Financial Imbalances, Macroeconomic Vulnerabilities, and Monetary Policy*

David Aikman† Andreas Lehnert‡ Nellie Liang§ Michele Modugno¶

January 14, 2016

Preliminary and incomplete: do not distribute – contact the authors for the most recent version

Abstract

We define a measure to be a *financial vulnerability* if, in a VAR framework that allows for nonlinearities, shocks to the measure lead to an economic contraction. We evaluate alternative measures of financial imbalances as vulnerabilities: private sector debt, risk appetite of financial sector participants, and the maturity mismatch of financial firms. We also evaluate the ability of monetary policy shocks to affect these imbalances. We find that shocks to debt and financial firm mismatch are vulnerabilities, while shocks to risk appetite are expansionary. However, shocks to risk appetite lead to growth of other imbalances. We find that these effects are nonlinear, and generally greater in times of higher imbalances. Moreover, we find that monetary policy is generally ineffective at stemming imbalances, particularly when they are already high.

Keywords: Financial imbalances, leverage, credit, monetary policy

JEL classification: E58, E65, G28

1 Introduction

The recent global financial crisis highlighted in dramatic fashion the damage to economic performance from falling asset prices amid high levels of debt and fragile financial institutions. Policymakers have since been encouraged to monitor the financial system for the

*We would like to thank Shane Sherlund, Cindy Vojtech, and Maria Perozek for help and advice in constructing some of the measures we use. We benefitted from helpful comments from Tobias Adrian, William Bassett, Rochelle Edge and Michael Kiley as well as participants at the Federal Reserve Bank of Boston's conference "Macroprudential Monetary Policy", held on Oct. 2-3, 2015 and a seminar at the Federal Reserve Board. Collin Harkrader provided excellent research assistance. Any remaining errors are own responsibility. The views expressed here are ours and not those of our employers.

†Bank of England, David.Aikman@bankofengland.co.uk

‡Board of Governors of the Federal Reserve System, andreas.lehnert@frb.gov

§Board of Governors of the Federal Reserve System, jnellie.liang@frb.gov

¶Board of Governors of the Federal Reserve System, michele.modugno@frb.gov

buildup of so-called macrofinancial "imbalances" that could make the system vulnerable to shocks such as a large decline in asset prices. Indeed, cross-sectional studies of advanced economies have found that nonfinancial sector credit, asset valuations, and financial sector maturity transformation are early warning indicators of economic recessions and financial crises (see Borio and Lowe (2002), Drehmann and Juselius (2015), Schularick and Taylor (2012), Anundsen, Hansen, Gerdrup, and Kragh-Srensen (2014)). In addition, studies have found that credit growth and asset bubbles combined lead to significantly weaker economic recoveries (see Jorda, Schularick, and Taylor (2013)). Financial stability monitoring frameworks, based on this growing body of theoretical and empirical research, focus on the levels and growth rates of these so-called macrofinancial imbalances (see Adrian, Covitz, and Liang (2013)).

But which imbalances should policymakers be particularly concerned with? Which imbalances lead, as an empirical matter, to risks to future macroeconomic performance? Does the macroeconomy perform differently when imbalances are high or low? To what extent can monetary policy influence the trajectory of imbalances? And how, if at all, do such imbalances relate to each other?

In this paper we shed empirical light on these questions using a threshold VAR model using data the U.S. economy from 1975 to the present. Using alternative measures of macrofinancial imbalances, we test whether shocks to the measures lead to subpar economic performance and the ability of monetary policy shocks to affect the measures. To test for nonlinearities, we divide the sample into periods depending on whether the measure is above or below its average.

We view our primary contribution as determining empirically which measures of financial imbalances lead to lower expected economic performance. We label such measures as "vulnerabilities." Vulnerabilities are the measures that should be the focus of policy. Our paper is also a contribution to the empirical literature on the role of financial markets in business cycles; see, for example, Lopez-Salido, Stein, and Zakrajsek (2015). While others have identified a role for shocks to certain credit aggregates and asset prices to contribute to business cycle fluctuations, this paper is the first to systematically examine a commonly-cited set of financial imbalances. In addition, cross-country studies acknowledge the importance of the institutional details of different countries' financial systems. Because financial markets play a uniquely prominent role in intermediation in the U.S., an important contribution of this paper is to test for market-wide imbalances that are particularly useful to monitor for the U.S.

We examine three imbalances usually cited in studies of financial crises: the level of private-sector debt, investor sentiment or asset valuations, and maturity transformation among financial institutions.[1] We briefly describe each imbalance in turn, how we measure it, and the rationale for including it in our framework. We are currently undertaking work on financial sector leverage as a vulnerability.

Note that our first two imbalances, debt and asset valuations, are conceptually different from maturity transformation. The first set are economy-wide measures and do not de-

[1] We do not consider the current-account balance as a potential vulnerability in our framework. While this has been emphasized in cross-country studies of small open economies, we leave this as a future exercise in our framework.

pend on particular institutional features. The second is defined relative to specific financial institutions such as money market mutual funds.

The first measure is private-sector debt, using primarily the credit-to-GDP gap, defined as the difference between the ratio of private nonfinancial sector credit outstanding to GDP and its long-term trend (e.g. Borio and Lowe (2002, 2004); Borio and Drehmann (2009)).[2] We also evaluate components of this measure–household or business borrowers and provision by bank or nonbank providers–to test more hypotheses about specific vulnerabilities, such as the role of real estate, which is often identified as a key risk to financial stability.

A second measure is the extent of "froth" in financial markets – that is, relatively rich asset valuations or relatively high investor risk appetite. We construct a direct measure of investor risk appetite, dubbed ALLM, based on asset valuations and lending standards in four markets: business credit, commercial real estate, household credit (including consumer credit and residential mortgages), and equities. We also consider the the excess bond premium of Gilchrist and Zakrajšek (2012), which has been found to be a useful predictor of macro performance, as a measure of risk appetite. Higher asset values relative to historical averages may reflect greater risk-taking behavior which could lead to a buildup in financial imbalances and make the economy more vulnerable to an adverse shock. Boom-bust cycles in real estate prices are viewed by many economists as key sources of financial fragility (see, for instance, Cecchetti, 2008 and Iacoviello, 2005). Jorda, Schularick, and Taylor (2015) find that based on data for nearly 150 years for 17 countries, asset price bubbles associated with rapid credit growth are more costly than bubbles without credit growth, and that housing bubbles are more costly than equity bubbles. Others have emphasized the information in bond risk premiums (Stein (2013) and Lopez-Salido et al (2015)). According to this view, when risk premiums are unusually low there is a greater probability of a subsequent rapid reversal, which may be associated with significant adverse economic effects. Brunnermeier and Sannikov (2014), among others have argued that low volatility may spur risk taking, with the potential for a destabilizing unraveling when volatility eventually spikes.

Our last measure is related to financial institutions and their role as amplification mechanisms, mechanisms that have been studied by Adrian and Boyarchenko (2015) and Gertler and Kiyotaki (2015), among others. We examine maturity transformation by financial intermediaries as a vulnerability with non-deposit claims that are pay-on-demand but that carry credit risk, based on Bao, David, and Han (2015). The greater the prevalence of these "runnables", the greater the exposure of the economy to a self-fulfilling withdrawal by investors which in turn precipitates a series of fire sales and deleveraging by financial intermediaries. In principle, the importance of this channel has been recognized since Diamond and Dybvig (1983). More recently, wholesale liabilities of the banking sector have been found to be an indicator of banking crises in cross-sectional studies (Anundsen, et al, 2014), and short-term liabilities in the repo market and asset-backed commercial paper market were subject to runs in the U.S. financial crisis (Gorton and Metrick, 2012, and Covitz, Liang, and Suarez, 2013).

Our systematic examination of these vulnerabilities indicate that shocks to private-sector

[2] Borio and Lowe (2002) evaluate the roles of rapid credit growth and rising asset prices as amplifiers, and find in cross-section analysis that the private nonfinancial credit-to-GDP gap is a high-quality early-warning indicator, and also is useful when combined with property prices.

debt and financial firm maturity mismatch are vulnerabilities, while shocks to risk appetite are expansionary. Specifically, a primary finding is that shocks to the credit-to-GDP gap lead to decreased output, indicating that the credit gap is a vulnerability. Moreover, the dynamics are nonlinear and depend on the level of the gap: When the gap is high, a positive credit shock results in a significant decline in real output and an increase in the unemployment rate several quarters later. By contrast, in the early phase of the financial cycle when the credit gap is low, credit shocks have no such adverse effects. Evaluating the responses to monetary policy shocks also suggests nonlinear dynamics that depend on the level of the credit gap. When the gap is low, we find that the economy and vulnerabilities respond to monetary policy shocks as expected, with an increase in unemployment and a contraction in GDP and a decline in credit, but the economy and credit are unresponsive to monetary policy shocks when the credit gap is high. These results suggest that monetary policy may not be effective at stopping a credit boom or cleaning up a bust once the economy is in a high credit-gap state.

Turning to investor risk appetite, we find that shocks to our measure, ALLM, are followed by economic expansions in the near term. Thus, it does not meet our definition of a vulnerability. This result is not surprising: when financial conditions become more accommodative, economic performance improves. However, this positive effect is smaller when ALLM is already high.

An obvious channel by which risk appetite could affect economic performance is via credit growth. Indeed, we find that a shock to ALLM does stimulate an increase in the credit-to-GDP gap. (Also see Danielson, Valenzuela, and Zer, 2015 for evidence that low volatility leads to greater risk-taking, as measured by credit-to-GDP gap). Moreover, the effect of a shock to ALLM on the credit gap tends to be larger in periods when the credit-to-GDP gap is already high. There is some suggestion that, left long enough, this dynamic could push the credit-to-GDP gap sufficiently high to produce an economic contraction.

Taken together, the results for shocks to credit and ALLM suggest the following story: exogenous increases in credit lead to a misallocation of resources or leave agents more exposed to inevitable negative shocks. Moreover, during episodes of high credit-to-GDP, agents' willingness to borrow and lend is less sensitive to the cost of funds. What might spark such a rise in credit relative to income? An increase in ALLM is one clear possibility suggested by our results.

