Macroeconomic Overheating and Financial Vulnerability
[PRELIMINARY DRAFT]

Elena Afanasyeva[*], Seung Jung Lee[†], Michele Modugno[‡], and Francisco Palomino[§¶]

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Abstract

An overheated economy has the potential to lead to financial imbalances, which in turn could generate or amplify economic distress. We study the link between macroeconomic performance and financial imbalances, focusing on the experience of the United States since the 1960s. We first follow a narrative approach to review historical episodes of significant financial imbalances and find weak links between periods of strong growth and financial imbalances. We then look for evidence of a statistical link between measures of economic slack and financial system vulnerability. Despite strong in-sample links, the gains from using the economic slack information to forecast financial vulnerability are typically limited out of sample. Measures of nonfinancial leverage constitute a notable exception, where the links are strong. In a non-linear setting of quantile regressions, measures of economic slack have a small effect on the distribution of financial conditions. Overall, we find that macroeconomic overheating can contribute to the build-up of financial vulnerabilities only via the increase in nonfinancial sector leverage.

JEL classification: C32; G21; N22.

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[*]E-mail: elena.afanasyeva@frb.gov.
[†]E-mail: seung.j.lee@frb.gov.
[‡]E-mail: michele.modugno@frb.gov.
[§]E-mail: francisco.palomino@frb.gov.
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1 Introduction

The Global Financial Crisis (GFC) renewed a significant interest in understanding the relationship between macroeconomic performance and financial vulnerabilities, producing a considerable body of research. Building upon seminal theoretical work such as Fisher (1933) and Bernanke and Gertler (1989), this research has mostly focused on studying channels in which vulnerabilities in the financial sector, such as high leverage in households' or banks' balance sheets, exacerbate economic downturns (e.g. Adrian and Shin (2010), Gilchrist and Zakrajsek (2012), Brunnermeier and Sannikov (2014), Mian and Sufi (2014), Gertler and Gilchrist (2018)). In contrast, the opposite relationship, namely whether macroeconomic performance has any bearing on the buildup of financial vulnerabilities has been less studied in the literature. The available empirical research linking business and financial (or credit) cycles (e.g., Claessens et al. (2012), Schularick and Taylor (2012), Borio (2014)) tends to emphasize relationships around the bust phases of these cycles, and pays less attention to the economic conditions that preceded the onset of financial vulnerabilities. To the extent that an overheated economy has the potential to lead to the build up of these vulnerabilities, which in turn could generate or amplify economic distress, the study of these conditions may contribute to our understanding of the dynamics linking business and financial cycles.

To properly frame our study, we need to start defining the two main concepts we are going to work with, i.e., macroeconomic overheating and financial vulnerability. While the first concept can be easily identified through the period in which official statistics from the Congressional Budget Office (CBO) about output and unemployment were respectively above and below their gaps, the definition of financial vulnerability may be more challenging. For this reason, we rely on Adrian et al. (2015) that defines financial vulnerabilities "as the collection of factors that contribute to the potential for widespread financial externalities. Vulnerabilities include leverage, maturity transformation without government insurance, compressed pricing of risk, interconnectedness, and complexity." Where "the potential for widespread financial externalities to amplify financial shocks and, in extreme cases, to disrupt financial intermediation," is the definition of systemic risk.

As already noted by Adrian et al. (2015), it is possible that macroeconomic overheating is linked to some dimensions of financial vulnerabilities. For example, "during expansionary booms and low measures of risk, funding constraints are looser and intermediaries can build up leverage and maturity mismatch." The broad scope of this paper is to shed light on the connection between macroeconomic overheating and financial vulnerabilities, focusing on the experience of the United States since the 1960s. Given this broad scope, we use two complementary approaches for our analysis. We use a narrative approach to study whether macroeconomic overheating preceded financial crises, and an econometric approach to identify whether macroeconomic overheating episodes predicted a deterioration in financial conditions, and therefore a build up of vulnerabilities, even if

they did not end up in crises.

In Section 2, we take a careful look at narrative historical accounts of periods of strong macroeconomic performance to see if they were associated with an increase in financial vulnerabilities. We do this by studying the literature associated with episodes of financial distress, both large and small, surrounding these overheating periods. We find that, although there were many overheating episodes that ended up in financial distress, the buildup of major financial vulnerabilities leading up to these disruptions in the United States appears to be more related to financial innovation and the development of different financial markets rather than to strong economic growth. Regulatory factors, policy regimes, and other external factors also appear to have played a more important role than macroeconomic overheating in inducing various financial disturbances.

The narrative approach, however, is less useful to detect more subtle ways in which overheating can be related to subsequent financial disturbances. To complement the narrative approach, in Section 3 we look for evidence of a statistical link between measures of economic slack and financial system vulnerability. In particular, we examine the bivariate relationship between the CBO measures of output or unemployment gap, in turn, and the National Financial Conditions Index (NFCI) of the Chicago Fed, described in Brave and Butters (2015), which provides a comprehensive estimate of US financial conditions in money markets, debt and equity markets, and the traditional and shadow banking systems. Although Granger causality tests point to strong in-sample links between the variables, an out-of-sample forecasting exercise shows that there are very modest gains from using economic slack information to predict broadly defined financial vulnerabilities. This conclusion is further supported in the conditional forecasting exercises, which focus on overheating episodes in particular rather than the entire sample. However, when we analyze the relation among the CBO measures and the components of the NFCI, we find a strong out-of-sample link between measures of economic slack and nonfinancial sector leverage, i.e., an overheated economy does predict an increase in nonfinancial sector leverage. Finally, we also test for the presence of a nonlinear relationship, which may be obscured when looking at linear specifications. We estimate quantile regressions to understand how economic slack affects the conditional distribution of future realization of the index of financial conditions and find that nonlinearities in the relationship between measures of economic slack and the NFCI (or its components) are modest.

Overall, as summarized in Section 4, using both the narrative and statistical approaches, and then a broad characterization of the link between macroeconomic overheating and financial vulnerabilities, we find that macroeconomic overheating can contribute to financial vulnerability only via the channel of nonfinancial sector leverage.

2 Narrative approach

We rely on a meta-analysis of historical accounts—based on literature summarized in Table 1—to describe whether periods of overheating in the United States economy coincided with or were followed by a buildup of vulnerabilities in the financial system. We also report on whether those vulnerable periods were followed by an economic downturn, either material or limited.

We look at the narratives of a comprehensive list of financial disturbances since 1960. The disturbances we consider arise from periods of credit crunches, banking crises, and financial market crashes. **In our historical accounts, we also include a few episodes of financial stress that emanated from abroad and carried the potential for large adverse spillovers to the United States. –There is only one episode in this section and I think we should get rid of it, see below** Figure 1 highlights the most representative episodes, while Table 1 provides a summary of all analyzed episodes. We focus on the narrative surrounding the shaded historical periods of overheating in which either the unemployment rate in the United States was below the Federal Reserve Board staffs real-time estimate of its natural rate or in which the output gap was positive: 1964:Q1 - 1970:Q3, 1972:Q2 - 1974:Q3, 1978:Q1 - 1980:Q1, 1987:Q2 - 1990:Q3, 1997:Q2 - 2001:Q3, and 2005:Q3 - 2007:Q4.[1]

At first glance, Figure 10 shows a tendency for significant financial disturbances to occur during periods of macroeconomic overheating, consistent with the hypothesis that investors and intermediaries take greater risks during buoyant economic phases. Indeed, the index of overall financial conditions—the National Financial Conditions Index (NFCI) produced by the Federal Reserve Bank of Chicago—shows that vulnerabilities builded up during or after several of the past identified overheating periods since 1960. However, an account of financial events for the period under study suggests a more tenuous relationship between macroeconomic overheating and financial vulnerability in the United States.

