well before the 2007-09 financial crisis. Section 5 describes some of the limitations of the FSVM. Inevitably, it cannot cover all potential vulnerabilities. Also, as a quantitative tool, it does not incorporate qualitative information that can be essential to financial stability analysis. Section 6 describes how the monitor should be interpreted and used. The final section concludes.

2 Financial System Vulnerabilities and Financial System Heat Maps

The FSVM fulfills two aspects of the OFR's mandate: (1) to monitor U.S. financial stability and (2) to develop tools for measuring risks to financial stability. Measuring risks to financial stability requires examining a large body of heterogeneous data series. The heat-map format of the FSVM allows users to more easily examine a large and heterogeneous set of data because it standardizes and color-codes the data. The standardization allows users to compare across otherwise incomparable data series. The color-coding allows users to look at a large set of data and quickly identify the areas of highest potential vulnerabilities — namely, those that are scored red or orange.

Other institutions also find the heat-map format valuable for monitoring financial stability data. The International Monetary Fund (IMF) and the Federal Reserve Board (FRB) also produce heat maps of financial stability (see Dattels and others, 2010, and Aikman and others, 2017). The FSVM is distinguished from these other heat maps by its focus on the United States and by its availability to the public. The IMF heat map is global, consistent with the IMF's mandate, and does not specify the degree of risk to the U.S. financial system. The Federal Reserve updates its heat map internally on a regular basis but the ongoing results are not available to the public. Its methodology and initial results were published in Aikman and others (2017).

The FSVM also uses a set of indicators that differ from those in the other heat maps. **Figure 2** displays the main high-level categories of indicators. While there are some common categories of indicators — credit risk, market risk, liquidity risk — there are substantive differences. Unlike the IMF heat map, the FSVM does not incorporate monetary and financial conditions or emerging market risks (the scope of the FSVM is U.S. vulnerabilities). Unlike the FRB heat map, the OFR FSVM includes macroeconomic risk and contagion risk.[2]

Figure 2. Heat Map Indicator Categories

Office of Financial Research	International Monetary Fund	Federal Reserve Board
Macroeconomic	Macroeconomic risks	Nonfinancial sector imbalances
Market	Monetary & financial conditions	Risk appetite / asset valuation
Credit	Credit risks	Financial sector vulnerability
Solvency and leverage	Risk appetite	
Funding & liquidity	Market and liquidity risks	
Contagion	Emerging market risks	

Sources: Office of Financial Research, Dattels and others (2010), Aikman and others (2017).

The FSVM and FRB heat maps differ from that of the IMF in their use of data versus judgment. The colors displayed in the IMF heat map represent a combination of data results and expert judgment. "The final choice of positioning on the Map represents the best judgment of IMF staff," according to Dattels and others (2010). In contrast, the FSVM and FRB heat maps represent the

[2] The four remaining categories of the OFR FSVM cover the three categories of the FRB heat map. The FSVM category "market" measures the vulnerabilities included in the FRB category "risk appetite/asset valuation." The "credit" category measures vulnerabilities included in "nonfinancial sector imbalances." The "solvency and leverage" and "funding and liquidity" categories measure vulnerabilities included in "financial sector vulnerability," while also measuring market liquidity.

data alone and are not necessarily in line with staff assessments. They are only starting points for broader staff assessments.

3 Construction of the Monitor

The FSVM is a heat map constructed of 58 quantitative indicators. The indicators measure potential vulnerabilities that could originate, transmit, or amplify disruptions in the U.S. financial system.

The development of the monitor involved three steps:

1. Indicator selection,
2. Indicator scoring,
3. Aggregation.

3.1 Indicator Selection

Indicator selection began with a broad review of studies of financial stability vulnerabilities, including empirical studies and monitoring frameworks used by others in the official sector.[3] This review yielded more than 200 quantitative indicators that could be considered. We organized indicators using six key categories of vulnerabilities that can contribute to financial instability. The OFR also uses these categories to organize its overall assessment of financial stability in its *Financial Stability Report* and *Annual Report*. Those categories are defined in **Figure 3.**

[3] See **References** for the list of studies and sources consulted in creating the indicator set.

Figure 3. FSVM Indicator Category Definitions

Category	Definition
Macroeconomic	Contains measures of macroeconomic risks to the financial system such as inflation, excessive government borrowing, and excessive reliance on cross-border financing.
Market	Contains measures of market risk such as excessive valuations, low risk premiums, and excesses in financial risk appetite and risk-taking.
Credit	Contains measures of credit risk in the real economy — the risk of widespread credit defaults or delinquencies by households and nonfinancial businesses.
Solvency & leverage	Contains measures of excessive leverage at financial institutions or other risks to their solvency.
Funding & liquidity	Contains measures of risks in short-term funding arrangements and liquidity for financial markets and financial institutions.
Contagion	Contains measures of potential vulnerabilities from stress transmission across financial institutions and markets, within concentrated financial sectors, and from other countries to the U.S. financial system.

Source: Office of Financial Research

We selected indicators for inclusion in the FSVM using the following criteria:

- The indicator must measure a potential vulnerability for the U.S. financial system, including vulnerabilities to the United States that emanate from abroad.
- The indicator must vary over time, and its variance should measure the vulnerability in question; it should not contain any trend, shift, or break that is plausibly caused by any factor other than the vulnerability in question.[4]
- The indicator must have sufficient data to establish a multi-cycle distribution (in practice, the data must include at least two U.S. recessions and expansions, beginning with the 2001 U.S. recession).
- Indicators that provide an earlier signal of vulnerability get priority. In other words, where multiple indicators of the same vulnerability satisfy the other selection criteria, the indicator that provides the earliest signal is selected. This improves the early-warning power of the monitor.

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[4] In considering this criterion, we performed standard tests of stationarity to inform our decisions and considered transformations that allowed indicators to pass such tests. However, we did not use these test results in isolation, as formal stationarity is not required for this heat map and many transformations caused loss or distortion of empirically valuable signals. We instead evaluated each indicator for trends, shifts, and breaks, and investigated whether such movements could plausibly be caused by any factor other than the vulnerability in question.

- The full set of selected indicators should cover all six risk categories and key subcategories identified in the literature, to the extent permitted by available data.
- The full set of selected indicators should cover all major components of the U.S. financial system, to the extent permitted by available data.

The selected indicators are listed in **Appendix A**, with their specifications and data sources.