We turn now to our other imbalance: financial sector maturity transformation. We find that, as with the credit gap, shocks to the runnable liabilities-to-GDP gap result in economic contractions when the gap is high but not when it is low; thus, runnables meet our definition of a vulnerability. In addition, when the runnable gap is high, monetary policy shocks have no effect on runnables or economic activity. When runnables are low a monetary policy shock does affect runnables as well as economic performance (albeit with large error bands). The reasons for this asymmetry warrant further study.

We conduct a number of robustness tests, particularly in cases where the variable we use may only imperfectly measure the underlying macrofinancial imbalance. For example, as discussed earlier, we use a number of different proxies for the level of asset valuations or investor risk appetite. The credit-to-GDP gap as commonly used in the literature is an imperfect measure of the degree to which the nonfinancial sector is excessively indebted, so we consider alternatives including a specification with just the (log) level of credit and

replacing actual GDP with potential GDP.

Our results bear on a number of strands of the literature. We show that a number of macrofinancial aggregate measures, including those specific to the financial sector, have implications for real activity and employment in the U.S., adding to the literature on macro-financial linkages. These results also provide empirical support for macroeconomic models with occasionally binding financial constraints. In addition, our findings suggest that the results from cross-sectional analysis are relevant to the US. In that vein, this empirical approach could be adopted for other countries.

Second, our finding that macroeconomic responses are nonlinear and depend on whether the credit gap is above or below normal adds to this growing line of research. Haubrich and Tetlow (2014) use a regime switching model to evaluate the relative effectiveness of monetary policy by whether the economy is in a financial crisis state. Meitu, Hilberg, and Grill (2014), find a strong asymmetry in the macroeconomic responses to a risk premium shock depending on whether credit conditions are normal or tight.

Relatedly, our finding that monetary policy is less effective when the credit gap is high is relevant for evaluating the relative effectiveness of macroprudential and monetary policies. Ajello, Laubach, López-Salido, and Nakata (2015) look at whether monetary policy should respond to the risk of a financial crisis which depends on credit conditions (lagged bank loan growth), based on a simple calibrated model of the U.S. economy. They find that optimal interest rate policy does respond to crisis risk, but only by a very small amount. This result echoes Svensson (2015), who argues that the costs of directing interest rate at financial stability risks (in terms of reduced output today) are likely to significantly exceed the benefits (reduced probability of a future crisis).

The remainder of our paper is organized as follows: in section 2 we describe and characterize our proxies for vulnerability; in section 3 we evaluate whether credit and risk appetite, separately and jointly, satisfy our definitions of a macrofinancial vulnerability. In section 4 we evaluate whether the measure tied to the maturity transformation of financial institutions, runnables, satisfy our definition. Section 5 concludes.

2 Data

In this section we describe the measures of macrofinancial imbalances that we test, as well as characterizing their evolution since 1975. In certain cases important structural changes in the financial environment – including changes to the bankruptcy code – will motivate the use of certain subperiods of our sample. Our outcomes of interest are subpar economic performance – contractions in GDP and increases in the unemployment rate – rather than full-blown financial crises. This is because there are relatively few financial crises in the U.S. data since 1975. Of the four U.S. recessions in that period, only the 2007 to 2009 episode has been defined to be a financial crisis (in the Reinhart and Rogoff (2009) framework). The wave of bank failures that began in 1984 and culminated in 1988-1992 with the failure of almost 1,600 depository institutions associations has also been labelled a crisis (Leaven and Valencia (2008)), suggesting that perhaps the 1990 recession could also be associated with a crisis. Jorda, Schularik and Taylor (2013) find that roughly 30 percent of recessions in their sample of 14 advanced economies from 1870 to 2008 involve financial crises.

2.1 The credit-to-GDP gap

We follow the literature in defining the credit-to-GDP gap as the difference between the ratio of nonfinancial private sector debt to GDP and an estimate of its trend, which is designed to be slow-moving. In addition to testing this broad measure, we also test decompositions of the credit-to-GDP gap: a sectoral decomposition of credit provided to households and businesses; and a bank vs. nonbank decomposition, based on where the credit exposures are being held.[3]

As shown in figure 1, the credit-to-GDP ratio since 1975 shows two distinct build-ups: the first starts in the early 1980s and ends in the recession of 1990-91; the second starts in the late 1990s and accelerates for a sustained period until the Great Recession. Even after falling significantly from its peak in 2009, the level remains elevated relative to previous decades. These measures are based on final estimates of credit-to-GDP; real-time estimates provided an earlier warning and showed the sustained increase starting earlier, during the mid-1990s (see Edge and Meisenzahl (2011) for a discussion of real-time vs final estimates of the credit-to-GDP gap.) Relative even to its upward trend (estimated with a HP filter with a smoothing parameter of 400,000), the gap peaked at about 13 around the height of the financial crisis, and dropped to a 40-year low in 2014 at around -10.

The figure highlights a well-known property of the credit-to-GDP gap: that it tends be high – thus signaling elevated vulnerabilities – for a significant period after the financial cycle turns, which may have implications for the strength of a recovery. The gap also tends to continue to increase during the recession before turning down, which may reflect borrowers drawing upon pre-committed lines of credit that they have with banks in such situations, which delays the recognition of tight financing conditions in credit measures, or that GDP, the denominator of the ratio, may fall more quickly than credit in the early stages of a downturn because of long-lived debt contracts, such as mortgages. (This suggests the credit-to-GDP gap measure may be too lagging an indicator to be useful in highlighting the need to release countercyclical macroprudential tools.) In our empirical analysis we consider some alternative measures including the level of credit and the credit gap estimated using *potential* GDP. This latter measure in particular removes the mechanical increase in the gap caused by a more rapid fall in GDP.

Another concern with using measures based on credit-to-GDP is the upward trend in the ratio. As an empirical matter, this is dealt with by focusing on the gap with respect to an estimate of the trend designed to be slow moving. As a theoretical matter, the trend is often ascribed to financial deepening, as credit markets have evolved to make loans more accessible to previously unserved households and businesses.

Decomposing the credit-to-GDP ratio into its components shows that the upward trend in the U.S. is largely due to an increase in household credit. As shown in the middle panel of figure 1, household credit has nearly doubled since 1975, while the increase in business credit has been more modest. Household credit rose both because of the extensive margin

[3] We also considered a third decomposition into debt secured by commercial or residential real estate ("property" debt) vs debt not secured by real estate ("nonproperty" debt). Anundsen, Hansen, Gerdrup, and Kragh-Srensen (2014) find that both household and business credit are important crisis predictors in a sample of 16 countries from 1970 to 2013. The results were not markedly different than those for the household vs. business decomposition so we do not discuss them here.

– more households became homeowners – and the intensive margin – existing homeowners took on more debt. These increases are due to a combination of public policies, including the tax advantage of mortgage debt. Notably, the share of mortgage credit funded by the housing government-sponsored enterprises, Fannie Mae and Freddie grew from 12 percent in 1975 to roughly 60 percent in 2014 [Flow of Funds, Table L.218]. The GSEs faced lower capital charges for funding residential mortgages than did banks, and benefited as well from an implicit backstop by the U.S. government.[4] On the extensive margin, the homeownership rate also rose: from 64.0 in 1990:Q1 to a peak of 69.2 in 2004:Q4 (since then it has fallen steadily, returning to its 1990 level).

Household and business credit-to-GDP gaps (middle panel of figure 1) clearly illustrate the lower frequency of cycles in the household credit gap relative to the business credit gap, as well as the differences in amplitude of changes. Differences in the household and business credit gaps may be important for setting macroprudential policies if one of the sectors proves to be a more prominent vulnerability than the other, and we evaluate this proposition in estimations below.

The bottom panels of figure 1 decompose the credit-to-GDP ratio into credit provided by banks and nonbanks. The bank credit-to-GDP ratio appears to be stationary, and has gone through three cycles, roughly in sync with household credit, with peaks in the late 1970s, late 1980s, and then in 2009. Our measure of nonbank credit includes many different types of providers, including: shadow banks, which offer credit which is funded by short-term debt without insurance or a public backstop; the GSEs; pension funds and life insurers, which tend to have long-dated liabilities; and mutual funds, which issue shares that are loss-absorbing (see Bassett et al (2015) for more detail).

There is a secular upward trend in the share of overall credit held by nonbanks, due importantly to the growth of shadow banks and the GSEs, though it too fell sharply in 2008, when shadow banking collapsed. Rajan (2005) argues that developments in financial markets – deregulation, technological and financial innovations, and globalization–have lowered financial frictions and improved efficiency, but may also lead to new and higher risks. For example, credit that is increasingly funded via financial markets rather than bank deposits makes credit more sensitive to market disturbances. See Bassett, Daigle, Edge, and Kara (2015)

2.2 Measures of risk appetite

Our second candidate measure is an index related to investors' willingness to accept risk that we constructed (denoted ALLM). To link the existing literature we compare our measure to the excess bond premium measure (EBP) of Gilchrist and Zakrajšek (2012). Both measures (he top panel of figure 2) are more volatile than the credit-to-GDP ratio and show more cycles.

We construct our measure, ALLM, in the spirit of the methodology described in Aikman, Kiley, Lee, Palumbo, and Warusawitharana (2015). The measure includes indicators of

[4]For a discussion of the capital advantages enjoyed by the GSEs, see Hancock, Lehnert, Passmore, and Sherlund (2006). A large pre-crisis literature debated the extent to which the GSEs lowered borrowing costs for homeowners. This debate centered in large part on the role of the GSEs' *retained portfolios*; that is, the GSEs' practice of buying the very securities they issued. See Passmore (2005).

asset price valuations and lending standards in four areas: equity markets; business credit; commercial real estate; and household and residential mortgage credit. The overall measure is then a weighted average of the standardized index for each of the four sectors.[5] The bottom panel of figure 2 shows the four components.