We describe in chronological order the principal financial disturbance episodes in the context of macroeconomic overheating periods. More detailed references to the academic sources covered in our review are available in Table 1. While we take the view that financial disturbances are signs

[1]Non-accelerating inflation rate of unemployment (NAIRU) estimates by the Board staff are publicly available until 2011. The Federal Reserve staffs real-time estimates of the NAIRU should be interpreted with caution since there are multiple definitions of this indicator. The definition used in Federal Reserve Board staffs estimates of the NAIRU has evolved over time, and the natural rate of unemployment has become the more common terminology as modelers have moved away from accelerationist views of inflation. For further details, see https://www.philadelphiafed.org/research-and-data/real-time-center/greenbook-data/nairu-data-set. Output gap is measured as: 100*(Real Gross Domestic Product - Real Potential Gross Domestic Product) / Real Potential Gross Domestic Product. Real Gross Domestic Product data is from the U.S. Bureau of Economic Analysis, and Real Potential Gross Domestic Product data is from the U.S. Congressional Budget Office (CBO). Real potential GDP is the CBOs estimate of the output the economy would produce with a high rate of use of its capital and labor resources. The data are adjusted to remove the effects of inflation.

Table 1: Summary of Historical Analysis

Overheating Episode	Financial Disturbance	Date of Financial Disturbance	Literature Sources Consulted
1964-1970	Credit Crunch 1966	August-September 1966	Burger (1969); Wojnilower (1980); Bordo and Haubrich (2017)
	Credit Crunch 1970	May 1970	Wojnilower (1980); Bordo and Haubrich (2017)
1972-1974	Banking Crisis 1974	1974	Wojnilower (1980); Drehmann et al. (2012); Bordo and Haubrich (2017)
1978-1980	Latin American Debt Crisis	1982-1989	Kaminsky and Reinhart (1999); Drehmann et al. (2012); Bordo and Haubrich (2017)
1987-1990	S&L Crisis*	1988-1990	Bordo et al. (2000); Reinhart and Rogoff (2009); Romer (2013); Drehmann et al. (2012); Schularick and Taylor (2012); Laeven and Valencia (2013); Field (2017)
	Black Monday	October 1987	Romer (2013)
	Junk Bond Market Crash	October 1989	Wolfson (1994)
	Mexican Crisis (Tequila Crisis)	October 1992 / December 1994	Kaminsky and Reinhart (1999)
1997-2001	Asian Crisis, LTCM, Russia	1997 Q3 (Asian Crisis); 1998 Q3 (LTCM & Russian Crisis)	Romer (2013)
	Dot-Com Crash	Spring 2001	Romer (2013); Bordo and Haubrich (2017)
2005-2007	Financial Crisis	2007-2009	Diamond and Rajan (2009); Reinhart and Rogoff (2009); Schularick and Taylor (2012); Laeven and Valencia (2013); Bordo and Haubrich (2017)
	Euro Area Sovereign Debt Crisis	2009-2011	Lo Duca et al. (2017)

Note: The S&L Crisis* is dated to have a far wider range (1984 – 1991) in Reinhart and Rogoff (2009).

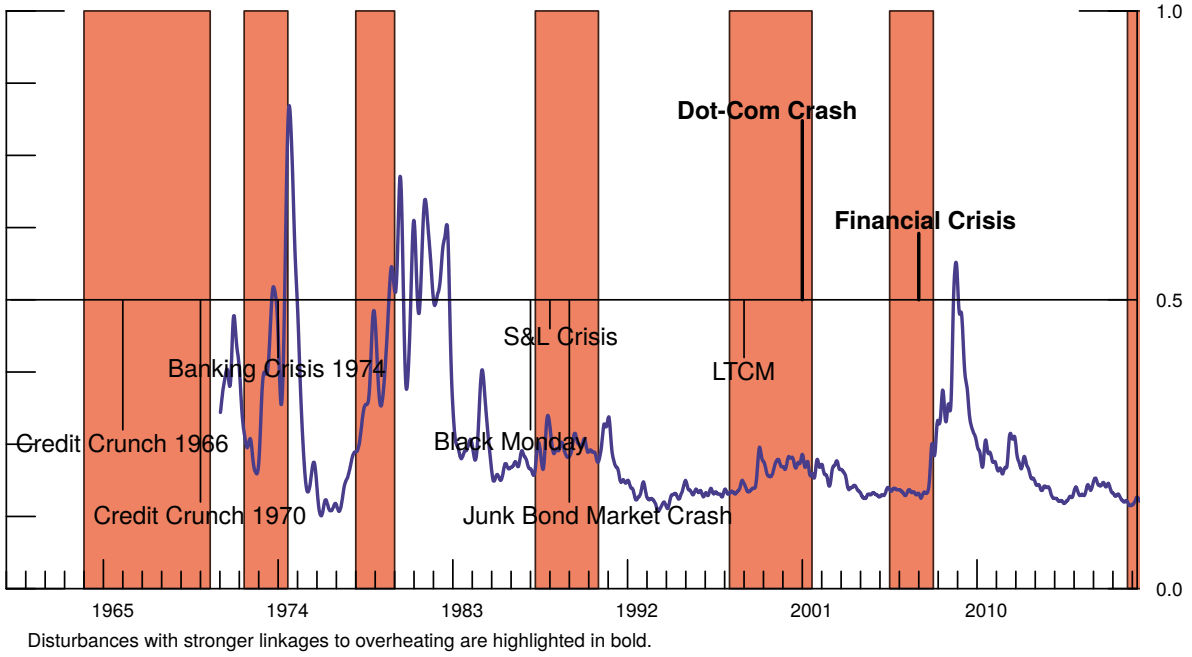

Figure 1: **Economic overheating, selected financial Disturbances, and the Chicago Fed National Financial Conditions Index.**

that an imbalance of some kind was building beforehand, which allows a broad consideration of financial imbalances, we do not precisely date the start of the buildup or quantify its evolution.

1964:Q1-1970:Q3

After a moderate recession, the early 1960s was a period of sustained output growth and a significant decline in the unemployment rate from levels around 7 percent in 1961 to around 4 percent in 1966, about 1 percentage points lower than its natural rate. This was also a period of high credit growth that coincided with the development of the commercial paper market and negotiable certificate of deposits as new sources of short-term funding. Banks, in turn, relied on such funding to invest more in high yield bonds (**what is the vulnerability here? maturity transformation is building up?**). In the context of these financial innovations, tightening monetary policy and binding Regulation Q ceilings **these are the shocks, not the vulnerability**—which imposed restrictions on the payment of interest on savings and time deposits—contributed to the credit crunches during the 1964-1970 overheating period. The Credit Crunch of 1966 forced nonbank financial intermediaries to sell long-term illiquid assets at sizable losses. The duration of the credit crunch, however, was relatively brief and, indeed, the macroeconomic overheating continued. Afterward, a commercial paper default by Penn Central Transportation Company in 1970 marked the beginning of another Credit Crunch concentrated in the commercial paper market. Although

emergency measures by the Federal Reserve Board (such as the suspension of Regulation Q rate ceilings on negotiable CDs of less than three months, and lending banks funds that could be lent to firms) helped avert a major financial crisis, this development effectively resulted in a tightening of lending standards and reduced borrowing capacity for businesses. However, when judged against the pronounced magnitude and duration of the overheating period (with real GDP growth above 4 percent over four years), the accompanying financial disruptions were moderate.

1972:Q2-1974:Q3

Real activity and credit were boosted by the commodity boom (**what is it? how did it boost credit?**), monetary policy easing, and strong global growth in the early 1970s. During this period, real GDP growth averaged around 2 percent annually and the unemployment rate declined around 1 percentage point to levels close to 5 percent, around 0.5 percentage point lower than its natural rate. After this brief overheating period, as interest rates **shock?** and loan volumes **leverage vulnerability?** reached high levels, the failure of Franklin National Bank triggered a general pullback by investors that made it difficult even for the largest banks to count on rolling over their commercial paper funding. These events triggered the 1974 Banking Crisis that coincided with a severe recession (the unemployment rate climbed to almost 9 percent in June 1975). Although some authors cite this banking crisis as one of the elements contributing to the recession, other factors, such as the first oil shock and the 1973 tightening of U.S. monetary policy, are often cited as more important.

