Financial Vulnerabilities, Macroeconomic Dynamics, and Monetary Policy*

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Abstract

We define a measure to be a financial vulnerability if, in a VAR framework that allows for nonlinearities, an impulse to the measure leads to an economic contraction. We evaluate alternative macrofinancial imbalances as vulnerabilities: nonfinancial sector credit, risk appetite of financial market participants, and the leverage and short-term funding of financial firms. We find that nonfinancial credit is a vulnerability; a high credit-to-GDP gap leaves the economy less resilient to adverse events. Monetary policy is generally ineffective at slowing the economy once the credit-to-GDP gap is high, suggesting potential benefits from avoiding excessive credit growth. Impulses to risk appetite lead to an economic expansion, though also to a higher credit gap over the longer-term. We also find that financial sector "runnable" liabilities are a vulnerability, consistent with the fragility of short-term funding and importance for transactions, though financial sector leverage relative to its trend appears to reflect investor risk appetite.

Keywords: Financial stability and risk, monetary policy, credit

JEL classification: E58, E65, G28

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1 Introduction

The recent global financial crisis highlighted in dramatic fashion the damage to economic performance from falling asset prices amid high levels of credit and fragile financial institutions. Policymakers have since been encouraged to monitor the financial system for the 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 private nonfinancial sector credit and asset valuations are early warning indicators of economic recessions and financial crises (see Borio and Lowe (2002), Drehmann and Juselius (2015), Schularick and Taylor (2012)). In addition, studies have found that high credit growth and asset bubbles combined lead to significantly weaker economic recoveries (see Jorda et al. (2013)). Financial stability monitoring frameworks, based on this growing body of theoretical and empirical research, focus on the levels and growth rates of these macrofinancial imbalances as potential vulnerabilities of the financial system (see Adrian et al. (2013)).

In this paper, we systemically evaluate several commonly-cited macrofinancial imbalances for whether they lead to higher risks to future macroeconomic performance. We shed empirical light on this question using a threshold VAR model using data for the U.S. economy from 1975 to 2014. Using alternative measures of macrofinancial imbalances, we test whether shocks to the measures lead to subpar economic performance, specifically lower GDP and a higher unemployment rate. We test for nonlinear dynamics by dividing the sample into periods depending on whether the measure is above or below its average. Measures of financial imbalances that are found to lead to weaker expected economic performance are defined to be "vulnerabilities." (Henceforth, we use the term *vulnerability* to refer generically to variables that measure candidate macrofinancial imbalances that might lead to economic contractions.)

We examine four vulnerabilities often cited in studies of financial crises: private-sector debt, investor sentiment or asset valuations, financial-sector leverage and maturity transformation among financial institutions.[1] We briefly describe each candidate vulnerability in turn, how we measure it, and the rationale for including it in our framework.

Note that the first two of our candidate vulnerabilities, debt and asset valuations, are conceptually different from financial-sector leverage and maturity transformation. The first set are economy-wide measures and do not depend on particular institutional features. The second are defined relative to specific financial institutions such as money market mutual funds or banks.

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 alternative disaggregations of this measure–household vs. business borrowers, bank

[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.

[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 of recessions, and also is useful when combined with property prices.

vs. nonbank credit, debt collateralized by property vs. other debt-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 excess bond premium of Gilchrist and Zakrajek (2012) as a measure of risk appetite, which has been found to be a useful predictor of macro performance. Higher asset values relative to historical averages may reflect greater risk-taking behavior which could lead to a buildup in financial vulnerabilities and make the economy less resilient to to adverse shocks. Boom-bust cycles in real estate prices are viewed by many economists as key sources of financial fragility (see, for instance, Cecchetti (2008), Iacoviello (2005), and Jorda et al. (2015)). Others have emphasized the information in bond risk premiums (Stein (2013b) 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 third measure is the leverage of the financial sector. This is an obvious potential vulnerability because more-leveraged financial institutions are less able to absorb losses. Faced with solvency concerns, these intermediaries may need to shrink, with negative consequences for the broader economy from fire sales or reduced credit supply. Of course, the leverage of financial intermediaries cannot rise in the absence of investor willingness to finance their borrowing, suggesting that risk appetite may play some role in leverage, a dynamic highlighted by Geanakoplos (2010). Further, Adrian and Shin (2010, 2014) document that the leverage employed by a crucial class of financial institution–broker dealers–is highly procyclical, in line with the tendency of asset price volatility to be low in booms and high in busts. We construct an aggregate measure of total assets to equity for financial intermediaries that are leveraged, including depository institutions, insurance companies, broker dealers, finance companies, REITs, and holding companies from the Financial Accounts of the U.S.