The ALLM index of risk appetite is distinctly below the (inverse of the) EBP when equity markets fell in the late 1970s, and when commercial real estate conditions in the early 1990s and household credit conditions in the mid 1990s were tight. Moreover, while the business credit component of the ALLM measure is quite similar to the inverse of the EBP, it recovers somewhat more slowly after the 1990 and 2008-09 recessions since it also includes credit conditions for small businesses, whereas the EBP is based on only publicly-traded corporations.

2.3 The prevalence of runnable liabilities

A third financial imbalance we consider is short-term funding. The measure we employ is based on wholesale short-term funding instruments which are "runnable," that is, pay-on-demand instruments issued by private agents with an embedded promise but are defaultable; see Bao, David, and Han (2015). Runnables are often part of longer intermediation chains, and the measure captures gross short-term funding rather than net because investors can run at any point in the chain. We include five components which have data back to 1975: repurchase agreements (repo), securities lending, retail and institutional money market mutual funds (MMMFs), and commercial paper . These components all proved vulnerable to investor runs in the financial crisis, and were a major amplification mechanism for the losses on subprime mortgages (Gorton and Metrick, 2012; Covitz, Liang, and Suarez, 2013; McCabe, 2010)).[6]

The ratio of runnables to GDP and the gap relative to trend are shown in the top two panels of figure 3. This ratio reflects structural as well as cyclical changes in money markets that have taken place since the mid-1970s. Runnables-to-GDP rose rapidly in the early years of our sample period and has fallen by nearly one-half since its peak in 2008. Growth of runnables accelerated in the late 1970s when interest rates and volatility began rising sharply in 1978, and the FOMC reformed its policy framework in October 1979, after it became evident that their previous policy of gradualism was not working to fight inflation

[5]The index is constructed as the weighted sum of the CDFs of the following time series: stock market volatility (actual before 1989 and the VIX after), the S&P 500 price-earnings ratio; the BBB-rated corporate bond spread to Treasury; the share of nonfinancial corporate bond issuance that is speculative-grade; the index of credit availability from the NFIB survey of small businesses; a commercial real estate price index deflated into real terms, commercial real estate debt growth, household residential house price-to-rent ratio, and lending standards for consumer installment loans from SLOOS,

[6]We exclude uninsured deposits at banks for two reasons: it is possible that depositors still view uninsured deposits to have some implicit backstop from the government, as suggested by implicit subsidies measured on debt issued by banks; and reporting forms for banks prior to 1980 did not distinguish between insured and uninsured, and the limit for insured deposits was raised to $250,000 during the financial crisis (which subsequently expired), but the reporting forms were not adjusted quickly enough to capture the change. We also exclude commercial paper issued by nonfinancial corporations because we are interested in short-term liabilities of financial firms. If money market mutual funds purchase CP issued by nonfinancial firms it would be included in our measure of runnables.

and reverse inflation expectations. Higher short-term rates and volatility, combined with Regulation Q – which set ceilings on rates that commercial banks and thrifts could offer on deposits – spurred the growth in nondeposit assets such as money market funds and hence the runnables measure.

The large rise in runnables in the late 1970s was concentrated in repo, and then in MMMFs in the early 1980s. First there was greater use of repo as corporations saw the opportunity cost rise of holding idle cash when market rates were rising. Banks benefited as well since repo rates were not subject to Reg Q and they were not required to hold reserves if the repo was collateralized by Treasuries. There also was a notable rise in the growth of marketable Treasury debt after 1974 that increased the amount of available collateral.

In addition, as investors were turning to MMMFs to earn higher rates, these accounts grew rapidly until the Garn St. Germain Act of 1982 directed the Depository Institutions Deregulation Committee (DIDC) to authorize accounts at banks and thrifts that could be competitive. In particular, DIDC authorized money market deposit accounts (MMDAs), available as of December 14, 1982, and Super NOW accounts, available as of January 5, 1983, but MMMF assets had already grown from $4 billion in 1977 to $235 billion at year-end 1982. (Regulation Q was phased out entirely by 1986.) Growth in runnables moderated for a couple of years, until repo rose again in 1984, after Congress enacted the Bankruptcy Amendments Act of 1984, which amended Title 11 of the U.S. Code covering bankruptcy. The legislation exempts repo in Treasury and agency securities, and other securities, from the automatic stay provision of the Bankruptcy Code. In practice, it enabled lenders to liquidate the underlying securities and resolved a major question about the status of repo collateral in bankruptcy proceedings.

Since these important structural changes in runnable liabilities occurred, they continued to grow until peaking at nearly 80 percent of GDP in 2008. The falloff of the runnable gap from its peak started about a year earlier than for the credit-to-GDP gap, and is even larger in magnitude.

Given the important structural changes in the demand and supply of runnable liabilities that took place in the mid-1980s, we conduct our analysis using both the full sample (1975–2014) and with the sample under the current legal regime (1985–2014).

2.4 Sample statistics

Table 1 gives sample statistics for our imbalance measures. In each case, the measures are divided into periods above their means ("high vulnerability") and below their means ("low vulnerability"). In certain instances, for comparison, we include the (negative) excess bond premium.

Both the credit-to-GDP and the runnables-to-GDP gaps show a similar pattern: in periods of low imbalance the unemployment rate, real GDP growth and the inflation rate are higher than in periods of high imbalance. However, in low periods the unemployment rate is falling and the fed funds rate is increasing. This is consistent with the idea that periods of high imbalances occur around business cycle peaks,

The contrast with ALLM , however, is striking. Periods of low ALLM are associated with worse overall economic performance: the unemployment rate is higher and rising; and real

Table 1: Sample statistics by imbalance

		Unemployment rate				Fed funds	
	Num. of obs.	Level	Δ^a	Real GDP^b	Inflation^b	Level	Δ^a
Credit-to-GDP gap (CY)							
Low	89	6.73	−8.40	3.23	3.77	6.38	3.58
High	68	6.28	11.04	2.10	2.61	4.42	−18.28
Runnables-to-GDP gap (RUN)							
Low	68	7.00	−8.09	3.20	3.64	4.56	13.22
High	89	6.18	6.21	2.39	2.99	6.28	−20.48
Risk appetite index (ALLM)							
Low	78	7.12	12.19	1.68	3.10	4.95	−21.67
High	79	5.96	−12.00	3.79	3.44	6.10	9.70

[a] Change in basis points.
[b] 400× quarterly change in log level.

GDP growth is significantly lower. Monetary policy appears to be easing in these periods, with the effective funds rate falling, on average, in such quarters.

These results raise the obvious question of how correlated our measures are. Table 2 gives the simultaneous pairwise correlations among these measures. The credit-to-GDP and runnables gap are fairly well correlated ($\rho = 0.63$). Our risk appetite index is essentially uncorrelated with the credit-to-GDP gap and only weakly correlated with the runnables gap ($\rho = 0.24$). Note that ALLM and the (negative) EBP are fairly well correlated ($\rho = 0.34$).

Given our focus on the interaction of the effectiveness of monetary policy with our imbalance measures, we report the number of quarters in which the effective funds rate rose (fell) by 25 basis points or more conditional on whether the vulnerability measure is high or low. One concern would be if the sample contained too few easing or tightening episodes for a particular value of a measure. The results are shown in table 3. Overall, in our sample, the effective funds rate fell 25 basis points or more in 41 quarters; changed less than 25 basis points in absolute value in 70 quarters; and rose 25 basis points or more in 46 quarters. As suggested by the results in table 3, the lowest sample sizes are for quarters in which credit and runnables are low (high) and monetary policy eases (tightens). While in these cases the number of observations is lower, the change in the funds rate was often larger. Thus, we conclude that there is sufficient variation in the federal funds rate across subsamples to reasonably estimate responses to monetary policy shocks in each subsample.

Table 2: Correlations of candidate vulnerability measures

	CY	*RUN*	*ALLM*	$-1\times$*EBP*
CY	1.0000			
RUN	0.6293	1.0000		
ALLM	0.0960	0.2398	1.0000	
$-1\times$*EBP*	−0.3406	−0.3780	0.3410	1.0000

Table 3: Effective federal funds rate conditional on candidate vulnerability measures

	Quarters in which funds rate								
	Eased			*Unchanged*			*Tightened*		
	N	*Level*	Δ	*N*	*Level*	Δ	*N*	*Level*	Δ
Credit-to-GDP gap (CY)									
Low	17	7.32	-140	41	4.10	0	31	8.89	88
High	24	5.05	-82	29	3.42	-2	15	5.36	52
Runnables-to-GDP gap (RUN)									
Low	11	5.20	-102	36	2.59	-2	21	7.59	99
High	30	6.28	-107	34	5.11	0	25	7.86	57
Risk appetite index (ALLM)									
Low	25	5.60	-126	40	2.77	-4	13	10.44	124
High	16	6.60	-75	30	5.22	2	33	6.68	57

NOTE. Columns labeled "Eased" ("Tightened") refer to quarters in which the effective federal funds rate increased (decreased) 25 basis points or more; quarters in which the effective federal funds rate changed less than 25 basis points in absolute value are label-led "Unchanged".

3 Results for Credit and ALLM

3.1 Specification

Our goal is to characterize the effect of shocks to macrofinancial imbalances on economic performance, whether these effects differ depending on whether the imbalance is high or low, and the extent to which the effects of monetary policy shocks differ depending on whether the imbalance is high or low.

We characterize these effects using threshold vector autoregressions estimated on quarterly U.S. macro data starting in 1975:Q1. We estimate the TVARs using Bayesian techniques, following the estimation strategy proposed by Giannone, Lenza, and Primiceri (2015) that is based on the so-called Minnesota prior, first introduced in Litterman (1979, 1980). This prior is centered on the assumption that each variable follows a random walk, possibly with a drift (for variables such real GDP that are not stationary); this reduces estimation uncertainty and leads to more stable inference and more accurate out-of-sample forecasts.

Our baseline specifications contain the following variables:

- 100 $\times$ logarithm of real Gross Domestic Product.
- 100 $\times$ logarithm of the Gross Domestic Product deflator.
- 100 $\times$ Unemployment rate.
- Measure of financial imbalance defined so that higher values indicate increased vulnerability
- 100 $\times$ Federal funds rate (effective), per annum.