3.2 Indicator Scoring

For each quarterly observation, an indicator is color-coded based on its position within a long-term range. The monitor uses six discrete colors, conveying increasing degrees of potential vulnerability, as shown in **Figure 4**.

Figure 4. FSVM Color Legend

Indicators are scored in two steps (see **Figure 5**). In the first step, each indicator's quarterly observations are ranked from lowest to highest potential vulnerability. Ranked scores are converted to percentiles. In the second step, percentiles are translated to heat-map colors. Each color represents one-sixth of the observations for each indicator.

Figure 5. FSVM Indicator Scoring Methodology

Step 1	Each indicator's quarterly observations are ranked from lowest potential vulnerability (1) to highest potential vulnerability (n), where n is the number of observations being scored for that indicator. Ranked scores are converted to percentiles: percentile = ordinal rank/n.
Step 2	Percentiles are translated to heat-map colors such that each color represents an equal share of the distribution, per the table below. Each color represents one-sixth of the observations for each indicator.

FSVM Color Thresholds

Color	Observation value
	83.3 < x <= 100 percentile
	66.6 < x <= 83.3 percentile
	50 < x <= 66.6 percentile
	33.3 < x <= 50 percentile
	16.6 < x <= 33.3 percentile
	0 < x <= 16.6 percentile

Source: Office of Financial Research

For each step, we considered various options before arriving at this method.

For Step 1 — transforming each indicator observation into a numerical risk score — we considered two classes of methods:

- The risk score is based on an ordinal ranking of each observation in its long-term distribution (the chosen method).
- The risk score is based on the observation's deviation from the center (such as the mean or median) of its long-term distribution.

For Step 2 — translating the numerical risk score into a heat-map color — we also considered two classes of methods:

- Each color represents an equal share of the long-term distribution (the chosen method).
- Colors represent different shares of the distribution, and those shares are determined by statistical methods or judgment.

We evaluated the various combinations of these methods based on three criteria:

A. *Timeliness*. The results should provide timely signals of the vulnerabilities that contribute to financial instability.
B. *Variation*. The results should have sufficient variation over time to make the signals credible.
C. *Simplicity*. The methodology should be as simple as possible, for ease of interpreting and explaining the signals generated by the monitor.

We found that several combinations of these methods perform well on criteria A and B. To maximize performance on criterion C — simplicity and ease of interpretation — we selected the ordinal-ranking and equal-shares methods. We judged that a simple ranking of observations from highest to lowest risk is more intuitive than scoring based on distance from center. We also judged colors that represent equal shares of the distribution to be easier to interpret, and we do not have a strong theoretical or empirical basis for any other alignment of the colors.

We only use data series that begin during or before the 2001 U.S. recession. This threshold assures the scores reflect variation in the indicators through at least two U.S. economic downturns and expansions. We do not use data prior to 1990, although some datasets go back further in time, because the structure of the U.S. financial system was quite different in the past. For example, the financial system changed in the 1990s with the growth in interstate banking, the increasing diversification of commercial-bank business models, and the growth of derivatives and other new products. Still, the choice of 1990 is judgmental, as there is no single transformation point for the structure of the system.

Scores are based on the full distribution of data available at the time of scoring. For example, the current score for an observation in the fourth quarter of 2008 is based on all the data we have today, including data from 2009 to the present. As such, scores for past dates reflect more information than was available at the time. This has two critical advantages over the alternative of scoring based exclusively on data available at each historical point. First, it allows direct comparison of observations for different points in time; it would not be advisable to compare an indicator's color in 2008 to its color today if those were based on different distributions. Second, it allows inclusion of more indicators in the monitor; some indicators lack sufficient historical data to be fully scored using the alternative methodology. The key disadvantage is that the FSVM does not show the signal that would have been available at the time of each observation. For example, it does not report what was known about the fourth quarter of 2008 at that time; rather, it reports what is known about that period today.

3.3 Aggregation

Scores for the six risk categories are created by aggregating the underlying indicator scores. As with the indicator scores, the category scores are color-coded to convey increasing degrees of potential vulnerability, based on each observation's position within its long-term range.

Aggregation involves three steps (see **Figure 6**). In Step 1, for each quarter in which all indicators in a category contain data, those indicators are aggregated as the arithmetic average of their percentile scores. In Step 2, as in Indicator Scoring Step 1, the resulting averages for each category are ranked from lowest to highest potential vulnerability. Ranked scores are converted to percentiles. In Step 3, as in Indicator Scoring Step 2, percentiles are translated to heat-map colors such that each color represents an equal share of the distribution.

Figure 6. FSVM Aggregation Methodology

Step 1	For each quarter in which all indicators in a category contain data, those indicators are aggregated as the arithmetic average of their percentile scores.
Step 2	The resulting average quarterly observations for each category are ranked from lowest potential vulnerability (1) to highest potential vulnerability (n), where n is the number of average observations being scored for that category. Ranked scores are converted to percentiles: percentile = ordinal rank/n.
Step 3	Percentiles are translated to heat-map colors such that each color represents an equal share of the distribution. Each color represents one-sixth of the observations for each indicator.

FSVM Color Thresholds

Color	Observation value
	83.3 < x <= 100 percentile
	66.6 < x <= 83.3 percentile
	50 < x <= 66.6 percentile
	33.3 < x <= 50 percentile
	16.6 < x <= 33.3 percentile
	0 < x <= 16.6 percentile

Source: Office of Financial Research

For Step 1 — aggregating each category's indicators into a single aggregate score for each quarter — we considered two classes of methods.

- Methods that estimate the "center" of the underlying indicator scores in each quarter:
  - Arithmetic average (the chosen method),
  - Geometric average,
  - Root mean square.

- Methods that estimate the center and also account for variance across the indicator scores. Accounting for variance is attractive when there is dispersion across indicator scores, as measures of center alone dilute the individual signals provided by divergent scores. Two methods were considered:
  - Arithmetic average plus one standard deviation,
  - Arithmetic average plus various fractions of one standard deviation.

We evaluated the various combinations of methods based on the same criteria as in indicator scoring: timeliness, variation, and simplicity.