1978:Q1-1980:Q1

During the 1970s, large oil price shocks created significant current account surpluses among oil-exporting countries and current account deficits in many Latin American countries. Large U.S. banks served as intermediaries providing the oil-exporting countries with a liquid place for their funds while lending those funds (in U.S. dollars) to Latin America. During the overheating period of 1978-1980, real GDP growth in the United States averaged about 2 percent, starting from a position of already-high resource utilization, and the unemployment rate fell below 6 percent. In 1982, as interest rates (**shock?**) were raised aggressively to fight inflation, Mexico was unable to service its outstanding debt to U.S. commercial banks and other creditors, marking the beginning of the Latin American Debt Crisis. Many Latin American countries rescheduled their public debt obligations and put strains on several of the largest banks in the United States. Regulatory forbearance in recognizing losses is considered to have been effective at forestalling greater panic and limited the negative macroeconomic consequences for the United States. **what is the vulnerability here? low risk aversion when giving credit to Mexico?**

1987:Q2-1990:Q3

Concerns about large vulnerabilities in the financial system in the 1980s started to build up well before the overheating period at the end of the decade. During the 1980s expansion, spurred by the development of the speculative (high-yield) bond market, corporate leverage rose significantly (**first vulnerability?**). Meanwhile, the unemployment rate went from around 9 percent in early 1984 to around 5.3 percent by the end of 1988, and high interest rates (**shock?**) continued to negatively impact the net worth of the Savings and Loan (S&L) sector as mortgages lost considerable value. Although there is a wide range of views about the dating of the onset of the S&L crisis (**second vulnerability?**), it is generally acknowledged that regulatory forbearance had the unintended effect of inducing S&Ls to make new and riskier loans other than residential mortgages, which expanded credit further but subsequently led to widespread insolvencies. Despite various interventions, around 1,400 S&Ls and 1,300 banks failed between 1984 and 1991. Some studies cite the S&L crisis as contributing importantly to the 1990-91 recession, while the Stock Market Crash in 1987 and the High-yield (Junk) Bond Market Crash in 1989 did not seem to have had a significant impact. The recession that followed is characterized as mild, as real GDP growth averaged around 1 percent and the unemployment rate reached a highest level of 7.6 percent in the first half of 1992.

1997:Q2-2001:Q3

The 1990s were characterized by solid economic growth amid various financial disruptions stemming from abroad, such as the Tequila Crisis, the Asian Financial Crisis, and the collapse of Long Term Capital Management **(how these events fit in our story? what kind of vulnerability were capturing? it doesn't seem connected with our story, i.e. not due to US overheating, and didn't affect our financial system)**. Timely coordinated policy interventions are considered to have substantially limited the imprint of these disruptions on economic activity. During this overheating period lasting 5 years, real GDP growth averaged about 3 percent and the unemployment rate mostly ranged between 4 and 5 percent. The expansionary economic conditions contributed to the domestic boom in telecom and internet firms amid euphoria over internet-based technologies, leading to rapidly rising equity prices **(low risk aversion vulnerability?)**. Eventually, the reversal in investor sentiment led to the Dot-Com Crash, which triggered a mild recession in the early 2000s, with the unemployment rate increasing from around 4 percent in September 2000 to 6.1 percent in June 2003. This financial episode provides the most compelling example of how overheating can lead to increased financial vulnerabilities and, in turn, how financial events can generate an economic downturn. However, compared with the relatively long overheating period, the accompanying financial disruptions and subsequent recession were modest.

2005:Q3-2007:Q4

During the overheating period from early 2005 to the Great Recession, real GDP growth av-

eraged about 2 percent, fueled by a rapid growth of homebuilding, mortgage credit, and house prices. However, the elevated levels of leverage, exposure to maturity transformation, and wholesale short-term funding at large financial institutions that caused the Financial Crisis of 2007-09 had already built up before the onset of overheating during this period. Aikman et al. (2017), and Lee at al. (2018) show that a comprehensive reading of vulnerabilities in the U.S. financial system was already elevated in 2004. Although some researchers link the buildup of those systemic vulnerabilities to macroeconomic overheating, others see those vulnerabilities as a consequence of independent financial engineering developments. In addition, others believe that accommodative monetary policy contributed to the buildup of financial vulnerability (e.g., Diamond and Rajan (2009) and Adrian and Liang (2018)). The Financial Crisis generated a severe recession with a subsequent sluggish recovery.

The Financial Crisis spread to the euro area resulted in bank bailouts and ballooning government deficits across Europe. A few European countries were unable to repay or refinance their government debt or to bail out over-indebted banks without the assistance of other euro area countries, the ECB, or the IMF, exacerbating weak economic activity in the region. Although the Euro Area Sovereign Debt Crisis, in turn, impacted financial markets in the United States, it is less clear whether there were permanent reverberations on real economic activity.

3 Econometric Analysis

The narrative approach offers a broad review of the overheating episodes. Our statistical analysis considers systematic patterns between business and financial cycles. We explore the link between indicators of financial imbalances and macroeconomic performance, focusing on the experience of the United States. Our approach involves a statistical analysis of the link between measures of economic slack and financial system vulnerability. In particular, we study bivariate time-series relationships between different measures of economic slack and financial vulnerability, relying on conventional measures of the business and financial cycles.

Figure 2 shows the U.S. output gap computed by the Congressional Budget Office and the publicly available historical estimate of the (negative of the) unemployment gap computed by the FRB staff plotted against the periods of macroeconomic overheating (shaded). Periods of macroeconomic overheating correspond to quarters when either output is above potential or unemployment is lower than the non-accelerating inflation rate of unemployment (NAIRU).[2] The measure of imbalances is the overall National Financial Conditions Index of the Chicago Fed (Figure 3, which comprises information of about 100 measures of financial activity (see Brave and Butters (2012) for more

[2]In order to make the comparison easier, Figure 2 reports the negative of the unemployment gap.

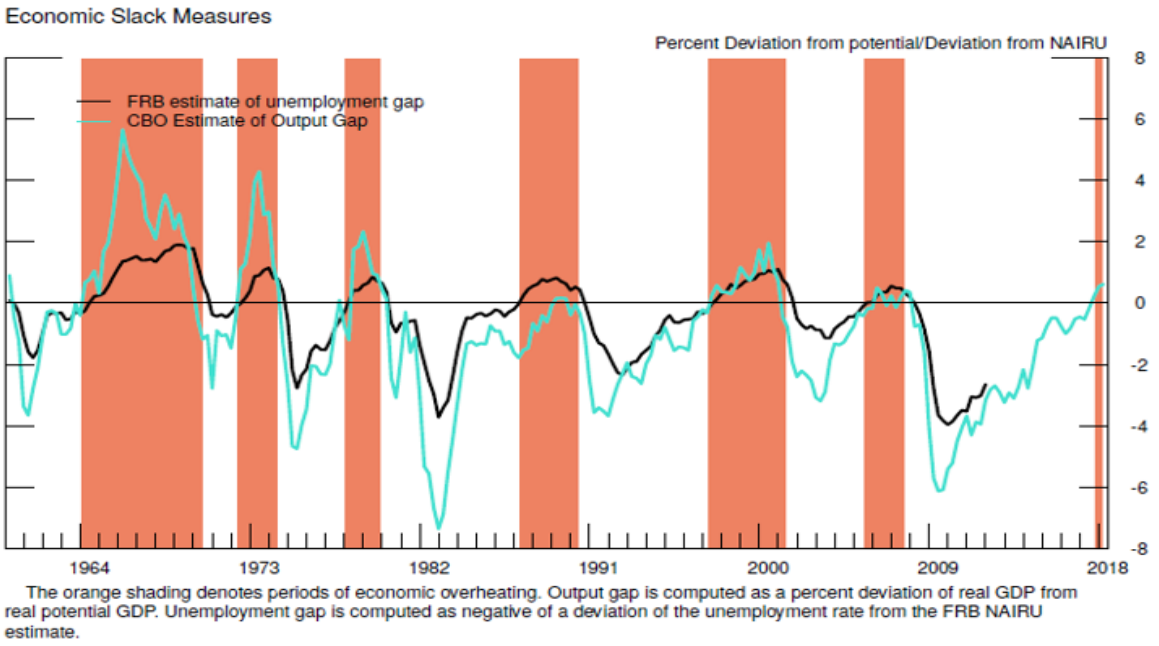

Figure 2: **Measures of Economic Slack**

details). Positive values of the NFCI indicate that financial conditions are tighter than average. The visual inspection of co-movement between the NFCI and economic slack reveals that they are rarely closely synchronized, with the notable exception of the onset of systemic crises and some of the recessions, when output gap decreases abruptly and the NFCI index increases steeply.