In computing impulse response functions, we identify shocks using a Cholesky decomposition. When identifying shocks to vulnerability measures, the shocks are ordered so that monetary policy reacts to all shocks in a period: the vulnerability measure reacts to all shocks within a quarter save monetary policy; and the unemployment rate, the GDP deflator, and real GDP react to shocks to the vulnerability measure and monetary policy with a one-quarter lag. This ordering is a reasonable strategy to identify shocks to slow-moving aggregates such as credit and runnables. Monetary policy is assumed to be able to react to risk appetite shocks in the same quarter. When identifying monetary policy shocks, we reverse the order and permit ALLM to react in the same quarter as a monetary policy shock. This is reasonable because ALLM contains financial market prices, so there may be significant within-quarter reactions to monetary policy shocks.

The VARs are estimated over disjoint subsamples with the thresholds determined by the vulnerability measure. We compute responses when the vulnerability measure is high (above its mean) and when the vulnerability measure is low (below its mean). This permits us to test for nonlinear dynamics: whether a shock to vulnerability (for example) has a different effect in times of high vs. low vulnerability. Thus, our baseline specification is a threshold VAR based on the level of the candidate vulnerability measure X_t, which has a sample mean

of μ_X, is:

$$\begin{aligned} y_t = &\left(c^{\text{high}} + A(L)^{\text{high}} y_t + \varepsilon_t\right) 1\left(X_t > \mu_X\right) \\ &+ \left(c^{\text{low}} + A(L)^{\text{low}} y_t + \varepsilon_t\right) 1\left(X_t < \mu_X\right). \end{aligned} \tag{1}$$

Here y_t is the vector of endogenous variables described above and $1(\cdot)$ is the indicator function, which is zero unless its argument is true.

Our empirical characterization of the relationship of measures of imbalance explores three elements. First, whether a positive shock to the measure results in subpar economic performance. Imbalances with this property we label as "vulnerabilities." Second, whether the effect of the vulnerability shock is nonlinear: that is, its ability to forecast subpar economic growth varies significantly in periods when it is high vs. low. Third, whether the effect of the monetary policy shock is also nonlinear: that is, whether the reaction to monetary policy shocks differs between high and low vulnerability states. One would be particularly interested whether the effect of the monetary policy shock is less in high vulnerability states.

3.2 Credit-to-GDP Gap As Vulnerability

We begin by evaluating the gap between the credit-to-GDP ratio and its trend, estimated using a Hodrick-Prescott filter (with $\lambda = 400,000$).

Real GDP appears in our baseline specification both directly and as a component of the credit-to-GDP gap. When we compute the impulse responses to shocks to the credit-to-GDP gap we do not mechanically adjust real GDP or the gap to reflect this accounting relationship. Thus, shocks to the gap can be interpreted as shocks to credit.

Baseline Results

Figures 4 and 5 show impulse response functions (IRFs) with respect to shocks to the credit-to-GDP gap and to monetary policy, respectively. The blue (red) lines show the impulse response functions from the system estimated in low (high) credit-to-GDP gap periods.

The credit-to-GDP gap satisfies our definition of a vulnerability. As shown by the red lines in figure 4, in periods of high credit-to-GDP gap an upward shock to credit presages subpar economic performance in the form of an eventual rise in the unemployment rate and decline in real GDP. These responses are statistically significant. The deterioration in economic conditions takes several quarters to materialize. As shown by the blue lines, this effect is not present when coefficients are estimated only in periods of low credit-to-GDP gap. There, an upward shock to the credit gap results in a boost to GDP and inflation (changes to the unemployment rate are not statistically different from zero). These quite different dynamics suggest a nonlinear response to credit shocks, with substantially larger effects when the credit-to-GDP ratio is above its long-run trend.

As shown by the blue lines in figure 5, in low credit gap periods, shocks to monetary policy have the expected effect on macroeconomic variables: an increase in the policy rate results in a contraction in real GDP, prices and an increase in the unemployment rate. The credit-to-GDP gap does not increase, suggesting that credit has contracted with GDP. In high gap periods (red lines), by contrast, monetary policy shocks have no effects on the

evolution of the system. This suggests that the system's dynamics in high gap periods are quite different than in low gap periods.

Robustness Tests

The use of the credit-to-GDP gap as a candidate indicator of vulnerability raises certain obvious questions. First, although we argue that shocks to this measure can be interpreted as credit shocks, it is instructive to test whether the *level* of credit (rather than a ratio to GDP) also results in the same general findings. Second, because actual GDP falls in bad times, one might be concerned that the causation runs from recessions to higher credit-to-GDP ratios. Third, if monetary policy is reacting to the credit-to-GDP gap, this may be the channel by which shocks to the gap translate to economic contractions.

Figure 6 shows the results of an alternative specification in which the credit-to-GDP gap is replaced with the log level of credit outstanding. In order to limit the number of changes in specification, as before, high/low vulnerability periods are defined relative to the credit-to-GDP gap. As shown, an upward shock to the *level* of credit during either high or low vulnerability periods results in real GDP growth. However, the same shock in a high vulnerability period results in lower economic performance than the in a low vulnerability period. Moreover, the boom in GDP experienced in a high vulnerability state is shorter-lived than that experienced in a low vulnerability state. From this we conclude that the economy responds differently to shocks to credit in high and low credit-to-GDP gap states, with economic performance relatively worse in a high gap state.

A shock to monetary policy when the system includes the log level of credit rather than the credit-to-GDP gap reinforces the previous finding that monetary policy is more effective in low-vulnerability states than in high. Figure 7 shows that in low vulnerability states, when credit is low relative to GDP, monetary policy shocks induce a contraction in economic activity with real GDP and prices falling and the unemployment rate increasing.

To remove the mechanical effect of recessions in increasing the credit-to-GDP ratio, figure 8 shows the results in a specification in which the credit-to-GDP gap is estimated using *potential* GDP. Comparing figures 4 and 8 shows very small differences. (It's worth noting here that potential GDP is a real concept; there might also be an affect on nominal GDP via the price level.)

Finally, monetary policy responds to credit shocks, either directly or indirectly through their effects on output and inflation, and is potentially confounding. In figure 9 we show results with changes in the effective fed funds rate set to zero, i.e. with monetary policy shut down. In these IRFs, there is a clear difference in economic performance following a shock to the credit-to-GDP gap depending on whether the gap is high or low.

Is All Credit Created Equal?

Our credit-to-GDP gap vulnerability measure is based on total nonfinancial debt. Thus, it lumps together forms of debt, such debt owed by households or secured by property, and credit, such as credit provided by nonbanks. For a variety of reasons, one might suspect that different forms of debt may pose more or less danger to the financial system.

In order to test whether, in fact, all credit is created equal, we revised our baseline

Table 4: Results disaggregating the credit-to-GDP gap

	Real GDP response when vulnerability is:	
Shock to	Low	High
Household vs. nonfinancial business debt		
Household debt	Expansion	Expansion
Business debt	Expansion[a]	Contraction
Property vs. nonproperty debt		
Property debt	Expansion	Expansion
Nonproperty debt	Contraction	Contraction
Bank vs. nonbank credit		
Bank credit	Expansion	Contraction[a]
Nonbank credit	Expansion	Contraction[a]

a Indicates response is not statistically different from zero.

specification in the following way: we divided total credit, D_t into two components, D_t^a and D_t^b where $D_t^a + D_=^b D_t$. We then form separate credit-to-GDP ratios using each component, $d_t^j = D^j/\text{Nominal GDP}_t,\ j = a, b$, and compute trend and cycle components of d_t^j using the Hodrick-Prescott filter with $\lambda = 400,000$ as before. We then estimate the baseline system using two candidate vulnerability measures, the gaps x_t^a and x_t^b. In order to keep the number of specifications limited, we continue to define periods of high/low vulnerability using the aggregate credit-to-GDP gap X_t. We then test whether a shock to a particular form of credit leads to subpar economic performance in periods of high vulnerability.

We consider disaggregations of total credit by the type of borrower and the type of lender: first, into debt owed by households vs. debt owed by (nonfinancial) businesses and second into credit provided by banks vs. nonbanks.

These divisions were suggested in part by the boom-bust cycle that ended in 2009. The boom was associated with borrowing by households and provided by the nonbank sector.

As an example of our results, figures 10 and 11 show IRFs to shocks to the household and business credit-to-GDP gaps. (Again, high/low vulnerability periods are defined as before, using the aggregate credit-to-GDP gap.) As shown, during periods when total credit is already high relative to GDP, a shock to business credit presages subpar economic performance. The lack of a similar result for household credit is something of a surprise given the role of household credit in the recent financial crisis. (When we define periods of high credit gaps using just the gap of household debt to its own trend–not shown–there is more of a macro response.)

Table 4 summarizes the results of our decompositions. In summary, in periods when the credit-to-GDP gap is high, upward shocks to business and nonproperty debt are followed by economic contractions. Both bank and nonbank credit have this property. These results suggest that in high vulnerability periods policymakers should focus on forms of credit that are not traditionally associated with housing bubbles.

3.3 Risk Appetite As Vulnerability

In this section we describe results using the index of risk appetite (ALLM) we described in Section 2. Here, we divide the sample into periods in which ALLM is above (below) its mean. Impulses to ALLM lead to similar macroeconomic outcomes in both environments (figure 12). In particular, in a low ALLM environment, an impulse to ALLM leads to a short-run expansion in output and decline in unemployment. In a high ALLM environment, the effects are similar, although the increase in GDP and decline in unemployment are more modest. In both high and low ALLM, the initial shock peters out over time, and monetary policy is unaffected.

Thus, ALLM does not satisfy our definition of a vulnerability. Rather, ALLM functions more as a financial conditions index, where an increase eases borrowing constraints and boosts economic activity. As intuition would suggest, the effect is greater when the index is low – when borrowing constraints are relatively tight.