For Step 1, we found that methods accounting for center and variance do provide timelier signals of the vulnerabilities known to exist before the 2007-09 financial crisis. However, they could falsely signal benign conditions in the future. That is because they could signal lower risk when all indicator scores are elevated (low variance) than they would signal when some are elevated and others are low (high variance). We consider this an unacceptable result: a state in which most or all indicator scores are elevated should be more concerning than one in which fewer are elevated. We thus limited our consideration to methods that account strictly for the center of underlying indicator scores. In doing so, we accept that aggregate scores will dilute the signals from divergent indicators. Aggregation involves some loss of the underlying information, which makes it critical to consider any category score alongside its underlying indicator scores.

Among the methods that account for the center of the indicator scores, all perform similarly in providing timely signals before the financial crisis (criterion A) — none provides a consistently superior early warning across indicators. After Step 2, all methods provide an identical amount of variation over time (criterion B). Therefore, we selected the simplest and most easily interpreted method among them (criterion C). That method is the simple arithmetic average of underlying indicator scores.

We calculate aggregate scores only for those quarters in which all the underlying indicators have data. By doing so, we keep the information represented by the aggregate score consistent. A changing set of underlying indicators would make the category's score in one quarter incomparable with its score in other quarters.

4 Performance

The initial heat-map scores for all indicators are presented in **Appendix B**. Scores for the category aggregates are presented in **Appendix C**. Updated scores for the categories and indicators are published each quarter on the OFR's FSVM Web page.

The heat map meets our three criteria for indicator scoring and aggregation.

Criterion A: The FSVM should provide timely signals of the vulnerabilities that contribute to financial instability.

We find that the FSVM shows elevated levels of key vulnerabilities well before the financial crisis. Specifically, key indicator scores within market risk (real estate valuations), credit risk (mortgage credit risk), solvency/leverage risk (bank and bank holding company capital and leverage ratios), and funding/liquidity risk (bank and bank holding company liquidity ratios) show increasingly elevated vulnerabilities *three to five years* before the financial crisis.

However, not all vulnerabilities have equally timely indicators. In particular, key measures of funding risk, trading liquidity risk, and cross-institution contagion risk fail to signal vulnerabilities until stress occurs, at which point there is limited or no time to mitigate the vulnerability. We included these indicators nonetheless because they measure relevant financial system vulnerabilities.

Finally, most indicators in this monitor measure vulnerabilities that were not strongly associated with the 2007-09 U.S. crisis. They were selected because theoretical or empirical studies demonstrate their contribution to breakdowns in the functioning of financial systems (see **References** for a full set of the studies and frameworks reviewed in choosing indicators). Appropriately, many indicators in the monitor do not signal high vulnerabilities in the pre-crisis period.

Criterion B: The FSVM should have sufficient variation over time to make the signals credible.

It would be possible to engineer a heat map in which the indicators were always red or orange. However, such a heat map would be a poor early-warning system. Our methodology guarantees sufficient variation across the six colors: for all indicators and categories, each heat-map color is reported an equal share of the time.

Criterion C: The methodology should be as simple as possible, for ease of interpreting and explaining the signals generated by this monitor.

Once criteria A and B were satisfied, we made methodological decisions to maximize simplicity. The result is a monitor that is straightforward to interpret, as discussed below in **Interpretation and Use of the Monitor.**

5 Limitations of the Monitor

The FSVM is a useful starting point for assessing financial system vulnerabilities. It is not the sole basis for that assessment because it is limited in two key ways.

First, the FSVM does not cover all vulnerabilities. Many vulnerabilities lack sufficient data to enter into this monitor (for example, leverage in hedge funds). Some vulnerabilities must be evaluated qualitatively (for example, many operational risks). Other vulnerabilities do not vary enough over time to be properly measured in a heat map based on variation from high to low states of vulnerability (for example, structural features such as run risk in money market funds).

Second, the FSVM does not incorporate qualitative information, mitigating factors, or expert interpretation — all of which are required to properly assess the level of vulnerability.

Given these limitations, the FSVM must be interpreted and used in the context of other information and expert analysis, as described in the next section.

6 Interpretation and Use of the Monitor

Interpreting the indicator and category scores is straightforward, given the simplicity of the methodology. Most important, all indicators and categories report each heat-map color one-sixth of the time.

A red score signals that an observation is within the sextile (one-sixth or $16.\overline{6}$ percent) of values that indicates the highest potential vulnerability.[5] The other color scores signal that an observation is within a lower sextile of its distribution (see **Figure 7**), indicating lower potential vulnerabilities.

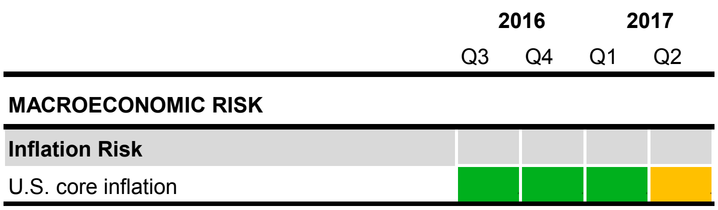
Figure 7. FSVM Color Thresholds

Color	Observation value
	83.3 < x <= 100 percentile
	66.6 < x <= 83.3 percentile
	50 < x <= 66.6 percentile
	33.3 < x <= 50 percentile
	16.6 < x <= 33.3 percentile
	0 < x <= 16.6 percentile

[5] As discussed in Section 4, this is based on quarterly values reported since 1990.

For example, consider the score of the first indicator in the Macroeconomic Risk category: U.S. core inflation risk (see **Figure 8**)[6]. The color score changed from light green in the first quarter of 2017 to dark yellow in the second quarter of 2017, according to data reported as of October 2017. This signals that the value of that indicator increased from its fifth-highest sextile to its third-highest sextile.

Figure 8. Score Change Example



Source: Office of Financial Research

The FSVM measures U.S. core inflation as core Personal Consumption Expenditure inflation (core PCE), calculated as the absolute distance from a 2 percent year-on-year rate of change (as reported in the indicator table in **Appendix A** and on the FSVM webpage). From this we know that the core PCE inflation rate was further from 2 percent in the second quarter than in the first quarter. .

As we have stated, no signal from the heat map by itself provides conclusions about financial stability. The core inflation indicator signals that the potential vulnerability from U.S. core inflation increased in the second quarter of 2017. Further assessment would be needed to determine why it increased and whether that in turn increased the vulnerability of the U.S. financial system.