Our last measure is related to maturity transformation of financial institutions. This function and its role as an amplification mechanism have been studied by Adrian and Boyarchenko (2015) and Gertler and Kiyotaki (2015), among others. We approximate maturity transformation by financial intermediaries with non-deposit claims that are pay-on-demand but that carry credit risk, based on Bao et al. (2015). Our measure comprises five components which have data back to 1975: repurchase agreements (repo), securities lending, retail and institutional money market mutual funds (MMMFs), and commercial paper. 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 et al. (2013)). Krishnamurthy and Vissing-Jorgensen (2015) argue that issuance of Treasury debt affects the supply of short-term liquid claims issued by financial institutions, which are associated with financial crises.

Our tests indicate that private-sector debt is indeed a vulnerability in the sense of presaging economic contractions, while shocks to risk appetite are expansionary. Specifically, a primary finding is that impulses to the credit-to-GDP gap lead to decreased output and higher unemployment when the credit gap is above zero, indicating that the credit gap is a vulnerability. These results suggest that when the economy has a high credit gap, it is more vulnerable to adverse events which lead to recessions. By contrast, in the early phase of the financial cycle when the credit gap is low, credit shocks do not have adverse effects; indeed, they stimulate economic growth, consistent with the equilibrium relationship between debt and economic growth more common to macroeconomic models. Another primary finding is that the responses to monetary policy impulses also suggest nonlinearities that depend on the level of the credit gap. When the credit gap is low, impulses to monetary policy lead to an increase in unemployment, a contraction in GDP, and a decline in credit, all as expected. However, when the credit gap is high, output, unemployment, and credit appear unresponsive to similar impulses to monetary policy.

Our finding that monetary policy shocks have less effect on activity and inflation when debt-to-GDP is above trend is consistent with at least two theories. First, as asset price increases and associated credit growth gain steam, monetary policy may be less effective at restraining activity (see Dokko et al. (2009)), perhaps because an overriding speculative motive made increases in the cost of funds a relatively less important consideration. (Foote et al. (2012); Cheng et al. (2014)). Second, monetary policy may be less effective at stimulating activity after a credit-fueled boom, perhaps because the overhang of debt accumulated during the boom reduces consumers' or firms' capacity to borrow (Guerrieri and Lorenzoni (2015); Dobridge (2016)) or because the boom stimulated a misallocation of resources (Mian et al. (2015)). We shed some light on this by redefining our threshold in terms of the growth of the debt-to-GDP ratio, so that the sample is divided in periods when the ratio is rising or failing rather than high or low. We find that monetary policy is ineffective when the ratio is rising but effective when it is falling, suggesting perhaps more support for the first story rather than the second.

Turning to investor risk appetite, we find that impulses 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. Moreover, the effects of a shock to ALLM on the credit gap tend 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 impulses 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.

Turning to the other candidate vulnerabilities, we find that financial sector leverage has similar dynamics in the near term to the ALLM measure in that shocks are expansionary. Thus, it does not satisfy our definition of a vulnerability. We also find that shocks to the runnable liabilities-to-GDP gap result in economic contractions when the gap is high but not when it is low; thus, the runnables gap, like the credit gap, does meet our definition of a vulnerability.

There are a few explanations for this pattern. The work of Adrian and Shin (2010) suggests a strong linkage between financial leverage and asset prices and volatility, and thus, potentially, risk appetite, but not necessarily to real economic activity. A decline in runnables appears associated with a decline in economic activity, which makes obvious intuitive sense because of the strong tie of short-term funds to transactions. A decline in leverage, however, could be driven either by mounting losses, as following a peak in the credit cycle, or by increased risk aversion, as in periods of low risk appetite and tight financial conditions. It may also be the case that, because of the growth of the derivatives market, leverage has become more difficult to measure.

We conduct a number of robustness tests, particularly in cases where the variable we use may only imperfectly measure the underlying vulnerability. For example, as discussed earlier, we use a number of different proxies for the level of asset valuations or investor risk appetite. In addition, we consider alternatives to the credit-to-GDP gap, including a specification with just the (log) level of credit and replacing actual GDP with potential GDP.

Our results bear on several strands of the literature. We show that a number of macrofinancial aggregate measures have implications for real activity and employment in the U.S., adding to the empirical literature on the role of financial variables in business cycles, starting with Bernanke and Gertler (1989). Our results indicate that a high credit gap makes the economy less resilient and increases the likelihood of a recession. These findings suggest some important financial frictions that affect macroeconomic performance, such as borrowing being driven by changes in the supply of credit (see Lopez-Salido et al. (2015) and Mian et al. (2015)), or that individuals do not consider the effects on aggregate credit when they make their borrowing decisions (as suggested in a model by Korinek and Simsek (2014)). In addition, 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 vulnerabilities, including those specific to the financial sector. In particular, impulses to short-term wholesale liabilities of financial firms increase the likelihood of subpar economic activity, perhaps because they leave the system vulnerable to fire sales and significant disruptions in transactions.

Second, our finding that macroeconomic responses are nonlinear and depend on whether the credit gap is above or below normal adds to a growing line of research arguing that transmission channels may operate differently depending on underlying conditions. Hubrich and Tetlow (2012) 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.