3.1 Predictability

In statistical tests of Granger causality, which focuses on in-sample fit, we find significant linkages running from measures of economic slack to the various measures of financial vulnerability (see Table 1).

The cross-correlograms (4) further illustrate the in-sample linkages between economic slack and financial vulnerability. Although contemporaneous correlations are rarely strong and significant, there are strong dynamic links. In particular, a positive (overheated) slack is associated with more financial vulnerability (higher NFCI values) in the future. This relationship is particularly strong (higher correlations and very narrow error bands) for the Nonfinancial Leverage subcomponent of the overall NFCI measure.

To gauge the strength of the linkages and their robustness across different samples, we consider

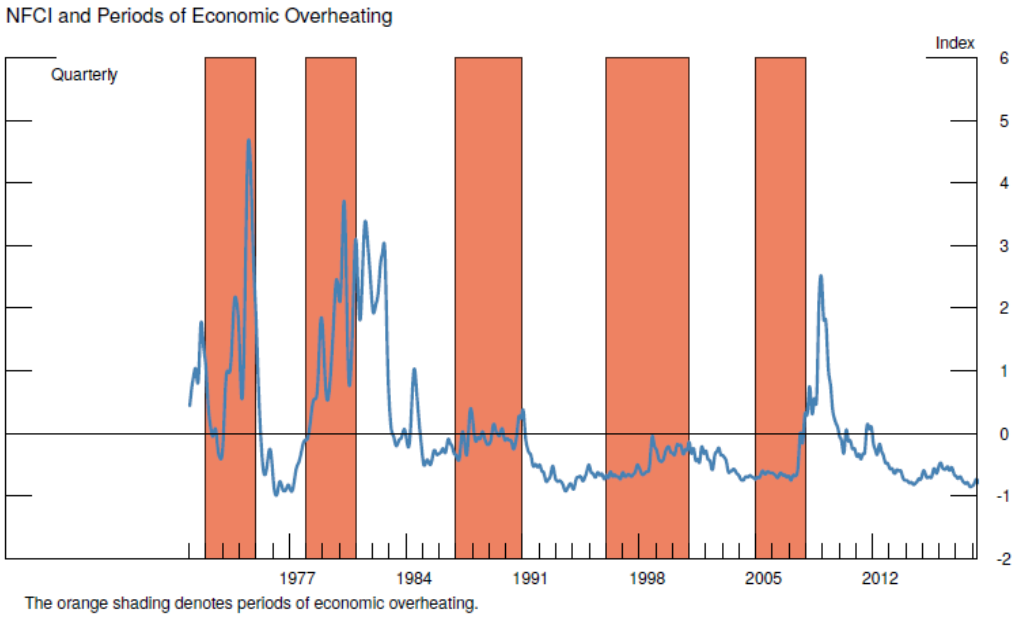

Figure 3: **Financial Vulnerability Measure: the National Financial Conditions Index.**

Table 1: Granger Causality Results: P-Values for the Rejection of the Null (No Causality)

Financial Vulnerability Measure	UNR Gap	Output Gap
NFCI	0.0021	0.0000
ANFCI	0.0003	0.0000
Leverage	0.1406	0.0010
Nonfinancial Leverage	0.0000	0.0000
Credit	0.0000	0.0000
Risk	0.0074	0.0040

Notes: To test for Granger causality links, we examine bivariate VARs, containing one financial vulnerability and one economic slack measure. The lag order of the VAR is chosen with the AIC.

out-of-sample forecast performance, shown in Tables 2 through 7 as well as in Figure 5.

The first out-of-sample exercise tests whether the business cycle helps to forecast the future evolution of the financial cycle. To this purpose, we estimate bivariate vector auto-regressions (VARs) including measures of financial vulnerability and macroeconomic slack. In particular, we estimate regressions that include the overall NFCI index, its adjusted version (ANFCI), which is the NFCI conditional to the prevailing macroeconomic conditions, or its subcomponents (Risk, Credit, Leverage, Nonfinancial Leverage) and the output gap. For robustness, we also test our results for a different measure of economic slack – the unemployment gap.

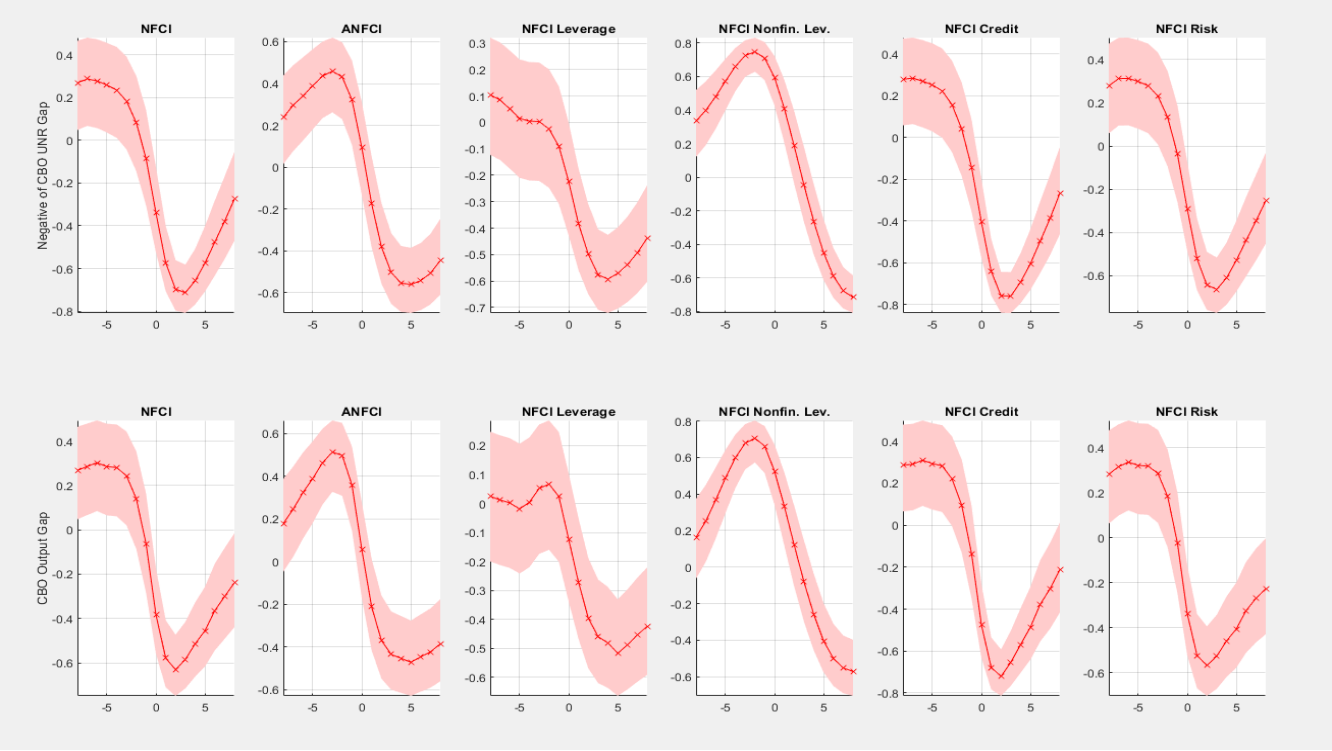

Figure 4: **Cross-Correlations between Measures of Economic Slack and Financial Vulnerability at Various Leads and Lags**
Notes: Time units on the horizontal axis in each panel are quarters. Bands around the point estimates reflect the 95% confidence bands.