The OFR did this assessment — along with interpreting the signals from all other FSVM indicators and a much wider set of information — and summarized its view of Macroeconomic Risk on pages 31-33 of the *2017 Financial Stability Report*. The OFR found that the core PCE inflation rate had fallen in the second quarter of 2017 — increasing its absolute distance from 2 percent, thus increasing its risk color — but that inflation expectations remained close to the 2 percent rate associated with consumer price stability in the United States. The assessment did warn that low

[6] Figure 8 reports FSVM colors as of October 2017. The colors for these quarters are subject to change as future data change the scoring distribution for this indicator.

inflation in the current context of full employment could indicate a greater risk of sudden shifts in inflation or inflation expectations that might have negative effects.

As this example demonstrates, the FSVM should be used in the context of a full financial stability monitoring and assessment process. At the OFR, this process has three components:

- **Quantitative Monitoring:** Monitoring data on key features of the financial system and key indicators of vulnerability and stress. This begins with the FSVM and Financial Stress Index. It extends to a much broader set of data than can be included in these two tools.
- **Qualitative Monitoring:** Gathering intelligence and tracking news and outside analysis. This work complements and informs quantitative monitoring by providing information that is not available in quantitative form and by providing context with which to interpret quantitative indicators.
- **Investigation and Assessment:** Investigating potential threats identified in monitoring. This involves conducting a full assessment of financial system stability, considering sources of risk as well as sources of resilience and other mitigating factors.

The OFR carries out this monitoring and assessment on an ongoing basis, reporting potential threats and its systemwide assessment in its *Financial Stability Report* and *Annual Report*.

7 Conclusion

The FSVM is a quantitative tool that signals potential vulnerabilities to the U.S. financial system. It indicates areas where investigation is needed.

The monitor is constructed as a heat map of 58 indicators in six categories. Each indicator is scored by ranking its quarterly observations from lowest potential vulnerability to highest and color-coding those ranked observations in six equal-sized groups. The indicator scores are aggregated into category scores using a similar process. Category aggregates can dilute the information in the underlying indicators. They should always be considered in the context of the underlying indicator scores.

The FSVM can provide an early and public warning of potential vulnerabilities in the U.S. financial system. Its indicator and category scores show increasingly elevated vulnerabilities three to five years before the 2007-09 financial crisis.

The FSVM alone cannot provide final conclusions about financial stability. Not all vulnerabilities have the data or properties necessary to be included in the FSVM. Qualitative information and expert assessment are needed to draw conclusions about financial system vulnerabilities. The OFR monitors the broader set of information on an ongoing basis and provides an expert assessment of U.S. financial stability in its *Financial Stability Report* and *Annual Report*.

The design of the FSVM will allow the OFR to revisit and improve indicator selection and vulnerability identification over time as we observe its performance, acquire better data, and respond to the evolution of the financial system.

Appendix A: FSVM Indicators

Macroeconomic Risk

Indicators	Notes	Direction of Vulnerability	Sources	Data Start
Inflation risk				
U.S. core inflation	Core personal consumption expenditure inflation. Measured as absolute distance from 2 percent year-on-year change.	Higher values	Haver	Q1:1990
U.S. consumer inflation expectations	University of Michigan survey. Consumer-expected average rate over next five years, measured as absolute distance from 2 percent year-on-year change.	Higher values	Haver	Q1:1990
Fiscal risk				
U.S. federal government fiscal balance/GDP	Fiscal balance measured as four-quarter sum.	Lower values	Haver	Q1:1990
U.S. federal government debt/GDP	Federal government debt measured as marketable U.S. Treasury debt held by public.	Higher values	Haver	Q1:1990
U.S. federal government interest/revenues	Interest and revenues measured as four-quarter sums.	Higher values	Haver	Q1:1990
External balance risk				
U.S. current account balance/GDP	Current account balance measured as four-quarter sum.	Lower values	Haver	Q1:1990
U.S. cross-border financial liabilities/GDP	Ratio measured as difference from ten-year moving average.	Higher values	Haver	Q1:1990

Market Risk

Indicators	Notes	Direction of Vulnerability	Sources	Data Start
Valuations/risk premiums				
U.S. equity valuations	Valuation measured as Cyclically-Adjusted Price/Earnings: the ratio of the monthly S&P 500 price level to trailing ten-year average earnings (inflation adjusted).	Higher values	Haver	Q1:1990
U.S. Treasury term premium	Ten-year term premium. Adrian-Crump-Moench model.	Lower values	Bloomberg	Q1:1990
U.S. corporate bond spread	Option-adjusted spread on Bank of America Merrill Lynch investment grade corporate bond index.	Lower values	Haver	Q1:1996
U.S. mortgage-backed security spread	Option-adjusted spread on 30-year Fannie Mae and Freddie Mac mortgage-backed securities.	Lower values	Bloomberg	Q1:1996
U.S. house price/rent ratio	House prices measured by CoreLogic national house price index. Rent measured by owners' equivalent rent on residence, as reported by the Bureau of Labor Statistics. Both series seasonally adjusted.	Higher values	Haver	Q1:1990
U.S. house price/income ratio	House prices measured by CoreLogic national house price index. Income measured by U.S. disposable personal income per capita. Both series seasonally adjusted.	Higher values	Haver	Q1:1990
U.S. CRE capitalization spread	Weighted average of CRE capitalization rates for the multifamily, industrial, office, retail, and hotel markets. Weighted by market capitalization. Spread over ten-year U.S. Treasury yield.	Lower values	Bloomberg	Q1:2001
Financial risk taking/appetite				
U.S. bond investor duration	Modified adjusted duration of the Barclay's U.S. Aggregate bond index.	Higher values	Bloomberg	Q1:1990
U.S. equity market volatility	Measured by the VIX index. Measured as absolute distance from long-term median.	Higher values	Bloomberg	Q1:1990