Finally, our finding that monetary policy is less effective when the credit gap is high, combined with our finding that a high credit gap is a vulnerability, suggests that credit is costly and may lead to more severe recessions. For example, Jorda et al. (2013) provide evidence that excess credit creation in the period preceding a recession substantially increases the depth of the subsequent recession, for both normal recessions and financial recessions (those with substantial losses to the banking sector).[3]

The relative ineffectiveness of monetary policy also is relevant for evaluating the use of monetary policy to reduce vulnerabilities and future crises, relative to the use of macroprudential policies. Svensson (2015) argues that the costs of directing interest rates at financial stability risks (in terms of reduced output today) would almost always significantly exceed the benefits (reduced probability of a future crisis by reducing credit growth). Ajello et al. (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 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. Our results provide stronger support for the use of monetary policy: credit is a vulnerability and a high credit gap leaves the economy less resilient and more prone to a recession. If monetary policy is increased and reduces the amount of credit, it not only would reduce the probability of a crisis but also the severity of a subsequent recession. Given monetary policy is not effective in a high credit gap state, there may be high returns to policymakers from avoiding such states. More targeted macroprudential policies may be a preferable way to reduce credit, but a high share of market-based finance may lead to situations in which such macroprudential measures' effectiveness is diminished and monetary policy should be considered.

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 measures tied to the leverage and maturity transformation of financial institutions, satisfy our definition. Section 5 concludes.

2 Data and Specification

In this section we describe the candidate measures of vulnerabilities that we test and the specification that we use to test them. In terms of the series, in certain cases important structural changes in the financial environment – including changes to the U.S. 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

[3]For example, in the fourth year after the peak, in a normal recession, the economy is well into a recovery, with real GDP per capita estimated to be 3.8 percentage points higher than the cyclical peak. But had credit exceeded average levels by one standard deviation, real GDP per capital would be estimated to be 1.8 percentage points less, at 2.0 percent. In the case of a financial recession, the effects are larger. In the fourth year after the peak, the economy has still not recovered, the GDP per capita level is -2.8 percentage points below the cyclical peak for average excess credit. If credit were one standard deviation higher, real GDP per capita would be as low as 3 percentage points lower, at -5.8 percent. These suggest significant effects for excess credit on the severity of the subsequent recession.

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 Reinhart and Rogoff (2009)). 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 (see Laeven and Valencia (2008)), suggesting that perhaps the 1990 recession could also be associated with a financial crisis. Jorda et al. (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 the components in three separate decompositions of the credit-to-GDP gap:

1. A sectoral decomposition of credit provided to households vs. to businesses;.

2. A collateral decomposition of credit backed by property (commercial or residential) vs. other forms of credit; that is, unsecured credit or credit secured by non-property collateral.

3. A bank vs. nonbank decomposition, based on where the credit exposures are being held.

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.

The estimated gap, the ratio less a trend estimated with a HP filter with a smoothing parameter of 400,000, shows a similar pattern over history, with peaks ahead of the recessions of 1990-91 and 2007-9. The gap we report is 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.)

The figure highlights a well-known property of the credit-to-GDP gap: that it tends be high 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. 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 ratio (and hence the gap) caused by a decline 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 – 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 and the funding advantage enjoyed by the housing-related government-sponsored enterprises, Fannie Mae and Freddie Mac.[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. Our measure of nonbank credit gathers 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).

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.

The nonbank credit-to-GDP ratio shows a secular upward trend, 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.

[4]The share of mortgage credit funded by Fannie and Freddie grew from 12 percent in 1975 to roughly 60 percent in 2014. (Financial Accounts of the United States, 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. For a discussion of the capital advantages enjoyed by the GSEs, see Hancock et al. (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).

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 Zakrajek (2012). Both measures (the 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 et al. (2015). The measure includes indicators of 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 equity and business credit components of ALLM are quite similar to the EBP, although ALLM recovers somewhat more slowly after the 1990 and 2008-09 recessions because it also includes credit conditions for small businesses, whereas the EBP is based on only publicly-traded corporations. However, ALLM also reflects changes in commercial and residential mortgage credit availability; these markets have cycles distinct from asset markets. As a result, the overall ALLM index is distinctly below the (negative) EBP in the late 1970s, when equity markets fell, and when commercial real estate conditions in the early 1990s and household credit conditions in the mid 1990s were tight.

2.3 Financial sector leverage

The final two candidate vulnerabilities we consider relate to features of financial institutions, starting with the leverage of financial-sector businesses. We construct an aggregate measure of total assets (A) to equity (E) for financial intermediaries that are leveraged, including depository institutions, insurance companies, broker dealers, finance companies, real-estate investment trusts (REITs), and financial holding companies.

As shown in figure 3 this measure, "AE", has a downward secular trend, reflecting primarily a substantial increase in regulatory capital requirements in the banking sector. Required capital among banks increased following the first Basel capital accords in 1988 and again starting in 2009 with the post-crisis capital reforms including the stress testing regime and Basel III. The series, adjusted for a long-term trend, features significant variation over time, including peaks in 1986, 1998 and 2004–2006. Since its most recent peak the series fell sharply and has remained quite low.