To understand if the business cycle measure has predictive power for the financial cycle we compare the pseudo out-of-sample forecast performances of VARs that include both a financial and a macroeconomic series against the performance of a simpler univariate autoregressive model estimated on the variable of interest. Table 2 reports the ratio of the root mean squared forecast error (RMSFE) produced by the VAR model to RMSFE produced by the AR processes for the variable of interest. Thus, a ratio below one indicates that information on one cycle helps forecast the other. We also test for equal forecasting performance of AR and VAR models with the Diebold-Mariano test. The table shows that there are no measurable gains from using information on the output gap to forecast the overall NFCI measure, regardless of the lag structure used. An analogous result obtains also for the unemployment gap. We further apply the same procedure to the ANFCI and the subcomponents of the NFCI, the results are displayed in Tables 3 - 7. For the majority of the subcomponents, the conclusions are very similar: the gains from the information on economic slack are very small when we predict financial conditions. One exception is the subindex in the category Nonfinancial Leverage, where we detect substantial improvement in forecasting

Table 2: Comparisons of Univariate and Bivariate Pseudo-Out-of-Sample Forecasts for the NFCI

RMSFE Ratio VAR/AR	NFCI & Output Gap		NFCI & UNR Gap	
Horizon	VAR(1)	VAR(4)	VAR(1)	VAR(4)
1	1.09	1.35	1.25	1.24
2	1.24	1.46	1.57	1.45
4	0.90	0.91	1.04	0.97
8	0.75	0.77	0.73	0.96

Notes: The table reports ratios of the Root Mean Squared Forecast Errors (RMSFE) from a bivariate VAR to the RMSFE for an AR process. The VAR includes the two variables in each panel. Ratios below 1 indicate that the VAR outperforms the AR process. For instance, value 1.09 under the heading NFCI indicates that forecasts from a bivariate VAR(1) including the credit-to-GDP gap and the output gap are less accurate than forecasts from an AR(1) process for the NFCI. Numbers in bold indicate a rejection of the Null Hypothesis of equal forecasting performance for the Diebold-Mariano test at the 5%-level.

Table 3: Comparisons of Univariate and Bivariate Pseudo-Out-of-Sample Forecasts for the ANFCI

RMSFE Ratio VAR/AR	ANFCI & Output Gap		ANFCI & UNR Gap	
Horizon	VAR(1)	VAR(4)	VAR(1)	VAR(4)
1	1.02	1.29	1.12	1.25
2	1.05	1.25	1.24	1.26
4	0.89	0.93	0.95	0.97
8	0.85	0.87	0.82	0.99

Notes: The table reports ratios of the Root Mean Squared Forecast Errors (RMSFE) from a bivariate VAR to the RMSFE for an AR process. The VAR includes the two variables in each panel. Ratios below 1 indicate that the VAR outperforms the AR process. Numbers in bold indicate a rejection of the Null Hypothesis of equal forecasting performance for the Diebold-Mariano test at the 5%-level.

performance stemming from the use of output gap data. We conclude that in this case some of the in-sample predictability uncovered by the Granger causality tests is robust out-of-sample. When comparing the VAR and AR forecast errors for Nonfinancial Leverage subindex over the entire sample (Table 8), we find that the largest gains from using economic slack data in forecasting financial conditions occur in recessions (especially at shorter horizons) and in expansions at medium-run horizons. We shed more light on this distinction in the next exercise.

The results presented so far pertained to average predictive performance. Next, we focus on the predictability at specific points in time, i.e., during the episodes of macroeconomic overheating, assuming advance knowledge of the evolution of the output gap measure (5). In particular, we focus on two specific periods at the edge of an economic expansion era. Following Bańbura et al. (2015), we produce forecast of the NFCI assuming that we know the evolution of the output gap into the expansion periods, up to 1-year ahead. Despite this informational advantage relative to real-time conditions, model predictions deviate substantially from the observed outcomes. The first conditional forecast in Figure 5, labeled A, is produced assuming knowledge of the financial index

Table 4: Comparisons of Univariate and Bivariate Pseudo-Out-of-Sample Forecasts for the NFCI-Risk

RMSFE Ratio VAR/AR	NFCI-Risk & Output Gap		NFCI-Risk & UNR Gap	
Horizon	VAR(1)	VAR(4)	VAR(1)	VAR(4)
1	1.10	1.38	1.23	1.28
2	1.21	1.50	1.47	1.48
4	0.92	0.92	1.03	0.95
8	0.78	0.78	0.75	0.91

Notes: The table reports ratios of the Root Mean Squared Forecast Errors (RMSFE) from a bivariate VAR to the RMSFE for an AR process. The VAR includes the two variables in each panel. Ratios below 1 indicate that the VAR outperforms the AR process. Numbers in bold indicate a rejection of the Null Hypothesis of equal forecasting performance for the Diebold-Mariano test at the 5%-level.

Table 5: Comparisons of Univariate and Bivariate Pseudo-Out-of-Sample Forecasts for the NFCI-Credit

RMSFE Ratio VAR/AR	NFCI-Credit & Output Gap		NFCI-Credit & UNR Gap	
Horizon	VAR(1)	VAR(4)	VAR(1)	VAR(4)
1	0.87	0.86	0.95	0.86
2	0.87	0.75	1.00	0.77
4	0.71	0.92	0.80	1.28
8	**0.73**	1.01	0.75	1.13

Notes: The table reports ratios of the Root Mean Squared Forecast Errors (RMSFE) from a bivariate VAR to the RMSFE for an AR process. The VAR includes the two variables in each panel. Ratios below 1 indicate that the VAR outperforms the AR process. Numbers in bold indicate a rejection of the Null Hypothesis of equal forecasting performance for the Diebold-Mariano test at the 5%-level.

through 2000:Q2 and of the output gap through 2001:Q2. The second conditional forecast, labeled B, is produced assuming knowledge of the financial index through 2005:Q1 and of the output gap through 2006:Q1. In both cases, the point forecasts imply a steep upward-sloping path for the financial index, which deviates substantially from the observed values. The 90 percent confidence intervals are, however, so wide as to point to the likelihood of both an increase and a decline in the financial index. These results indicate that there is sizable variation in the financial index that is independent of the output gap.

As the CBO estimates and projections of the output gap turn persistently positive starting from 2017:Q3, signaling the onset of yet another period of macroeconomic overheating, we also conduct another conditional forecast exercise, where instead of assuming advance knowledge of the output gap estimates, we condition on the CBO projections (point C in Figure 5). In this case, the jump-off point is the end of the sample, 2018:Q1, and the conditioning values for output gap stem from CBO projections, up to 2019:Q1. Although the projected financial index remains in the negative territory throughout, the point prediction suggests a relatively steep upward-sloping path

Table 6: Comparisons of Univariate and Bivariate Pseudo-Out-of-Sample Forecasts for the NFCI-Leverage

RMSFE Ratio VAR/AR	NFCI-Leverage & Output Gap		NFCI-Leverage & UNR Gap	
Horizon	VAR(1)	VAR(4)	VAR(1)	VAR(4)
1	1.11	0.98	1.12	1.02
2	1.16	1.05	1.18	1.04
4	0.93	0.89	0.98	1.03
8	0.89	0.98	0.91	1.05

Notes: The table reports ratios of the Root Mean Squared Forecast Errors (RMSFE) from a bivariate VAR to the RMSFE for an AR process. The VAR includes the two variables in each panel. Ratios below 1 indicate that the VAR outperforms the AR process. Numbers in bold indicate a rejection of the Null Hypothesis of equal forecasting performance for the Diebold-Mariano test at the 5%-level.

Table 7: Comparisons of Univariate and Bivariate Pseudo-Out-of-Sample Forecasts for the NFCI-Nonfinancial Leverage

RMSFE Ratio VAR/AR	NFCI-Nonfin. Lev. & Output Gap		NFCI-Nonfin. Lev. & UNR Gap	
Horizon	VAR(1)	VAR(4)	VAR(1)	VAR(4)
1	**0.64**	**0.55**	0.77	**0.68**
2	0.72	**0.62**	0.83	**0.69**
4	0.81	**0.50**	0.88	**0.70**
8	0.93	**0.80**	0.96	0.89

Notes: The table reports ratios of the Root Mean Squared Forecast Errors (RMSFE) from a bivariate VAR to the RMSFE for an AR process. The VAR includes the two variables in each panel. Ratios below 1 indicate that the VAR outperforms the AR process. Numbers in bold indicate a rejection of the Null Hypothesis of equal forecasting performance for the Diebold-Mariano test at the 5%-level.

for the financial index with confidence bands somewhat tighter than in previous two cases and also pointing upwards. The tighter link between the financial index and output gap in this case may be attributed to smaller estimation uncertainty (due to the larger data availability) and the inclusion of the Great Recession, when we observed a larger degree of co-movement between measures of economic slack and financial vulnerability.