Credit Risk

Indicators	Notes	Direction of Vulnerability	Sources	Data Start
Household credit risk				
U.S. consumer debt/income	Consumer debt is non-mortgage household debt. Income measured as household disposable income. Ratio measured as difference from ten-year moving average.	Higher values	Haver	Q1:1990
U.S. consumer debt/GDP growth	Consumer debt is non-mortgage household debt.	Higher values	Haver	Q1:1990
U.S. consumer debt service ratio	Consumer debt is non-mortgage household debt.	Higher values	Haver	Q1:1990
U.S. mortgage debt/income	Income measured as household disposable income. Ratio measured as difference from ten-year moving average.	Higher values	Haver	Q1:1990
U.S. mortgage debt/GDP growth		Higher values	Haver	Q1:1990
U.S. mortgage debt service ratio		Higher values	Haver	Q1:1990
Nonfinancial business credit risk				
U.S. nonfinancial business debt/GDP	Ratio measured as difference from ten-year moving average.	Higher values	Haver	Q1:1990
U.S. nonfinancial business debt/GDP growth		Higher values	Haver	Q1:1990
U.S. nonfinancial business debt/assets	Median ratio of nonfinancial businesses. Four-quarter moving average.	Higher values	Compustat	Q1:1990
U.S. nonfinancial business debt/earnings	Median ratio of nonfinancial businesses. Four-quarter moving average. Earnings measured as EBITDA.	Higher values	Compustat	Q1:1990
U.S. nonfinancial business earnings/interest expense	Median ratio of nonfinancial businesses. Four-quarter moving average. Earnings measured as EBITDA.	Lower values	Compustat	Q1:1990
Real economy borrowing levels and terms				
Lending standards for nonfinancial business	As reported in Federal Reserve Senior Loan Officer Opinion Survey. Business lending is defined as commercial and industrial loans.	Lower values	Haver	Q1:1990
Lending standards for residential mortgages	Median credit score of new U.S. residential mortgages, as reported in FRBNY Consumer Credit panel.	Lower values	Haver	Q1:1990

Solvency/Leverage Risk

Indicators	Notes	Direction of Vulnerability	Sources	Data Start
Financial institution solvency				
Median U.S. BHC risk-based capital	Tier 1 capital divided by risk-weighted assets. Median ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars).	Lower values	Federal Reserve FR Y-9C	Q1:1996
Aggregate U.S. BHC risk-based capital	Tier 1 capital divided by risk-weighted assets. Aggregate ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars).	Lower values	Federal Reserve FR Y-9C	Q1:1996
Median U.S. commercial bank risk-based capital	Tier 1 capital divided by risk-weighted assets. Median ratio of institutions filing Call Reports.	Lower values	FFIEC Call Report	Q1:1993
Aggregate U.S. commercial bank risk-based capital	Tier 1 capital divided by risk-weighted assets. Aggregate ratio of institutions filing Call Reports.	Lower values	FFIEC Call Report	Q1:1994
Financial institution leverage				
Median U.S. BHC leverage	Tangible equity divided by tangible assets. Median ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars).	Lower values	Federal Reserve FR Y-9C	Q1:1990
Aggregate U.S. BHC leverage	Tangible equity divided by tangible assets. Aggregate ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars).	Lower values	Federal Reserve FR Y-9C	Q1:1990
Median U.S. commercial bank leverage	Tangible equity divided by tangible assets. Median ratio of institutions filing Call Reports.	Lower values	FFIEC Call Report	Q1:1994
Aggregate U.S. commercial bank leverage	Tangible equity divided by tangible assets. Aggregate ratio of institutions filing Call Reports.	Lower values	FFIEC Call Report	Q1:1993
Median U.S. life insurer leverage	Total equity divided by total assets, per GAAP accounting. Median ratio of publicly-traded U.S. life insurers. Four quarter moving average.	Higher values	Bloomberg	Q1:2001
Median U.S. non-life insurer leverage	Total equity divided by total assets, per GAAP accounting. Median ratio of publicly-traded U.S. insurers other than life insurers. Four quarter moving average.	Higher values	Bloomberg	Q1:2001

Funding/Liquidity Risk

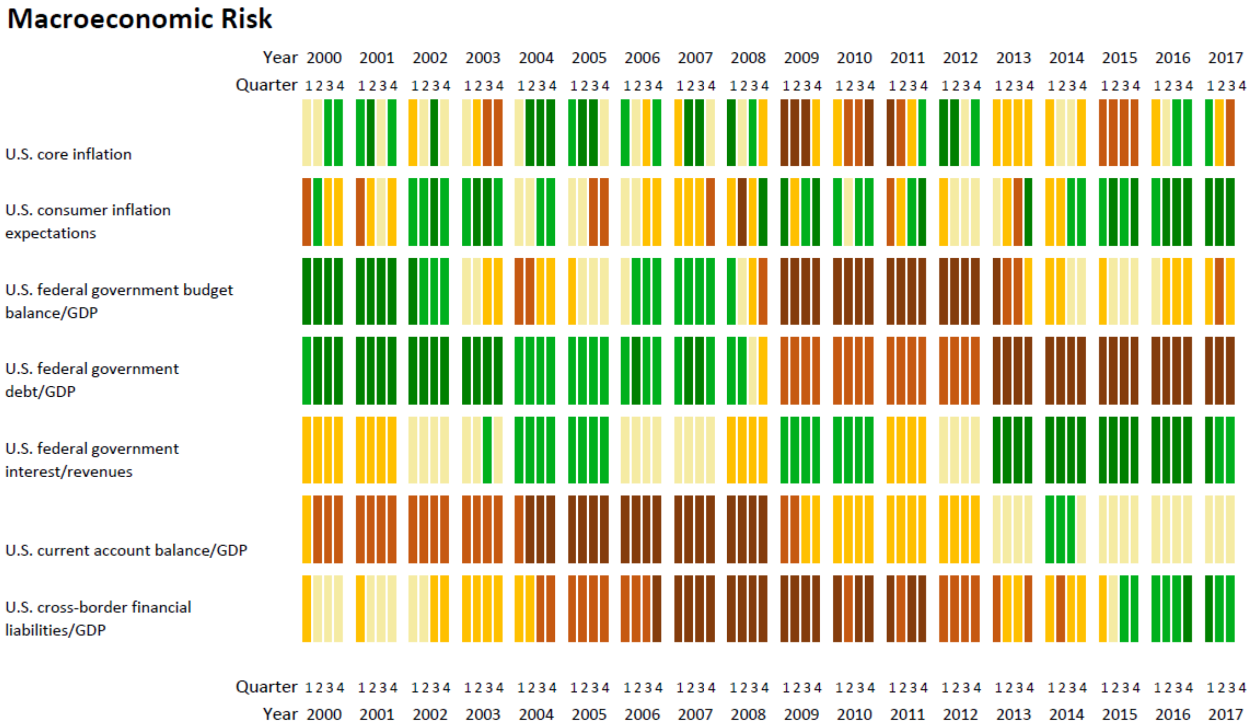
Indicators	Notes	Direction of Vulnerability	Sources	Data Start
Funding risk				
Ted Spread	Spread between three-month U.S. dollar LIBOR and three-month U.S. Treasury bill rate.	Higher values	Bloomberg	Q1:1990
U.S. financial commercial paper spread	Spread between 90-day financial firm commercial paper rate and three-month U.S. Treasury bill rate.	Higher values	Bloomberg	Q1:2000
Trading liquidity risk				
Dealer positions in U.S. Treasuries	Net broker-dealer position in U.S. Treasury securities, as reported in U.S. Financial Accounts. Indexed to marketable U.S. Treasury securities held by public.	Lower values	Haver	Q1:1990
Dealer positions in U.S. Agency-backed securities	Net broker-dealer position in U.S. Agency-backed securities, as reported in U.S. Financial Accounts. Indexed to U.S. Agency-backed securities.	Lower values	Haver	Q1:1990
U.S. Treasury bond turnover	Turnover measures trading volume divided by tradeable securities outstanding. Ratio measured as difference from one-year moving average.	Lower values	Haver	Q1:1994
U.S. equity turnover	Turnover measures trading volume divided by tradeable securities outstanding. Ratio measured as difference from one-year moving average.	Lower values	Bloomberg	Q1:2000
Financial institution liquidity risk				
Median U.S. commercial bank loans/deposits	Median ratio of institutions filing Call Reports.	Higher values	FFIEC Call Report	Q1:1993
Aggregate U.S. commercial bank loans/deposits	Aggregate ratio of institutions filing Call Reports.	Higher values	FFIEC Call Report	Q1:1990
Median U.S. BHC wholesale funding	Measured as nondeposit liabilities divided by total liabilities. Median ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars).	Higher values	Federal Reserve FR Y-9C	Q1:1990