This variable is highly correlated (contemporaneous ρ=.65) with our risk appetite variable, suggesting that once adjusted for secular trend, it may reflect risk-taking behavior of financial institutions and the willingness of investors to provide debt financing.

[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,

2.4 Runnable liabilities

A fourth vulnerability we consider is also related to financial institutions, specifically their 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 et al. (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. For example, it would count a repo loan extended by a money market fund to a dealer bank and the money fund shares, an apparent double counting. However, this is appropriate because there are two agents who can run in this example: the household could run on the money fund, and the money fund could run on the dealer.

We include five components which have data back to 1975: repurchase agreements (repo), securities lending, retail and institutional money market mutual funds (MMMFs), and financial 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 et al. (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 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 Regulation 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

[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.

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.[7] 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).

2.5 Sample statistics

Table 1 gives sample statistics for our candidate vulnerability measures. In each case, the measures are divided into periods above their means (labeled "high vulnerability") and below their means (labeled "low vulnerability"). In certain instances, for comparison, we include the (negative) excess bond premium. (We use the negative of the EBP so that high values have the same economic meaning as our other vulnerabilities.) For each measure, in periods when it is high or low, the table gives the level and quarterly change in the unemployment rate, real GDP growth, inflation, and the level and quarterly change in the average effective federal funds rate.

Both the credit-to-GDP and the runnables-to-GDP gaps show a similar pattern: when they are low, real GDP growth and the inflation rate are higher than in periods when they are high. Further, in these low periods, the unemployment rate is falling and the fed funds rate is increasing, suggesting such low periods occur near business cycle peaks. In contrast, periods of high vulnerability by these measures are associated with lower economic growth, low but rising unemployment and loosening monetary policy, suggesting that they occur near business cycle troughs.

The similarities between ALLM and AE are striking. Periods of low ALLM and AE are associated with worse overall economic performance: the unemployment rate is higher and rising; and real 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. Put another way, periods of high ALLM and AE are associated good economic performance, with higher real GDP growth, falling unemployment and tightening monetary policy.

These results raise the obvious question of how correlated our measures are. Figure 4 shows standardized values of all four vulnerabilities; that is, each vulnerability normalized to have zero mean and a unit standard deviation. All four vulnerabilities are quite low in

[7] Regulation Q was phased out entirely by 1986.

the early 1990s and have peaks somewhere in the 2004 to 2009 period, with ALLM and the leverage gap peaking earlier and the credit-to-GDP and runnables gaps peaking later. In general, the credit-to-GDP gap and the runnables gap appear correlated with each other, and they lag ALLM and the AE gap.

Table 2 gives the simultaneous pairwise correlations among these measures. The credit-to-GDP and runnables gap are fairly well correlated ($\rho = 0.63$). These two measures are however essentially uncorrelated with ALLM ($\rho = 0.10$ and 0.23 respectively) and less correlated with AE ($\rho = 0.28$ and 0.11 respectively).

As one might expect, our risk appetite index and leverage measure are fairly well correlated ($\rho = 0.70$). Note that ALLM is also somewhat correlated with the (negative) EBP ($\rho = 0.34$).

Given our focus on the interaction of the effectiveness of monetary policy with our vulnerability 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 subsample in a high or low value of a measure contained too few easing or tightening episodes. 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. Focusing just on the credit-to-GDP gap – the measure under which we evaluate the monetary policy transmission mechanism – the minimum sample size ($N = 15$) is for the combination of a high gap and policy tightening (46 total observations). Thus, our sample is not degenerate.

2.6 Specification

Our primary goal is to characterize the effect of shocks to our candidate measures of financial vulnerability on economic performance. Specifically, whether these effects differ depending on whether the vulnerability 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 et al. (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. As is standard in this literature, we report the 16th and 84th percentiles of the distribution of the impulse response functions; the shocks are 100 basis points for the vulnerability measures or monetary policy as appropriate (e.g. the shock to the credit-to-GDP gap used in the IRFs is 100 basis points).

Our baseline specifications contain the following variables:

- $100 \times$ logarithm of real Gross Domestic Product.
- $100 \times$ logarithm of the Gross Domestic Product deflator.
- Unemployment rate.

- Measure of financial vulnerability defined so that higher values indicate increased vulnerability
- 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, runnables and leverage. When identifying monetary policy shocks, monetary policy is assumed to be able to react to risk appetite shocks in the same quarter.[8] When identifying ALLM shocks, we reverse the order and permit ALLM to react in the same quarter as monetary policy. 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:

$$y_t = c^{(j)} + A(L)^{(j)} y_{t-1} + \varepsilon_t^{(j)} \qquad \begin{cases} j = \text{high}, & \text{if } X_t > \mu_X \\ j = \text{low}, & \text{if } X_t \leq \mu_X \end{cases} \tag{1}$$

Where y_t is the vector of endogenous variables described above.