3.4 Credit and risk appetite

Risk appetite and the credit-to-GDP gap may be capturing different concepts. In particular, risk appetite could set the stage for credit growth: indeed, the strongest correlation between RA and the credit gap is for risk appetite to lead the credit-to-GDP gap by 8 quarters. To determine whether a shock to ALLM can stimulate a reaction in the credit-to-GDP gap, we include both in a VAR. As described in section 3.1, we identify shocks to ALLM using a Cholesky decomposition in which monetary policy is permitted to react within the same quarter as the shock to ALLM.

Results in this augmented system are shown in figure 13. As before, we divide our sample into periods when the credit-to-GDP is above or below its mean. The response to a shock to risk appetite when the credit gap is low (blue lines) shows an increase in output, inflation, and a decline in unemployment; moreover, the credit-to-GDP gap increases modestly. In a high credit gap environment (red lines), the IRFs also show an increase in output and a decline in unemployment. Of particular interest, the credit-to-GDP gap rises significantly more in response to an RA shock in a high credit gap environment than in a low credit gap one. Previous results show that a shock to the credit gap when the credit gap is high would lead to contractions in real GDP and increases in unemployment. These results, while preliminary, suggest that a positive shock to risk appetite in a high credit gap environment leads to a further increase in the credit gap, perhaps sowing the seeds for a future crisis.

4 Imbalances Related to Financial Institutions

4.1 Runnable Liabilities As Vulnerability

As we discussed in Section 2, the prevalence of runnable liabilities in the economy has varied in response to legal and regulatory changes, moves in short-term interest rates, and the funding choices of businesses. These liabilities represent a structural vulnerability to the extent that they are backed by less liquid assets and issued by institutions without access to a lender of last resort.

Here, we present results that suggest that this measure is also a useful empirical measure of vulnerability.

Figure 14 shows the response of the system to a shock to the runnables-to-GDP gap estimated using our full data sample. Figure 15 shows the response using only the data following the bankruptcy reform in 1984. As before, we use the mean of this measure as the threshold to divide the sample. Both sets of figures show that, in states where this ratio is low, real GDP, inflation, the unemployment rate and monetary policy do not react significantly. The gap moves slowly and steadily back to zero. In states where this ratio is high, by contrast, an upward shock to the gap results in an economic contraction, declines in prices and an increase in the unemployment rate. Monetary policy does not react significantly. The gap itself remains high for a few quarters before falling precipitously to zero. Thus, the runnables-to-GDP gap satisfies the conditions we laid out for a useful measure of vulnerability. Importantly, this is true whether we estimate the response on the full sample or on the sample after the important legal changes that took place in 1984. The results estimated in the post-1984 sample have tighter standard error bars, likely reflecting the effect of the change in the legal environment. We consider our baseline specification with runnables to be that estimated using the more recent data only.

Figure 16 shows the response of a monetary policy shock with the runnables-to-GDP gap as a measure of vulnerability. The IRFs in the low vulnerability state (the blue lines) suggest, if anything a modest deterioration in unemployment as runnables rise in response, although the confidence bands are growing. (As in figure 15, the results are based on the system estimated using post-1984 data.) The IRFs in the high vulnerability state (the red lines) also suggest little effect on economic conditions, although the confidence bands are more narrow. The interaction of short rates, short-term funding, and vulnerability of the financial system warrants further study.

5 Conclusion

In this paper we systematically evaluated a set of financial imbalances to determine whether they represented measurable macroeconomic vulnerabilities and whether they affected the monetary policy transmission mechanism. The imbalances we considered were the the credit-to-GDP gap, risk appetite, and runnable liabilities.

We find that the credit-to-GDP gap is a useful vulnerability measure, with real GDP declining and unemployment rising following shocks to this measures. We decompose the credit-to-GDP gap into components related to the source of funding and the type of borrower. We find that shocks to business credit and credit supplied by nonbanks are also followed by economic declines. This suggests that it is important to monitor types of credit not associated with housing markets. The effects of credit shocks tend to be nonlinear, with greater responses during periods when credit is already high. In addition, we find that upward shocks to our measure of runnable liabilities also lead to economic contractions suggesting that it, too, serves as a useful measure of vulnerability. The same nonlinearity is present with this measure as well.

Shocks to our risk appetite measure are not followed by these kinds of economic contractions. Thus, consistent with findings in the literature, risk appetite functions as a measure of

financial conditions rather than financial imbalances, with upward shocks presaging increases in borrowing.

We also measured the level of maturity transformation present in the financial system using the ratio of runnable liabilities to GDP. Shocks to this imbalance result in economic contractions when the gap is high but not when it is low.

In periods when the credit-to-GDP gap or the runnables-to-GDP gap are high, the effect of monetary policy on economic conditions and these vulnerabilities is reduced. Because such periods tend to precede periods of economic contraction, this suggests a role for macroprudential tools in economic policy.

References

Adrian, T., and N. Boyarchenko (2015): "Intermediary Leverage Cycles and Financial Stability," Staff Report 567, Federal Reserve Bank of New York.

Adrian, T., and M. Brunnermeier (2014): "CoVaR," Staff Report 348, Federal Reserve Bank of New York.

Adrian, T., D. Covitz, and J. N. Liang (2013): "Financial Stability Monitoring," Finance and Economics Discussion Series 2013-21, Board of Governors of the Federal Reserve System.

Adrian, T., and N. Liang (2014): "Monetary policy, financial conditions, and financial stability," Staff Report 690, Federal Reserve Bank of New York.

Adrian, T., and H. S. Shin (2009): "Money, Liquidity and Monetary Policy," *American Economic Review Papers & Proceedings*, 99(2), 600–609.

——— (2010a): "Financial Intermediaries and Monetary Economics," in *Handbook of Monetary Economics*, ed. by B. Friedman, and M. Woodford, vol. 3, pp. 601–650. Elsevier.

——— (2010b): "Liquidity and Leverage," *Journal of Financial Intermediation*, 19(3), 418–37.

——— (2011): "Financial Intermediary Balance Sheet Management," *Annual Review of Financial Economics*, 3.

——— (2014): "Procyclical Leverage and Value-at-Risk," *Review of Financial Studies*, 27(2), 373–403.

Aikman, D., M. Kiley, S. J. Lee, M. G. Palumbo, and M. Warusawitharana (2015): "Mapping Heat in the U.S. Financial System," Finance and Economics Discussion Series 2015-59, Board of Governors of the Federal Reserve System.

Ajello, A., T. Laubach, D. López-Salido, and T. Nakata (2015): "Financial Stability and Optimal Interest-Rate Policy," Working Paper, Federal Reserve Board.

Anundsen, A. K., F. Hansen, K. Gerdrup, and K. Kragh-Srensen (2014): "Bubbles and crises: The role of house prices and credit," Working Paper 14/2014, Norges Bank.

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

Bao, J., J. David, and S. Han (2015): "The Runnables," FEDS Notes, Federal Reserve Board.

Bassett, W., A. Daigle, R. Edge, and G. Kara (2015): "Credit-to-GDP Trends and Gaps by Lender- and Credit-type," FEDS Notes, Federal Reserve Board.

Borio, C., and M. Drehmann (2009): "Assessing the risk of banking crises - revisited," Working paper, BIS.

Borio, C., and P. Lowe (2002): "Assessing the risk of banking crises," *BIS Quarterly Review*, 2002, 43–54.

——— (2004): "Securing sustainable price stability: should credit come back from the wilderness?," Working Paper 157, BIS.

Brunnermeier, M., and Y. Sannikov (2014): "A macroeconomic model with a financial sector," *American Economic Review*, 104(2), 379–421.

Cecchetti, S. G. (2008): "Measuring the macroeconomic risks posed by asset price booms," in *Asset Prices and Monetary Policy*, ed. by J. Y. Campbell, pp. 9–43. NBER Books.

Christiano, L. J., M. Eichenbaum, and C. Evans (1996): "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," *The Review of Economics and Statistics*, 78(1), 16–34.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (1999): "Monetary policy shocks: What have we learned and to what end?," in *Handbook of Macroeconomics*, ed. by J. B. Taylor, and M. Woodford, pp. 65–148. Elsevier.

Committee on the Global Financial System (2010): "The role of margin requirements and haircuts in procyclicality," Papers 36, CGFS.

Dell'Ariccia, G., L. Laeven, and G. Suarez (2013): "Bank Leverage and Monetary Policy's Risk taking Channel: Evidence from the United States," Working Paper 13-143, International Monetary Fund.

Dokko, J., B. Doyle, M. Kiley, J. Kim, S. Sherlund, J. Sim, and S. Van den Heuvel (2009): "Monetary policy and the Housing Bubble," Finance and Economics Discussion Series 2009-49, Board of Governors of the Federal Reserve System.

Drehmann, M., and M. Juselius (2015): "Leverage dynamics and the real burden of debt," Working Paper 501, BIS.

Edge, R. M., and R. R. Meisenzahl (2011): "The unreliability of credit-to-GDP ratio gaps in real time: implications for countercyclical capital buffers," *International Journal of Central Banking*, 7(4), 261–298.

Elliott, D. J., G. Feldberg, and A. Lehnert (2013): "The History of Cyclical Macroprudential Policy in the United States," Finance and Economics Discussion Series 2013-29, Board of Governors of the Federal Reserve System.

Gertler, M., and N. Kiyotaki (2015): "Banking, Liquidity, and Bank Runs in an Infinite Horizon Economy," *American Economic Review*, 105(7), 2011–2043.

Giannone, D., M. Lenza, and G. E. Primiceri (2015): "Prior Selection for Vector Autoregressions," *The Review of Economics and Statistics*, 2(97), 436–451.

Gilchrist, S., and E. Zakrajšek (2012): "Credit Spreads and Business Cycle Fluctuations," *American Economic Review*, 102(4), 1692–1720.

Hancock, D., A. Lehnert, W. Passmore, and S. M. Sherlund (2006): "The Competitive Effects of Risk-Based Bank Capital Regulation: An Example from U.S. Mortgage Markets," Finance and Economics Discussion Series 2006-46, Board of Governors of the Federal Reserve System.

Iacoviello, M. (2005): "House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle," *American Economic Review*, 95(3), 739–764.

——— (2014): "Missing," *Missing*, p. Missing.