Aggregate U.S. BHC wholesale funding	Measured as nondeposit liabilities divided by total liabilities. Aggregate ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars).	Higher values	Federal Reserve FR Y-9C	Q1:1990
Median U.S. BHC net stable funding	Ratio of estimated available stable funding/required stable funding. Median ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars). Available stable funding measured as the sum of the following (weights in parentheses): Tier 1 capital, Tier 2 capital, other capital, total deposits, borrowing with remaining maturity of one year or more (100%), borrowing with remaining maturity of less than one year (50%). Required stable funding measured per *Fire-Sale Spillovers and Systemic Risk,* Fernando Duarte and Thomas M. Eisenbach, Federal Reserve Bank of New York Staff Reports, no. 645 October 2013.	Lower values	Federal Reserve FR Y-9C	Q1:1997
Aggregate U.S. BHC net stable funding	Ratio of estimated available stable funding/required stable funding. Aggregate ratio of reporting bank holding companies with $1 billion or more in assets (2015 dollars). Available stable funding measured as the sum of the following (weights in parentheses): Tier 1 capital, Tier 2 Capital, other capital, total deposits, borrowing with remaining maturity of one year or more (100%), borrowing with remaining maturity of less than one year (50%). Required stable funding measured per *Fire-Sale Spillovers and Systemic Risk,* Fernando Duarte and Thomas M. Eisenbach, Federal Reserve Bank of New York Staff Reports, no. 645 October 2013.	Lower values	Federal Reserve FR Y-9C	Q1:1997