Our empirical characterization of the relationship of measures of vulnerability explores three elements. First, whether a positive shock to the measure results in subpar economic performance. 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. (We restrict this final analysis just to the credit-to-GDP gap for space reasons; we consider analysis of this vulnerability to be the main contribution of this paper.)

[8] In ongoing work, we are investigating the use of higher-frequency measures–in the spirit of Hanson and Stein (2015), of monetary policy surprises as an identification strategy. Our findings reinforce the results presented here: when the credit-to-GDP gap is above zero, the reaction of rates along the yield curve to monetary policy shocks is smaller. The attenuation is particularly pronounced at medium and longer maturities.

3 Results for Credit and ALLM

3.1 Credit-to-GDP Gap As Vulnerability

We begin by evaluating the gap between the log of 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 5 and 6 show impulse response functions (IRFs) with respect to innovations to the credit-to-GDP gap and to monetary policy. These results are based on the system estimated over the full sample; that is, without a threshold feature. As shown, following a shock to the credit-to-GDP gap economic activity expands for a few quarters, prices rise, monetary policy reacts and eventually the unemployment rate rises. The evolution of the system following an innovation to monetary policy is as expected: activity contracts, prices fall and the unemployment rate rises. Interestingly, the credit-to-GDP gap also shrinks. Based on these results it is not clear that the credit-to-GDP gap satisfies our definition of a vulnerability. Innovations to the gap do eventually lead to an increase in the unemployment rate, but this is likely driven by the monetary policy reaction function. Real GDP rises in the quarters following the credit shock.

Turning now to the system estimated using a threshold: figures 7 and 8 show impulse response functions 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.

Viewed in light of these threshold VAR results, the credit-to-GDP gap satisfies our definition of a vulnerability. As shown by the red lines in figure 7, 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, the system estimated only in periods of low credit-to-GDP gap behaves somewhat like the full-sample system shown in figure 5. As in the full-sample IRFs, an upward shock to the credit gap when the gap is low results in a boost to GDP and inflation; monetary policy reacts and the unemployment rate eventually rises. 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 8, 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 questions. First, as discussed above, monetary policy appears to react to the credit-to-GDP gap; if so, this may be the channel by which shocks to the gap translate to economic contractions. Second, 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. Third, because actual GDP falls in bad times, one might be concerned that the causation runs from recessions to higher credit-to-GDP ratios.

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 the coefficients in the equation describing the reaction of the effective fed funds rate to other variables in the system set to zero. The effectively gives the dynamics of the system 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. As shown by the blue lines, the unemployment rate does not rise following a shock to the credit-to-GDP gap when the gap is low and monetary policy is shut off. Our earlier finding of rising unemployment thus appears to be related to the monetary policy reaction.

Figure 10 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. In neither the high nor the low state does a shock to the credit level produce a recession. We can speculate that this is because the shock in levels is so persistent that it takes a long time to peter out. While the credit expansion is underway, economic activity continues to grow as well, with the ultimate end of the expansion happening far in the future.

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 11 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 12 shows the results in a specification in which the credit-to-GDP gap is estimated using *potential* GDP. Comparing figures 7 and 12 shows very small differences. Of course, potential GDP is a real concept while in our analysis nominal credit is deflated by nominal GDP. To form nominal potential GDP we multiply potential (real) GDP by the actual price level.

Any mechanical effect via the price level would still be in place.

Is All Credit Created Equal?

Our credit-to-GDP gap vulnerability measure is based on total private nonfinancial debt. Thus, it lumps together forms of debt that might be expected to have different relationships to asset prices and economic activity. 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 specification in the following way: we divided total credit, D_t into two components, D_t^a and D_t^b where $D_t^a + D_t^b = D_t$. 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, second into credit provided by banks vs. nonbanks and third into debt collateralized by property vs. other forms of debt.

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 13 and 14 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 (figure 14). The lack of a similar result for household credit (13) 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 aggregate 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 *also* focus on forms of credit that are not traditionally associated with housing bubbles; of course, measures such as mortgage credit growth warrant attention as suggested by the extensive literature documenting the relationship between housing credit booms and subsequent busts.

Alternative Cyclical Definition

The credit-to-GDP gap is high before and after a cyclical peak – during the boom and the subsequent bust. This is appropriate given the focus of the literature on the stock of debt. However, one might conjecture that the monetary policy transmission mechanism also depends on the reason for the high level of credit-to-GDP. In the "lean vs. clean" taxonomy of Stein (2013a), whether monetary policy might be more effective when used to lean against rapidly increasing credit or when used to clean up following a post-boom contraction.