In light of the overall predictability results discussed above, we also conduct the conditional forecasting exercise for the subindex 'Nonfinancial Leverage' (Figure 6). In contrast with our findings for the overall NFCI, conditional forecasts of its 'Nonfinancial Leverage' subcomponent are substantially more accurate in terms of point estimates, and the uncertainty range around the point forecasts is much narrower. In particular, at the first overheating episode (point A), the path of the conditional forecast displays the same shape as the actual data. At the next point (B), the conditional forecast correctly predicts the direction, even when accounting for the uncertainty bands around the point estimates. Overall, these results corroborate our earlier findings that economic

Table 8: Comparisons of Univariate and Bivariate Pseudo-Out-of-Sample Forecasts for the NFCI-Nonfinancial Leverage During Recessions and Expansions

RMSFE Ratio VAR/AR	NFCI-Nonfin. Lev. & Output Gap		NFCI-Nonfin. Lev. & UNR Gap	
Horizon	Expansion	Recession	Expansion	Recession
1	1.16	0.49	0.91	0.66
2	0.69	0.62	0.87	0.68
4	0.44	0.50	0.65	0.71
8	0.77	0.80	0.80	0.89

Notes: The table reports ratios of the Root Mean Squared Forecast Errors (RMSFE) from a bivariate VAR to the RMSFE for an AR process. The VAR includes the two variables in each panel. Ratios below 1 indicate that the VAR outperforms the AR process.

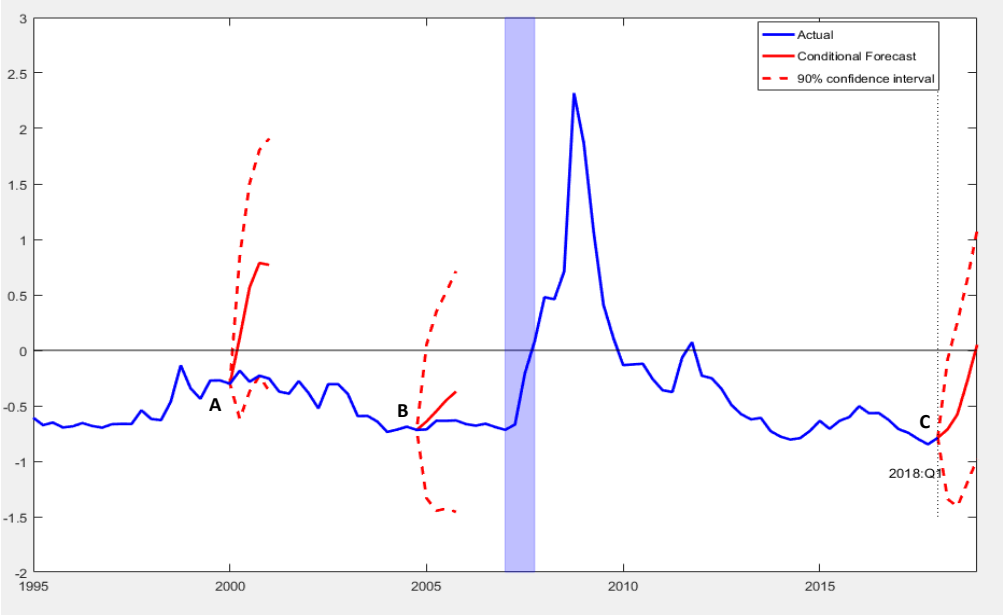

Figure 5: **Forecasts of the Chicago Fed National Financial Conditions Index Conditional on the Output Gap.**

slack is helpful in predicting the 'Nonfinancial Leverage' component of financial vulnerability.

3.2 Testing for Nonlinearities

Previous analysis concentrated on linear relationships between macroeconomic overheating and financial vulnerabilities. Following the approach by Adrian et al.(2017), we explore potential non-linearities between the variables of interest. In particular, we estimate the distribution of the 1-

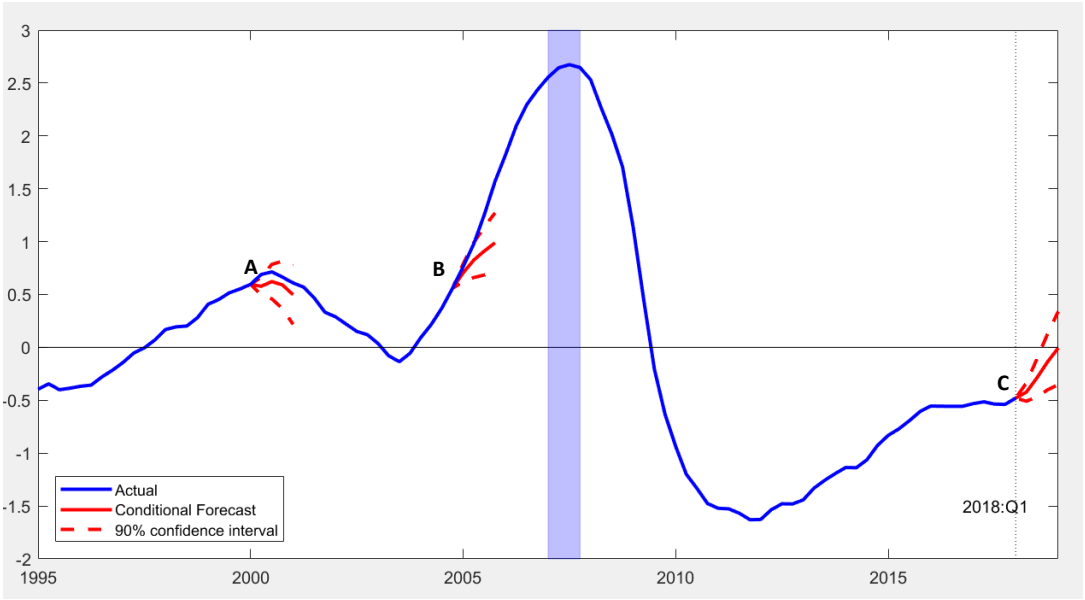

Figure 6: **Forecasts of the Chicago Fed National Financial Conditions Subindex 'Non-financial Leverage' Conditional on the Output Gap.**

and 4-quarter ahead distribution of the NFCI, conditional to the current financial conditions and economic conditions. This conditional distributions are estimated semiparametrically using quantile regressions. In this sense, we study the reverse question compared to Adrian et al. (2017), who model the distribution of GDP growth as a function of financial conditions.

More formally, we estimate the quantile regressions as follows. Denote by y_{t+h} the NFCI index in period $t+h$ and by x_t the vector of explanatory variables that includes a constant, contemporaneous level of NFCI in period t as well as contemporaneous level of the output or unemployment gap in period t. In the quantile regression, the resulting coefficients β_τ minimize the quantile weighetd absolute value of errors:

$$\beta_\tau = \underset{\beta_\tau}{\operatorname{argmin}} \sum_{t=1}^{T-h} \left(\tau \cdot \mathbb{1}_{(y_{t+h} \geq x_t \beta_\tau)} |y_{t+h} - x_t \beta_\tau| + (1-\tau) \cdot \mathbb{1}_{(y_{t+h} < x_t \beta_\tau)} |y_{t+h} - x_t \beta_\tau| \right), \qquad (1)$$

where $\mathbb{1}_{(\cdot)}$ is the indicator function. The results for horizons of one quarter ahead ($h = 1$) and one year ahead ($h = 4$) are presented in Figure 7. In both cases, the regression slopes across quantiles are relatively stable for output gap, suggesting that economic slack is relatively uninformative in predicting a tail event on the financial side. Nonlinearities (if any) primarily stem from the contemporaneous level of the NFCI itself. Figure **??** demonstartes that these results also hold for