Jimnez, G., S. Ongena, J.-L. Peydr, and J. Saurina (2012): "Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications," *American Economic Review*, 102(5), 2301–26.

Jorda, O., M. Schularick, and A. M. Taylor (2013): "When Credit Bites Back," *Journal of Money, Credit and Banking*, 45(2), 3–28.

Kiley, M., and J. Sim (2015): "Missing," *Missing*, p. Missing.

Kuttner, K., and I. Shim (2012): "Taming the Real Estate Beast: The Effects of Monetary and Macroprudential Policies on House Prices and Credit," in *Property Markets and Financial Stability*, ed. by A. Heath, F. Packer, and C. Windsor, pp. 231–59. Reserve Bank of Australia.

Litterman, R. B. (1979): "Techniques of forecasting using vector autoregressions," Working Papers 115, Federal Reserve Bank of Minneapolis.

——— (1980): "A Bayesian Procedure for Forecasting with Vector Autoregression," Working papers, Massachusetts Institute of Technology.

Lopez-Salido, D., J. C. Stein, and E. Zakrajsek (2015): "Credit-Market Sentiment and the Business Cycle," Finance and Economics Discussion Series 2015-028, Board of Governors of the Federal Reserve System.

Macroeconomic Assessment Group (2010): "Assessing the macroeconomic impact of the transition to stronger capital and liquidity requirements," Discussion paper, Financial Stability Board and the Basel Committee on Banking Supervision.

Paligorova, T., and J. A. C. Santos (2012): "When Is It Less Costly for Risky Firms to Borrow? Evidence from the Bank Risk-Taking Channel of Monetary Policy," Working Paper 12-10, Bank of Canada.

Passmore, W. (2005): "The GSE Implicit Subsidy and the Value of Government Ambiguity," Finance and Economics Discussion Series 2005-5, Federal Reserve Board.

Rajan, R. G. (2005): "Has Financial Development Made the World Riskier?," *Proceedings of the Federal Reserve Bank of Kansas City Economics Symposium*, 2005, 313–69.

Reinhart, C. M., and K. S. Rogoff (2009): "The Aftermath of Financial Crises," *American Economic Review*, 99(2), 466–72.

Repullo, R., and J. Suarez (2013): "The Procyclical Effects of Bank Capital Regulation," *Review of Financial Studies*, 26(2), 452–90.

Rubio, M., and J. A. Carrasco-Gallego (2015): "Macroprudential and Monetary Policy Rules: A Welfare Analysis," *The Manchester School*, 83, 127–152.

Schularick, M., and A. M. Taylor (2012): "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008," *American Economic Review*, 102(2), 1029–61.

Stein, J. C. (2012): "Monetary Policy as Financial Stability Regulation," *Quarterly Journal of Economics*, 127(1), 57–95.

——— (2013): "Overheating in credit markets: origins, measurement and policy responses," Speech given at the "Restoring household financial stability after the great recession: Why household balance sheets matter" research symposium sponsored by the Federal Reserve Bank of St. Louis, St. Louis, Missouri, February 7.

Svensson, L. E. (2015): "A simple cost-benefit analysis of using monetary policy for financial-stability purposes," in *Rethinking Macro Policy III: Progress or Confusion*, ed. by O. J. Blanchard, R. Rajan, K. S. Rogoff, and L. H. Summers. International Monetary Fund.

Figure 1: Measures of the credit-to-GDP ratio

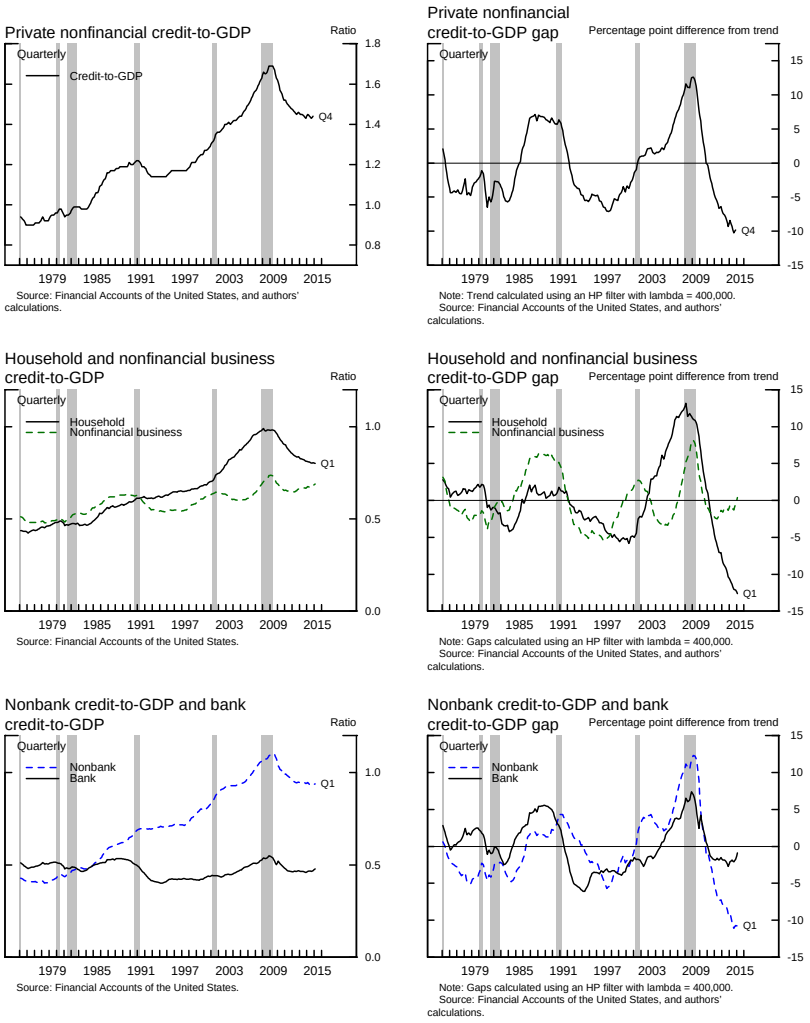
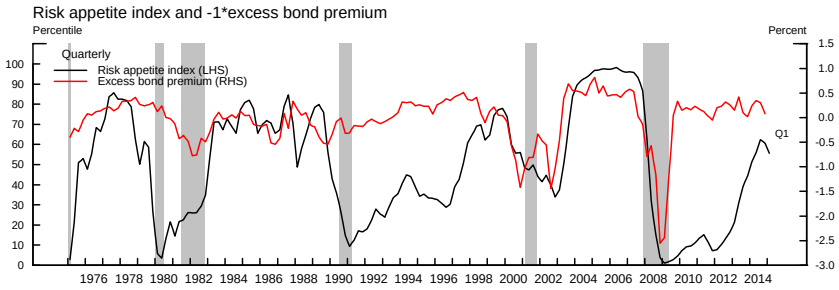
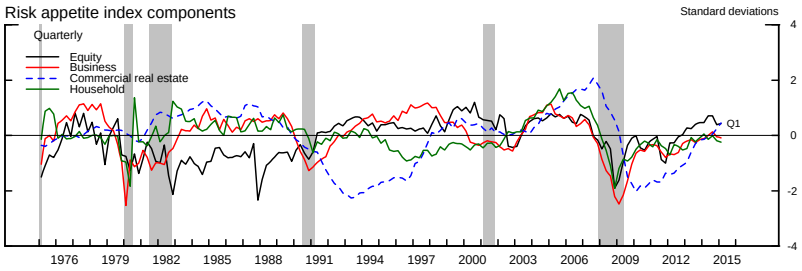


Figure 2: Measures of risk appetite: ALLM, its components and the EBP



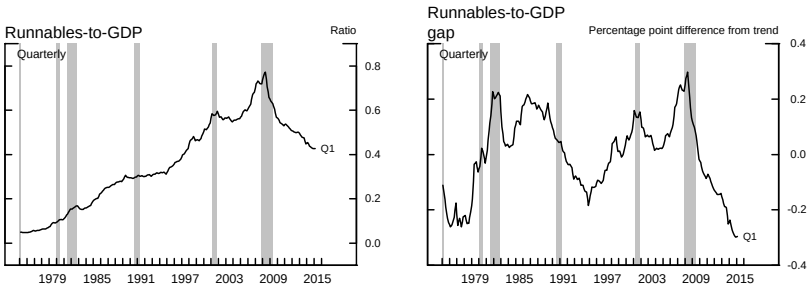
Source: Authors' calculations and Gilchrist & Zakrajsek (2012).



Note: The figure presents the component series of the risk appetite index. In computation of the index, these four components are respectively weighted by 2/10, 3/10, 2/10, and 3/10.

Source: Authors' calculations.

Figure 3: Runnables



Note: Trend calculated using an HP filter with lambda = 400,000.
Source: Financial Accounts of the United States, Money stock measures, and authors' calculations.

Source: Financial Accounts of the United States, Money stock measures, and authors' calculations.