One way to test this is to divide the sample into periods of an increasing credit-to-GDP gap, from the troughs to the peaks of the measure and into periods of a decreasing credit-to-GDP gap, from the peaks to the troughs. Figure 15 shows the impulse responses to a monetary policy shock in a system with the sample divided in this fashion. The blue lines show the IRFs in post-boom periods. It does appear that in such periods, monetary policy has an effect on real variables. During periods of rising credit-to-GDP gaps, however, monetary policy shocks appear to have no effect on real variables. In neither case, however, does monetary policy appear to have a clear effect on the credit gap itself, suggesting that these results warrant further investigation.

3.2 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 or below its mean. Impulses to ALLM lead to similar macroeconomic outcomes in both environments (figure 16). 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.

As a further check on this result, figure 17 shows the same results using the negative of the excess bond premium in place of ALLM. The results are quite similar: upward shocks to the negative EBP (i.e. a lower excess bond premium) presage economic expansions, with the effect stronger in low periods than in high periods.

3.3 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. Danielsson et al. (2015) find that low volatility – a measure of risk appetite – leads to an increase in the credit-to-GDP gap. 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 2.6, 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 18. 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 ALLM 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 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 weaker economic performance.

4 Vulnerabilities Related to Financial Institutions

4.1 Financial Leverage As Vulnerability

Figure 19 shows the impulse response to a shock to the gap between leverage, AE, and an estimate of its trend. As shown, the shock has a stimulative effect on economic activity, especially when the gap is low. Hence this measure of leverage does not satisfy our definition of a macroeconomic vulnerability.

Leverage poses a threat to the solvency of individual financial institutions: all else equal, an institution with less equity can withstand a smaller shock before imposing losses on its debt holders. However, we find that shocks to the leverage gap do not, in the aggregate, presage subpar economic growth. As we discussed in Section 2, there is strong evidence that the AE gap is correlated with overall financial conditions and risk appetite. This high correlation may reflect that, in our sample, there is a strong secular trend downward in financial leverage. Deviations from this trend reflect cyclical variation in the risk-taking behavior of financial institutions. Moreover, additional risk-taking of financial firms may be reflected mostly in higher asset prices and with only an indirect effect on economic activity to the extent it leads to an increase in private sector credit.

4.2 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.

Figure 20 shows the response of the system to a shock to the runnables-to-GDP gap estimated using our full data sample. Figure 21 shows the response using only the data following the bankruptcy reform in 1984. 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.

The significance of runnables as a vulnerability may reflect their important role in supporting the execution of transactions: private agents rely on these assets to pay for goods and services. A system more reliant on these runnable assets for its transactions will be more vulnerable to shocks.

5 Conclusion

In this paper we systematically evaluated in a threshold VAR framework a set of macrofinancial variables to determine whether they represented economic vulnerabilities. We considered the nonfinancial sector credit-to-GDP gap, risk appetite, financial sector leverage and runnable liabilities, and allowed for nonlinear responses.

We find that the credit-to-GDP gap is a vulnerability, with impulses to the credit gap leading to a decline in real GDP and a rise in unemployment when the credit gap is high. In contrast, impulses to the credit gap when it is low are expansionary. We decompose the credit-to-GDP gap into components related to the source of funding and the type of borrower. We find that impulses to business credit and credit supplied by nonbanks lead to economic declines when the aggregate credit gap is high. These results suggest that it is also important to monitor types of credit not associated with housing markets. Shocks to our risk appetite measure are not followed by economic contractions. Thus, consistent with findings in the literature, risk appetite better represents financial conditions rather than a financial vulnerability, though impulses to risk appetite presage increases in credit.

In addition, we find that impulses to financial sector runnable liabilities also lead to economic contractions when its gap to trend is high, suggesting that it, like the credit-to-GDP gap, is a vulnerability. However, shocks to financial leverage did not presage subpar economic times, but instead behaved more like shocks to risk appetite. Perhaps the cyclical (i.e. detrended) variation in leverage that we use is picking up changes in investor willingness to accept the liabilities of more leveraged institutions – a willingness that ought to be related to risk appetite.

Our results also indicate that impulses to monetary policy, as expected, lead to declines in activity when the credit gap is low, but that policy effectiveness is reduced when the credit-to-GDP gap is high. These results suggest that the credit gap affects monetary policy transmission channels, perhaps because of a debt hangover following a credit bust. Moreover, because high credit gap periods tend to precede economic contractions, policymakers may want to avoid these periods. Macroprudential tools that limit excessive credit growth could lead to substantial benefits for the economy, by reducing the likelihood of a contraction and its severity. Monetary policy could also be used to limit excessive credit growth, at the cost of lower current economic activity, particularly if macroprudential policies are not effective because some lenders and borrowers are out of the reach of regulatory and supervisory policies.