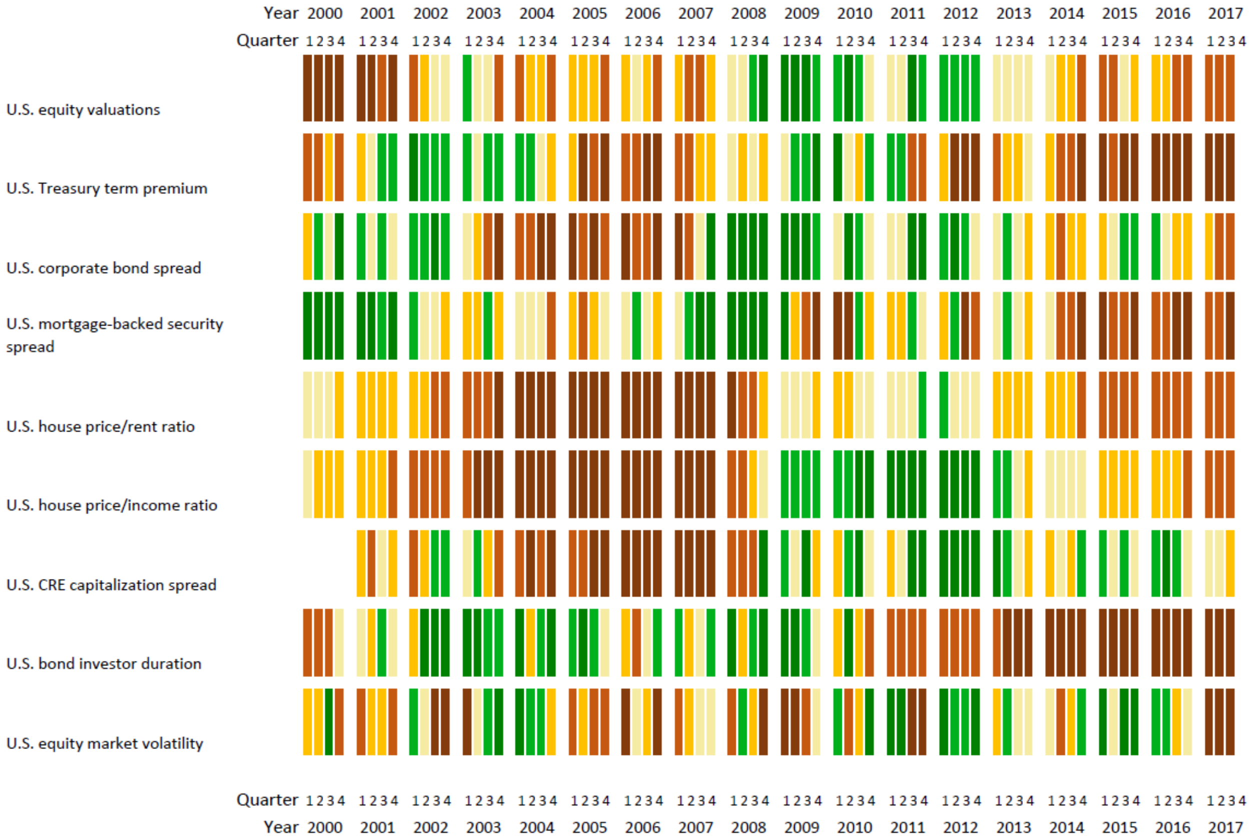
Contagion Risk

Indicators	Notes	Direction of Vulnerability	Sources	Data Start
Cross-institution contagion risk				
Asset fire-sale risk	Estimates the share of equity capital lost due to fire sale spillovers following for an indicative one percent decline in all asset prices. Aggregate for largest 100 U.S. bank holding companies, by assets. Methodology from *Fire-Sale Spillovers and Systemic Risk*, Fernando Duarte and Thomas M. Eisenbach, Federal Reserve Bank of New York Staff Reports, no. 645 October 2013, revised February 2015.	Higher values	SNL	Q1:1996
U.S. systemic capital shortfall estimate (SRISK)/GDP	Measured as the sum of positive SRISK values of 97 large U.S. financial institutions.	Higher values	The Volatility Laboratory of the NYU Stern Volatility Institute	Q2:2000
Financial sector concentration risk				
U.S. banking industry concentration	Herfindahl-Hirschman index of reporters, measured by assets.	Higher values	Federal Reserve FR Y-9C	Q1:1990
U.S. life insurance industry concentration	Herfindahl-Hirschman index of reporters, measured by assets.	Higher values	SNL	Q1:2001
U.S. mutual fund industry concentration	Herfindahl-Hirschman index of reporters, measured by assets.	Higher values	Morningstar	Q1:2000
Cross-border contagion risk				
U.S. cross-border financial assets/GDP	Ratio measured as difference from ten-year moving average.	Higher values	Haver	Q1:1990
U.S. bank cross-border claims/total assets	Cross-border claims measured on immediate counterparty basis. Divided by total assets for banks and bank holding companies reporting cross-border claims.	Higher values	Haver, Federal Reserve FR Y-9C, FFIEC Call Report	Q1:1990

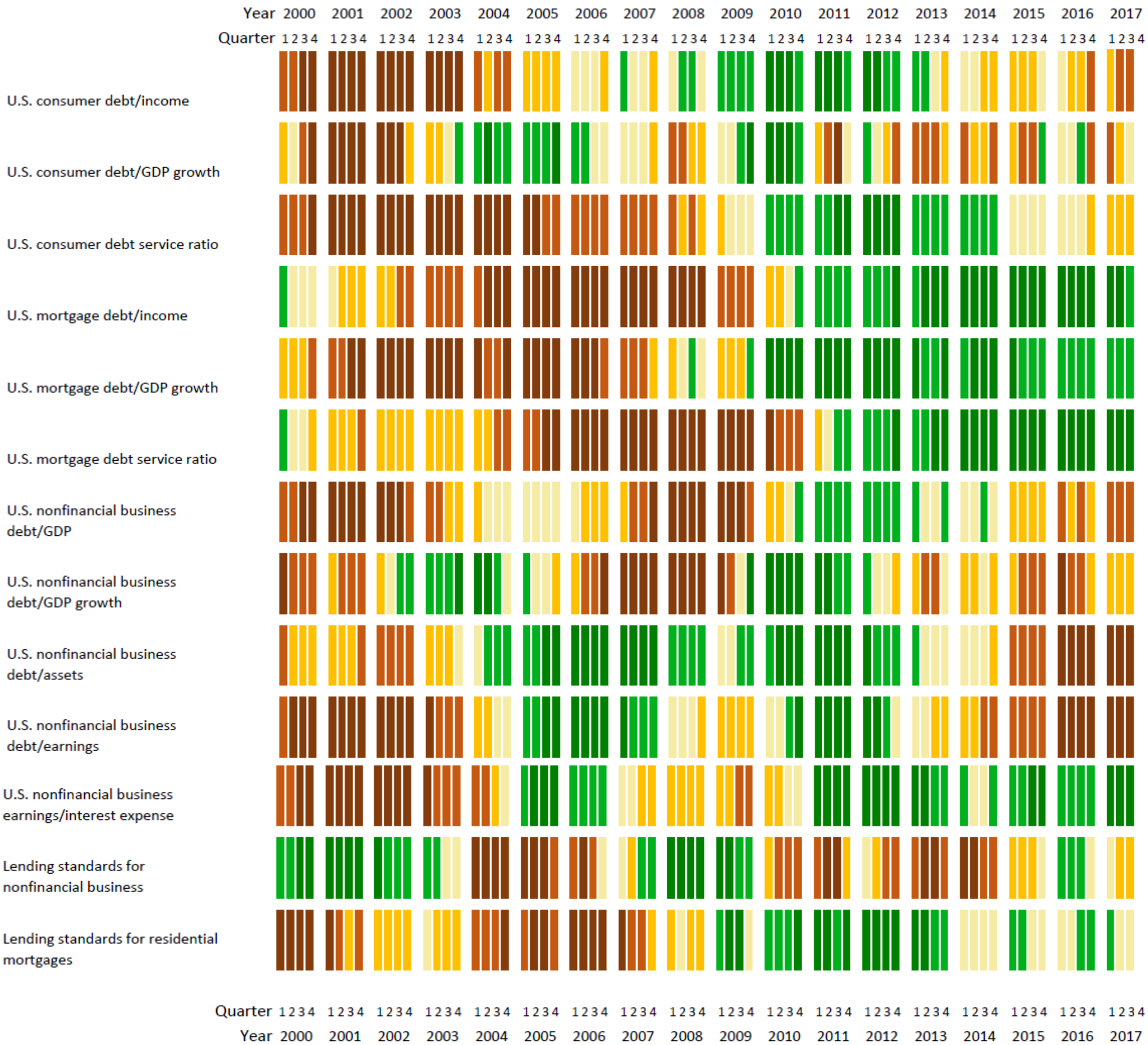
Appendix B: FSVM Indicator Scores



Market Risk


Year 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Quarter 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234
U.S. equity valuations
U.S. Treasury term premium
U.S. corporate bond spread
U.S. mortgage-backed security spread
U.S. house price/rent ratio
U.S. house price/income ratio
U.S. CRE capitalization spread
U.S. bond investor duration
U.S. equity market volatility
Quarter 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234 1234
Year 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