Figure 4: Credit shock when using credit-to-GDP as a measure of vulnerability

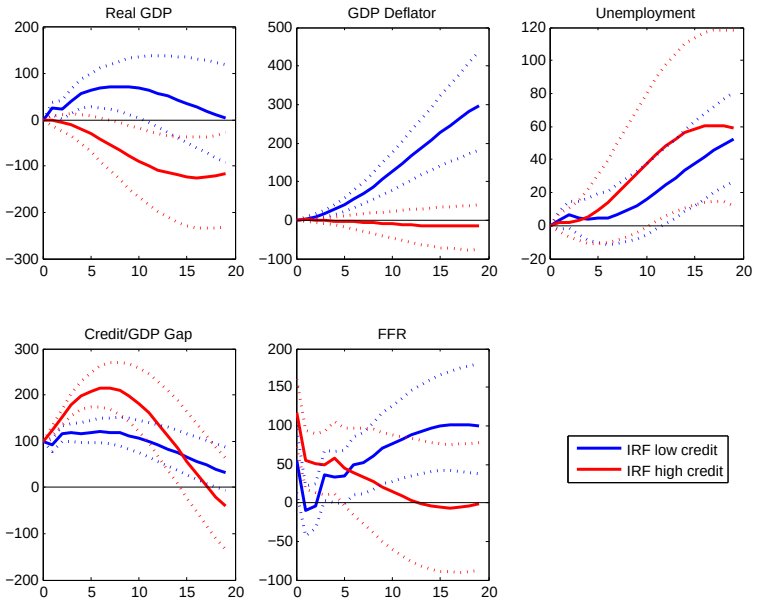


Figure 5: Monetary policy when using the credit-to-GDP gap as a measure of vulnerability

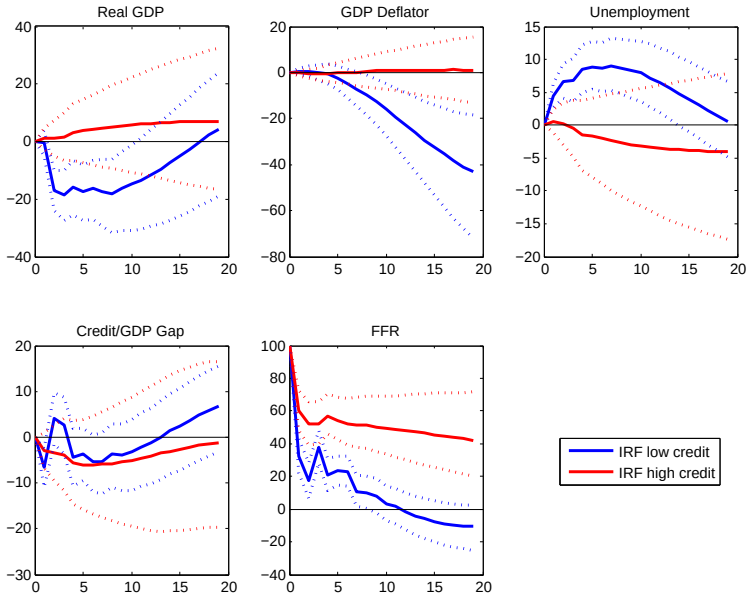


Figure 6: Shock to the level of credit when using the credit-to-GDP gap as a measure of vulnerability

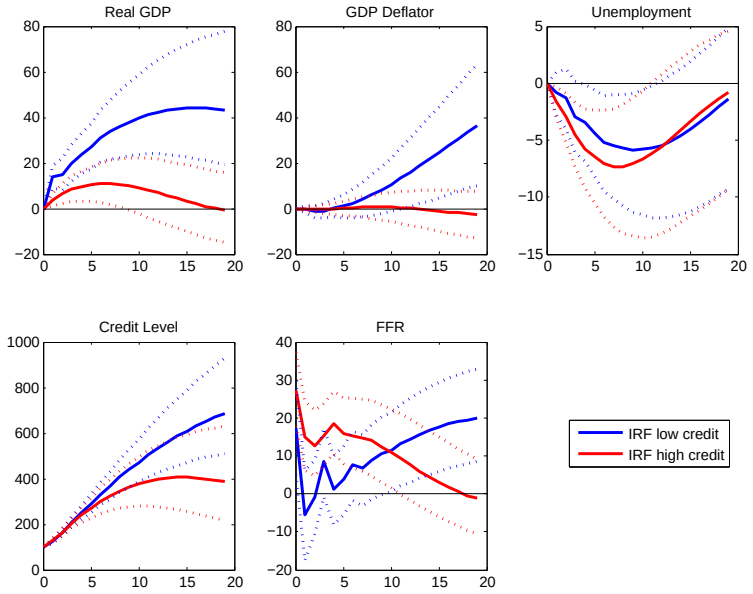


Figure 7: Shock to monetary policy in a system with the level of credit, using the credit-to-GDP gap as a measure of vulnerability

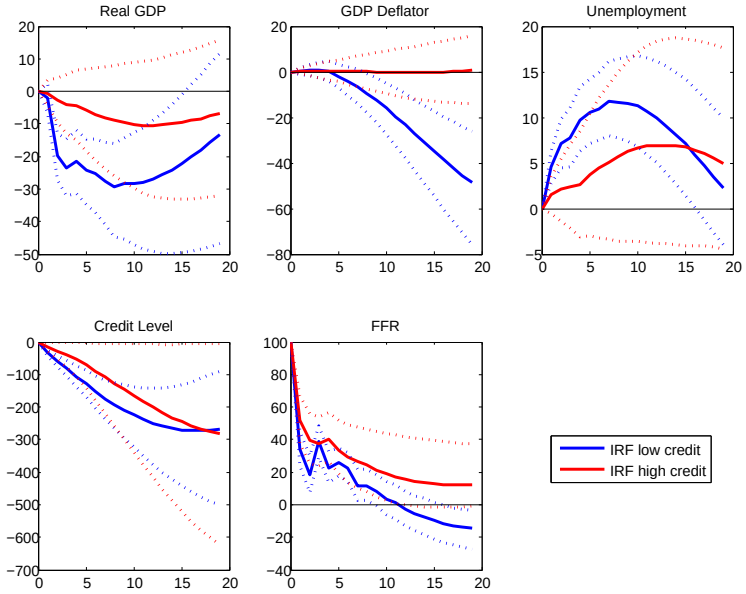


Figure 8: Credit shock using potential GDP to estimate the credit-to-GDP gap

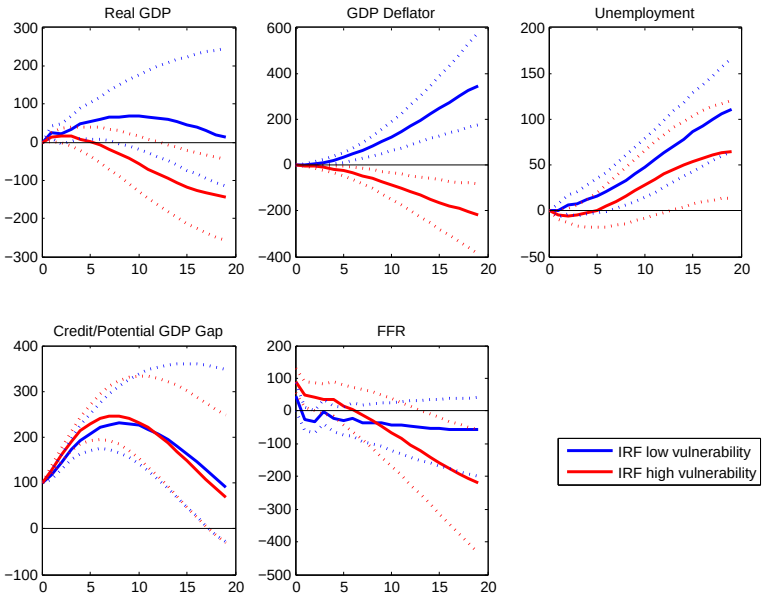


Figure 9: Credit shock using the credit-to-GDP gap as a measure of vulnerability with monetary policy response shut off

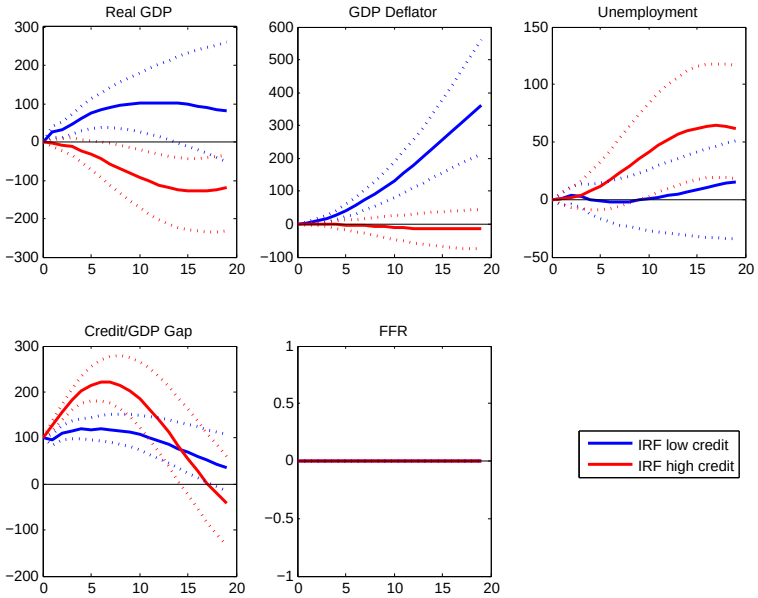


Figure 10: Response to a shock to household credit in a system with the credit-to-GDP gap disaggregated between household and business credit.

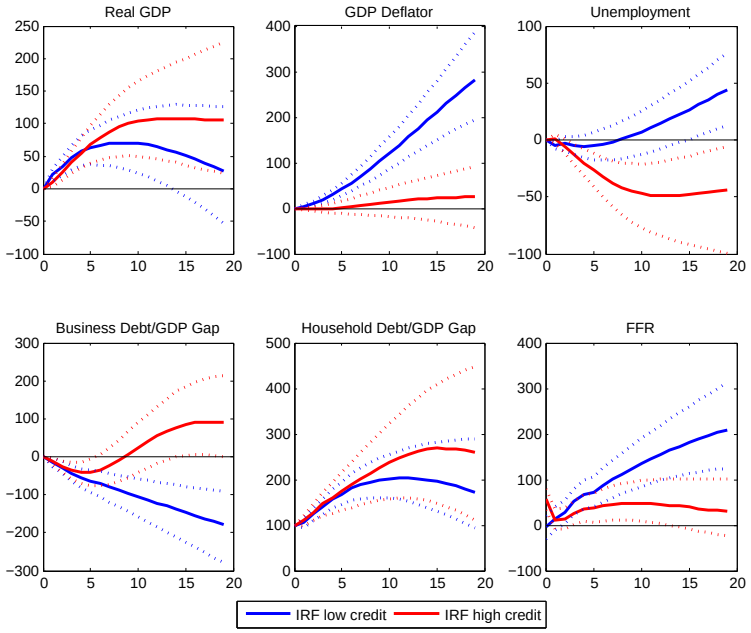


Figure 11: Response to a shock to business credit in a system with the credit-to-GDP gap disaggregated between household and business credit.