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Table 1: Sample statistics by vulnerability measure

	Num. of obs.	Unemployment rate Level	Unemployment rate Δ^a	Real GDP[b]	Inflation[b]	Fed funds Level	Fed funds 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
Assets-to-Equity (AE)							
Low	87	6.97	4.67	2.15	3.08	5.72	−8.53
High	70	5.99	−5.76	3.48	3.51	5.30	−2.60

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

Table 2: Correlations of candidate vulnerability measures

	CY	*RUN*	*ALLM*	$-1\times EBP$	*AE*
CY	1.00				
RUN	0.63	1.00			
ALLM	0.10	0.23	1.00		
$-1\times EBP$	−0.34	−0.38	0.34	1.00	
AE	0.28	0.11	0.70	0.32	1.00

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
Assets-to-Equity (AE)									
Low	23	6.66	-126	42	3.16	-2	22	9.63	101
High	18	5.13	-80	28	4.80	0	24	6.00	53

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".

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.

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

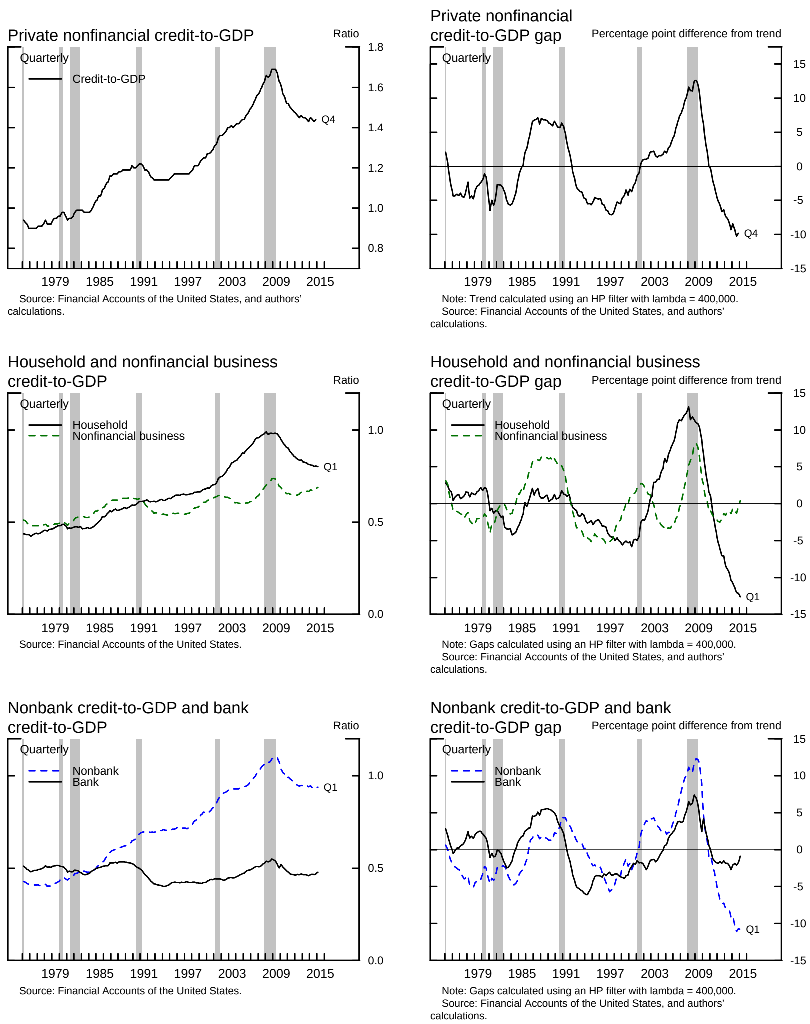
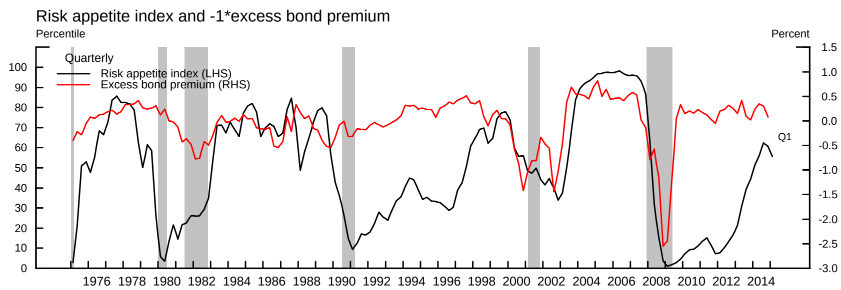
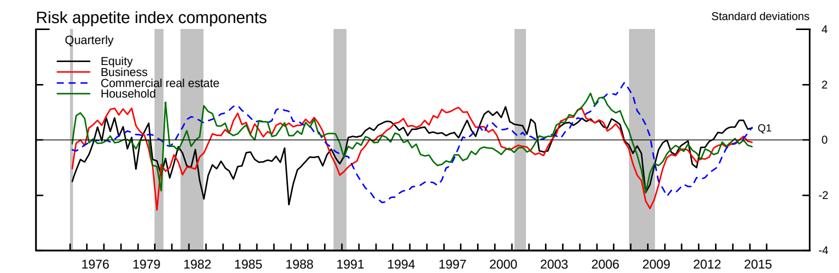


Figure 2: Measures of risk appetite: ALLM, its components and the EBP



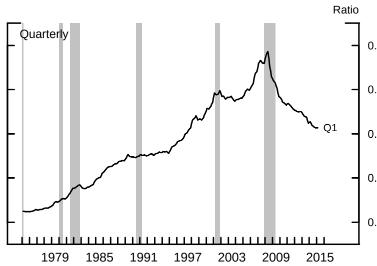
Source: Authors' calculations and Gilchrist & Zakrajsek (2012).