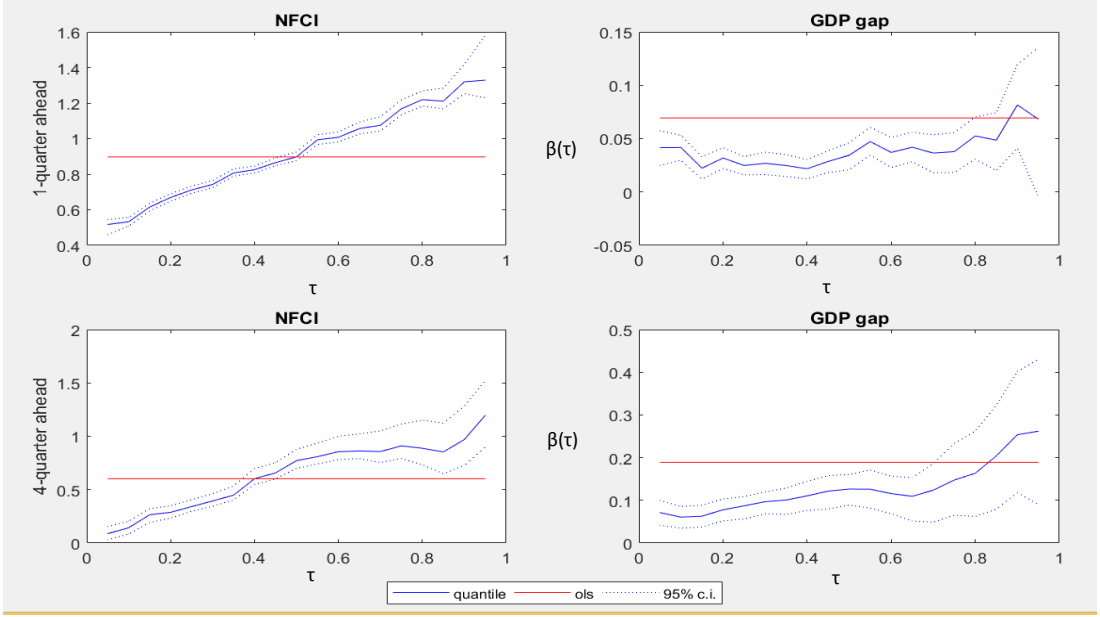

Figure 7: **Estimated Quantile Regression Coefficients for the Overall NFCI, Output Gap is the Slack Regressor.**

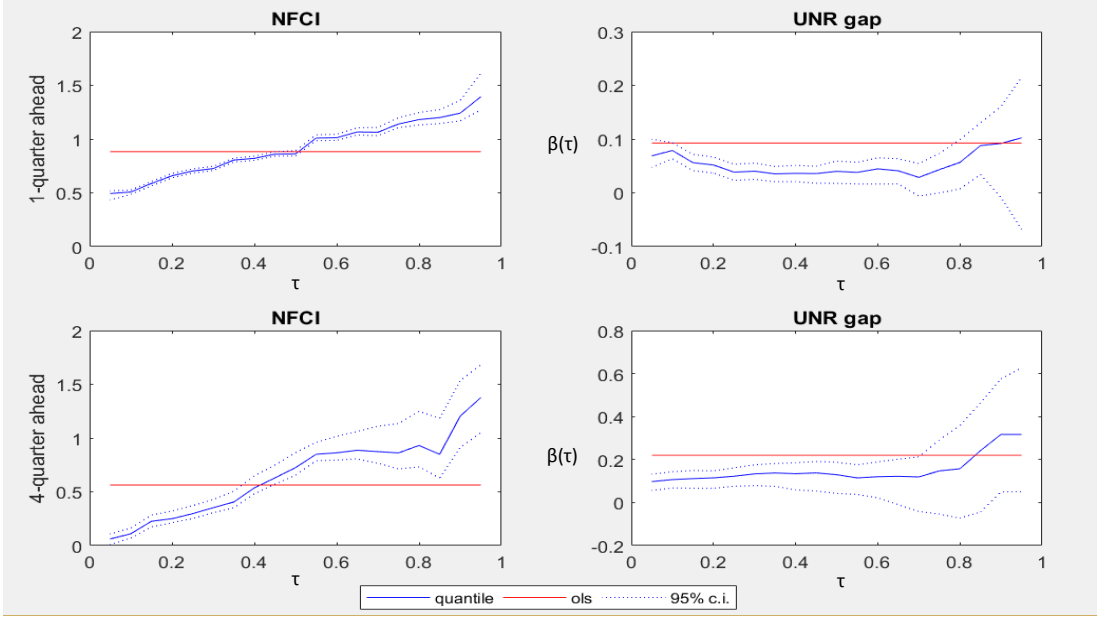

Figure 8: **Estimated Quantile Regression Coefficients for the Overall NFCI, Unemployment Gap is the Slack Regressor.**

the alternative measure of economic slack - the unemployment gap.

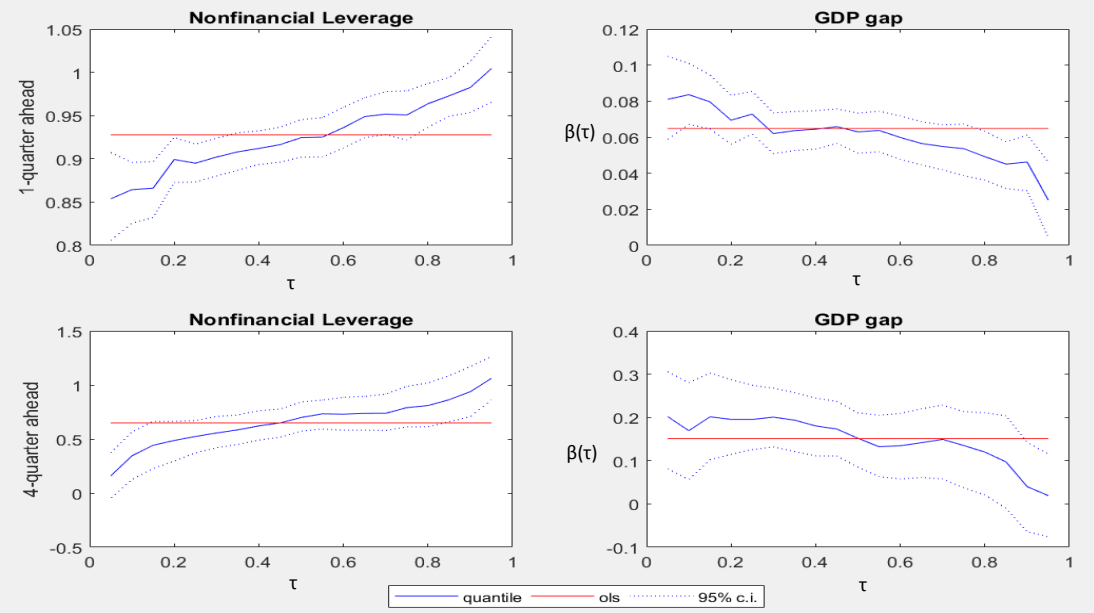

Figure 9: **Estimated Quantile Regression Coefficients for the 'Nonfinancial Leverage' Subindex of the NFCI, Output Gap is the Slack Regressor.**

As a further robustness check, we conduct this exercise for the subcomponents of the NFCI. The same tendecies generally hold. Even when we find minor non-linearities in the point estimates of some subindices (not shown), the confidence bands around those estimates are wide enough to support a flat relationship. In light of our previous findings for Nonfinancial Leverage, we report the results for this subcomponent for both measures of economic slack (Figure 9 and Figure 10). In this sace, the uncertainty bands around the quantile coefficients are even wider than for the overall NFCI and mostly include the standard linear OLS results.

Our results indicate that information on the business cycle is only modestly helpful in predicting the future course of vulnerability measures - with the notable exception of the Nonfinancial Leverage subcomponent of the NFCI. We do not find strong evidence in favor of a nonlinear relationship between macroeconomic overheating and measures of financial conditions. Thus, on the whole, our statistical analysis suggests that a sustained period of unusually strong macroeconomic performance can contribute, but typically only via the nonfinancial sector leverage channel, to the build-up of broad financial vulnerability.