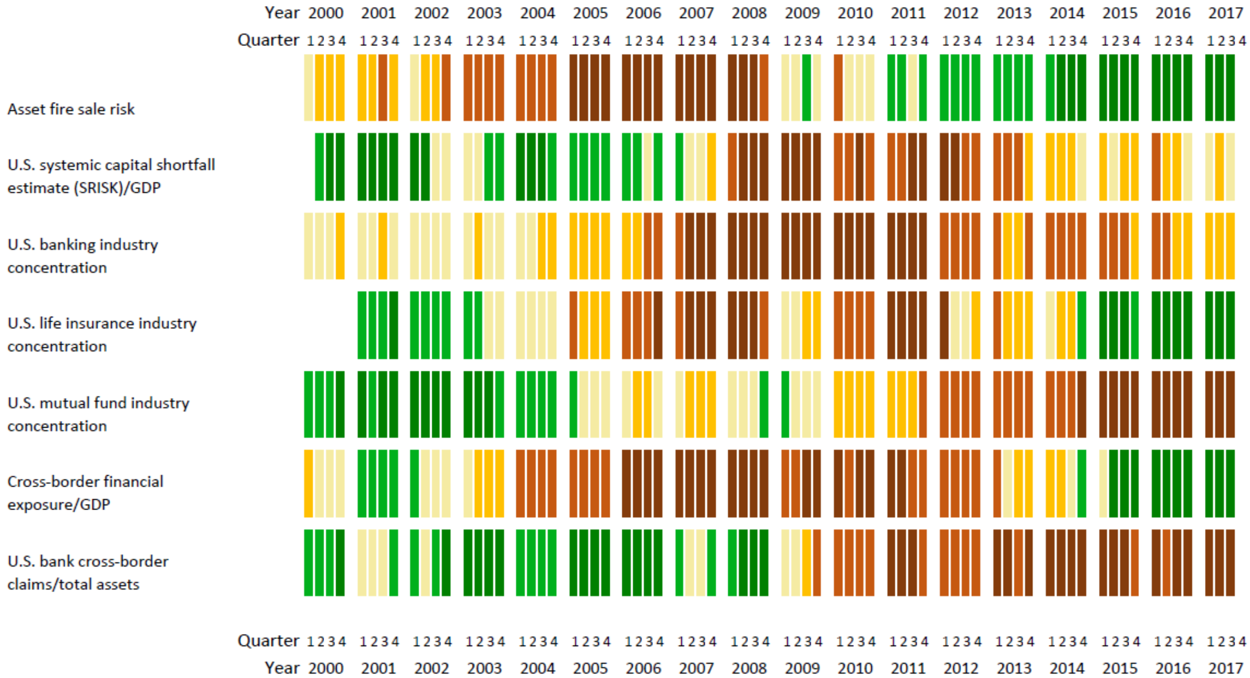
Credit Risk


Year 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Quarter 1 2 3 4
U.S. consumer debt/income
U.S. consumer debt/GDP growth
U.S. consumer debt service ratio
U.S. mortgage debt/income
U.S. mortgage debt/GDP growth
U.S. mortgage debt service ratio
U.S. nonfinancial business debt/GDP
U.S. nonfinancial business debt/GDP growth
U.S. nonfinancial business debt/assets
U.S. nonfinancial business debt/earnings
U.S. nonfinancial business earnings/interest expense
Lending standards for nonfinancial business
Lending standards for residential mortgages
Quarter 1 2 3 4
Year 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

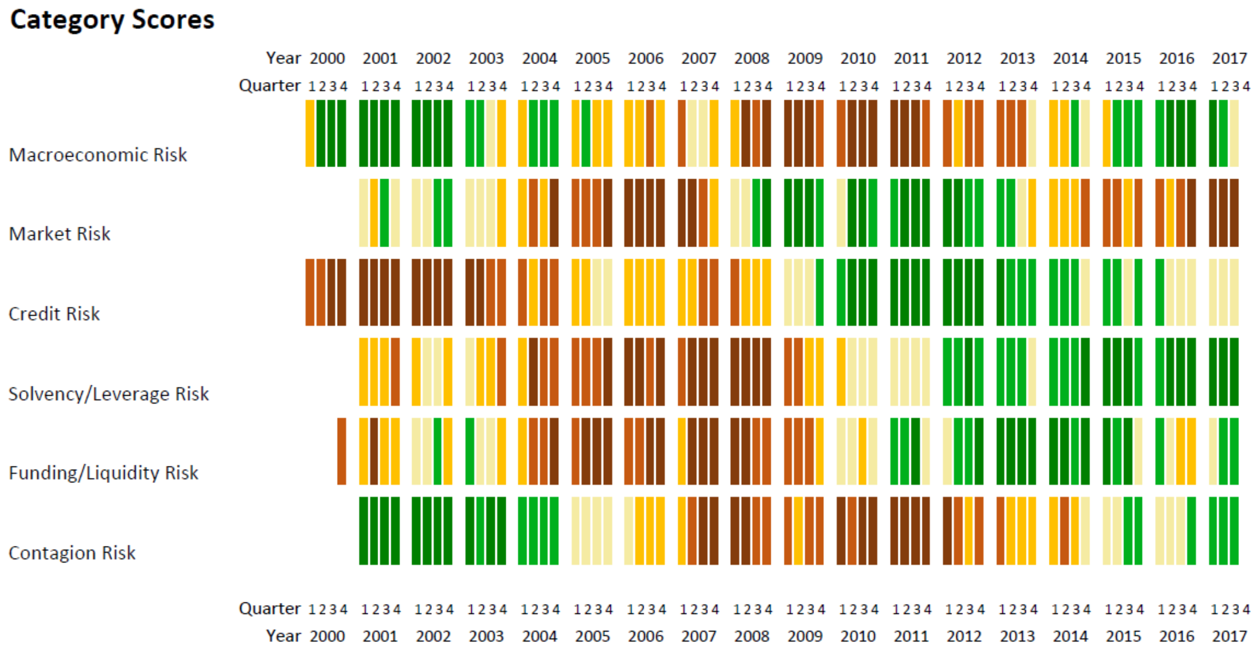
Solvency/Leverage Risk

Funding/Liquidity Risk

Contagion Risk



Appendix C: FSVM Category Scores



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