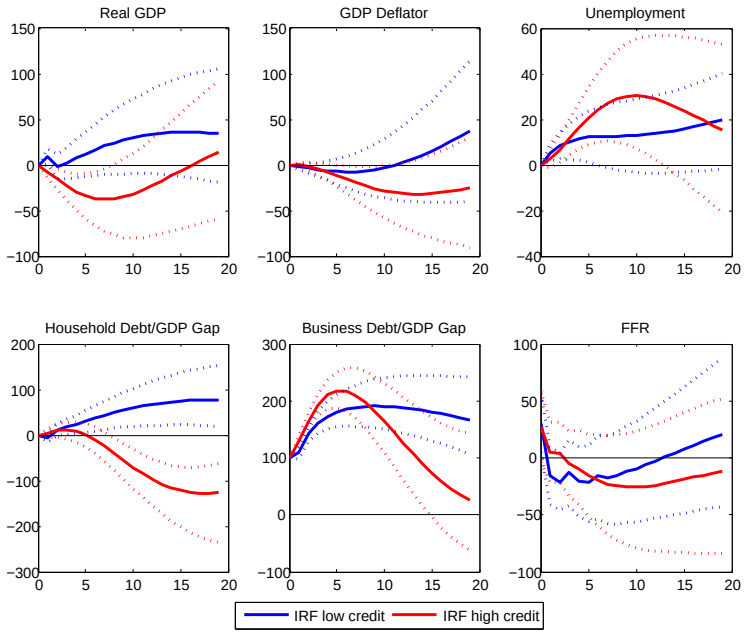


Figure 12: Impulse responses to a shock to our constructed measure of risk appetite (ALLM)

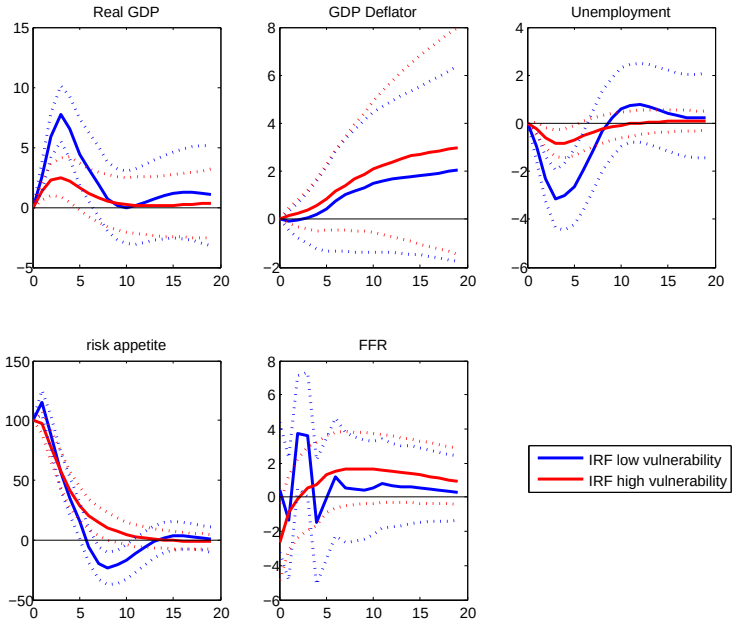


Figure 13: Impulse responses to a shock to our constructed measure of risk appetite, ALLM (in a system containing the credit-to-GDP gap where high/low vulnerability periods are defined using the aggregate credit-to-GDP gap).

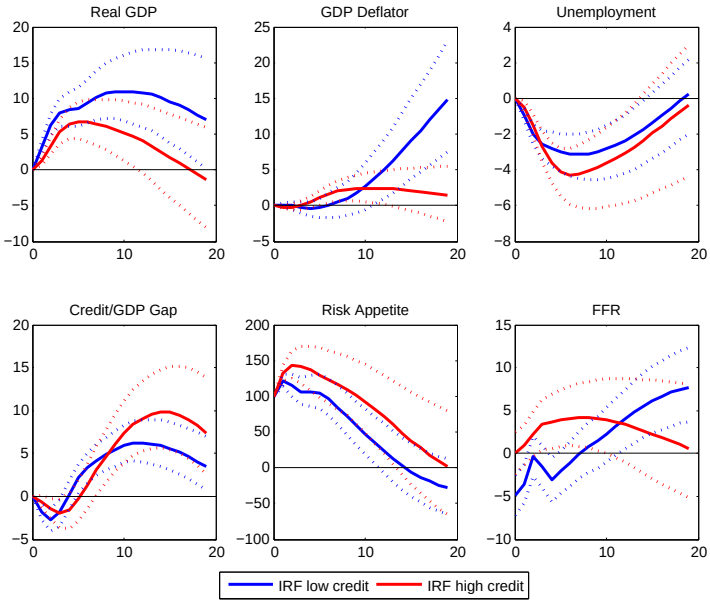


Figure 14: Impulse responses to a shock to runnable liabilities estimated over the full sample.

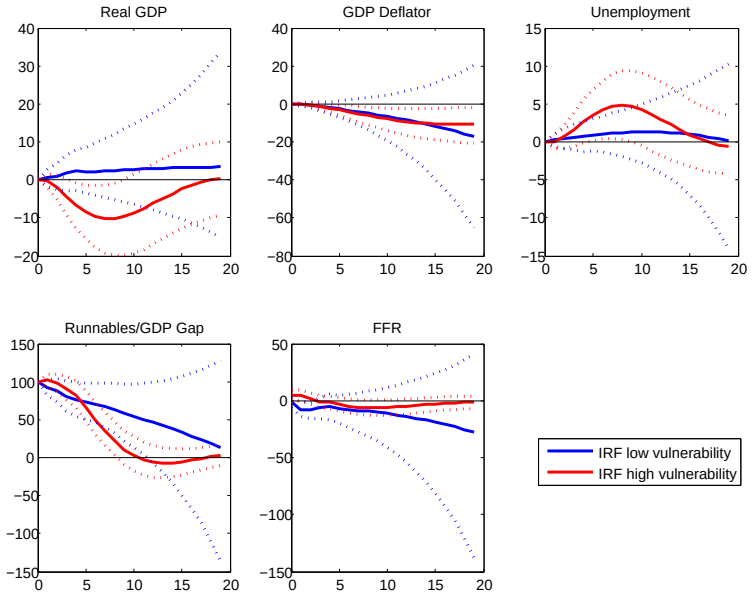


Figure 15: Impulse responses to a shock to runnable liabilities estimated over the sample after the Bankruptcy Amendments Act of 1984 (1985:Q1–2014:Q4).

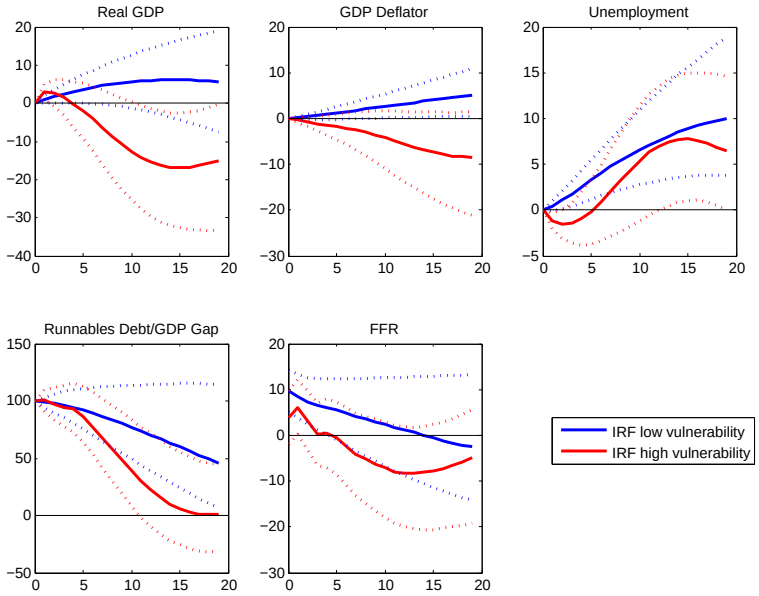
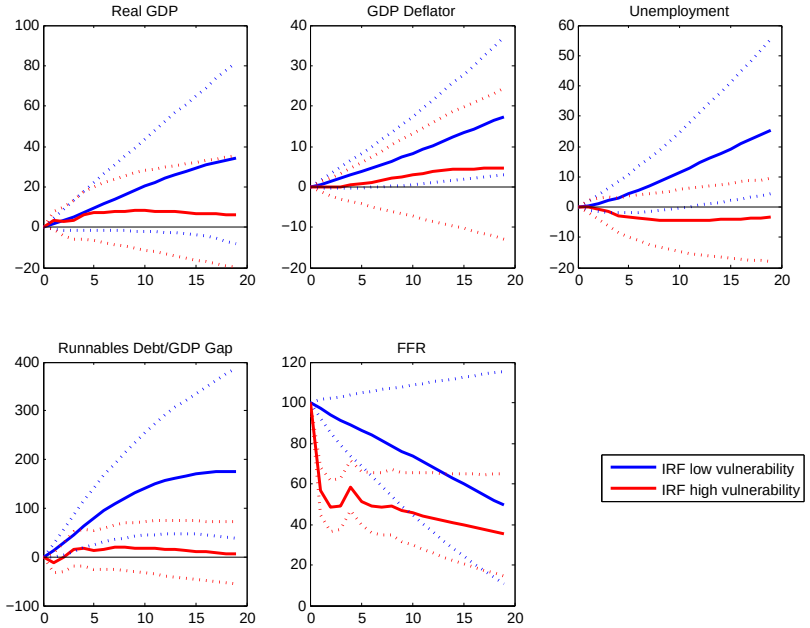



Figure 16: Impulse responses to a shock to monetary policy in a system measuring vulnerability using runnable liabilities estimated over the sample after the Bankruptcy Amendments Act of 1984 (1985:Q1–2014:Q4).