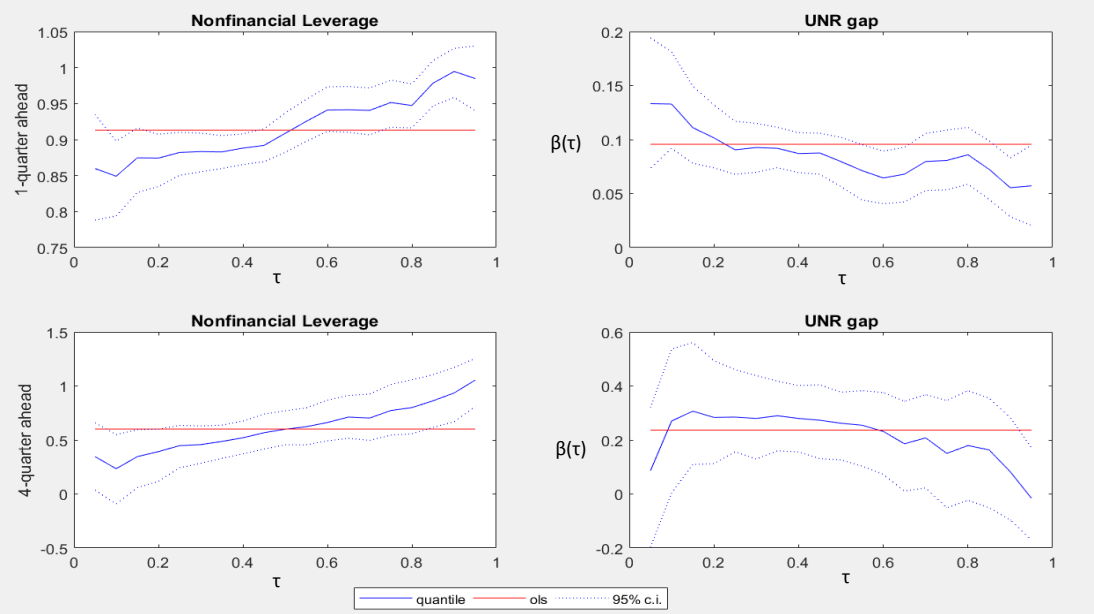

Figure 10: **Estimated Quantile Regression Coefficients for the 'Nonfinancial Leverage' Subindex of the NFCI, Unemployment Gap is the Slack Regressor.**

4 Conclusion

Although we document a tendency for significant financial disturbances to occur during periods of macroeconomic overheating, a literature review based on historical evidence does not support a strong direct link between macroeconomic overheating and the buildup of systemic financial vulnerabilities. Based on our narrative investigation, the buildup of major financial imbalances leading up to financial disruptions in the United States appears to have stemmed more from financial innovation and the development of different financial markets. Regulatory factors, policy regimes, and other external factors also appear to have played a more important role than macroeconomic overheating in inducing various financial disturbances. In particular, the imbalances that resulted in the S&L Crisis of the late 1980s are generally not considered related to overheating during that period. Although some researchers link the Financial Crisis of 2007-09 to macroeconomic overheating, much of the buildup of systemic vulnerabilities preceded the overheating phase. By contrast, the imbalances that resulted in the Dot-Com bust of the early 2000snot widely regarded a systemic eventwere most clearly associated with the strong performance of the United States economy. Finally, most financial disturbances in the United States since 1960 have left little imprint on the United States economy. In many cases, this may have been due to effective policy or regulatory interventions.

We reach similar conlcusions in our quantitative exercises when exploring the statistical links between various measures of economic overheating and financial vulnerability. Generally, these links are modest, especially out-of-sample, and there is limited evidence on the presence of non-linearities. That said, macroeconomic overheating appears to have substantial links with increased leverage in the nonfinancial sector. In that sense, and perhaps when combined with additional factors, macroeconomic overheating can carry a potential to sow the seeds of future financial vulnerabilities.

References

Adrian, Tobias and Daniel Covitz and Nellie Liang (2015). "Financial Stability Monitoring." *Annual Review of Financial Economics* 7(1): 357–395.

Adrian, Tobias and Hyun Song Shin (2010). "Liquidity and Leverage." *Journal of Fianncial Intermediation* 19(3): 418–437.

Adrian, Tobias and Nellie Liang (2018). "Monetary Policy, Financial Conditions, and Financial Stability." *Journal of Banking and Finance* 14(1): 73–131.

Aikman, David, Michael Kiley, Seung Jung Lee, Michael G. Palumbo, and Missaka Warusawitharana (2017). "Mapping Heat in the U.S. Financial System." *Journal of Banking and Finance* 81(C): 36–64.

Bańbura, Marta, Domenico Giannone,and Michele Lenza (2015). "Conditional forecasts and scenario analysis with vector autoregressions for large cross-sections." *International Journal of Forecasting* 31(3): 739–756.

Bernanke, Ben and Mark Gertler (1989). "Agency Costs, Net Worth, and Business Fluctuations." *The American Economic Review* 79(1): 14–31.

Bordo, Michael, Barry Eichengreen, Daniela Klingebiel, and Maria Soledad Martinez-Peria (2001). "Is the Crisis Problem Growing More Severe?" *Economic Policy* 16(32): 51–82.

Bordo, Michael and Joseph. G. Haubrich (2017). "Deep Recessions, Fast Recoveries, and Financial Crises: Evidence from the American Record." *Economic Inquiry* 1(55): 527–541.

Borio, Claudio (2014). "The Financial Cycle and Macroeconomics: What Have we Learnt?" *Journal of Banking and Finance* 45: 182–198.

Scott, Brave and R. Andrew Butters (2012). "Diagnosing the Financial System: Financial Conditions and Financial Stress." *International Journal of Central Banking* 8(2): 191–239.

Brunnermeier, Markus K. and Yuliy Sannikov (2014). "A Macroeconomic Model with a Financial Sector" *The American Economic Review* 104(2): 379–421.

Burger, Albert E. (1969). "A Historical Analysis of the Credit Ctunch of the 1966" *Review* (September): 13–30.

Claessens, Stijn, M. Ayhan Kose, and Marco Terrones (2012). "How Do Business and Financial Cycles Interact?" *Jounral of International Economics* 87(1): 178–190.

Diamond, Douglas W. and Raghuram Rajan (2009). "The Credit Crisis: Conjectures about Causes and Remedies." *The American Economic Review* 99(2): 606–610.

Drehmann, Mathias, Claudio Borio, and Kostat Tsatsaronis (2012). "Characterising the Financial Cycle: Don't Lose Sight of the Medium Term!" BIS Working Paper No. 380.

Field, Alexander J. (2017). "The Savings and Loan Insolvenices and the Costs of Financial Crisis." Chapter 3, pp. 65–113.

Fisher, Irving (1933). "The Debt-Deflation Theory of Great Depressions." *Econometrica* 1(4): 337 – 357.

Gertler, Mark and Simon Gilchrist (2018). "What Happened: Financial Factors in the Great Recession." *Journal of Economic Perspectives* 32(3): 3 – 30.

Gilchrist, Simon and Egon Zakrajsek (2012). "Credit Spreads and Business Cycle Fluctuations." *The American Economic Review* 102(4): 1692 – 1720.

Lee, Seung Jung, Kelly E. Posenau, and Viktors Stebunovs (2018). "The Anatomy of Financial Vulnerabilities and Banking Crises." *Journal of Banking and Finance*.

Lo Duca, Marco, Anne Koban, Maria Basten, Elias Bengtsson, Benjamin Klaus, Piotr Kusmierczyk, Jan Hannes Lang, Carsten Detken, and Tuomas A. Peltonen (2017). "A New Database for Financial Crises in European Countries." Occasional Paper Series No. 194, European Central Bank.

Mian, Atif and Amir Sufi (2014). "What Explains the 2007-2009 Drop in Employment?" *Econometrica* 82(6): 2197–2223.

Reinhart, Carmen M. and Kenneth S. Rogoff (2009). "This Time is Different: Eight Centuries of Fianncial Folly." Princeton, New Jersey: Princeton University Press.

Romer, David. "Preventing the Next Catastrophe: Where do we Stand?" Technical Report.

Schularick, Moritz and Alan M. Taylor (2012). "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises: 1870-2008" *The American Economic Review* 102(2): 1029–1061.

Wojnilower, Albert (1980). "The Central Role of Credit Crunches in Recent Financial History" *Brooking Papers on Economic Activity* 1980(2): 277–339.

Wolfson, Martin H. (1994). "Financial Crises: Understanding the Postwar U.S. Experience" *Taylor and Francis*.