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.

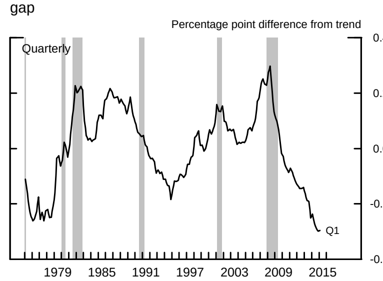
Figure 3: Financial Leverage and Runnables

Runnables-to-GDP



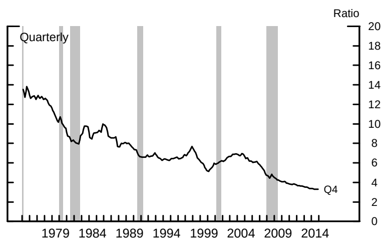
Note: Trend calculated using an HP filter with lambda = 400,000.
Source: Financial Accounts of the United States, Money stock measures, and authors' calculations.

Runnables-to-GDP gap



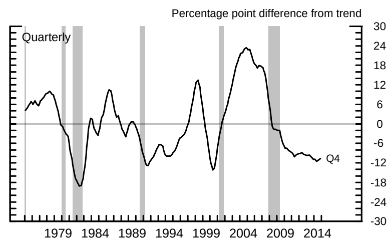
Source: Financial Accounts of the United States, Money stock measures, and authors' calculations.

Total Assets to Equity



Note: Total assets are calculated as the sum of total assets of depository institutions, insurance companies, and holding companies. Equity is computed as total assets less liabilities, save for holding companies where equity is computed as assets less liabilities less mutual fund shares and money market fund shares.
Source: Financial Accounts of the United States.

Total Assets to Equity gap



Note: Trend calculated using an HP filter with lambda = 400,000.
Total assets are calculated as the sum of total assets of depository institutions, insurance companies, and holding companies. Equity is computed as total assets less liabilities, save for holding companies where equity is computed as assets less liabilities less mutual fund shares and money market fund shares.

Figure 4: Standardized Vulnerability Measures

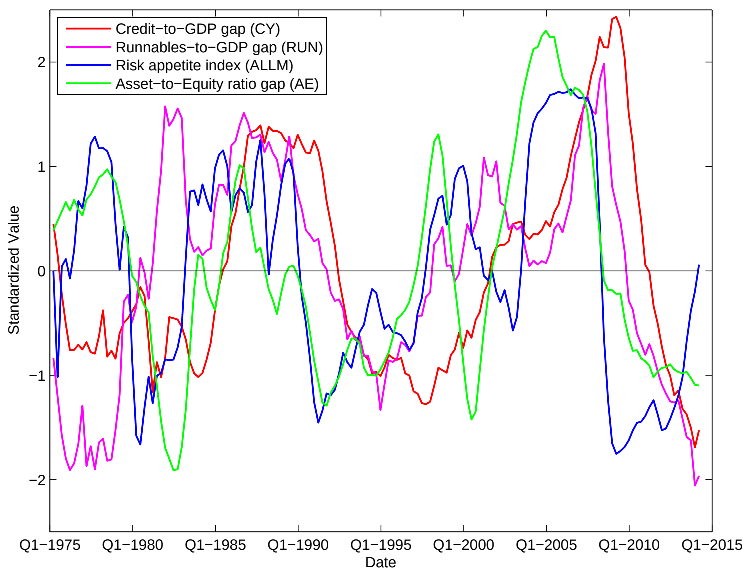


Figure 5: Credit shock when using credit-to-GDP as a measure of vulnerability (full sample)

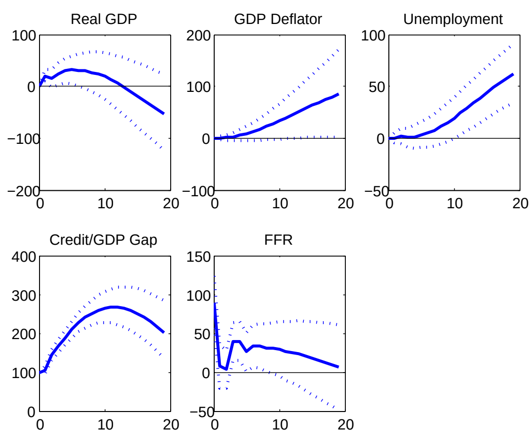


Figure 6: Monetary policy when using the credit-to-GDP gap as a measure of vulnerability (full sample)

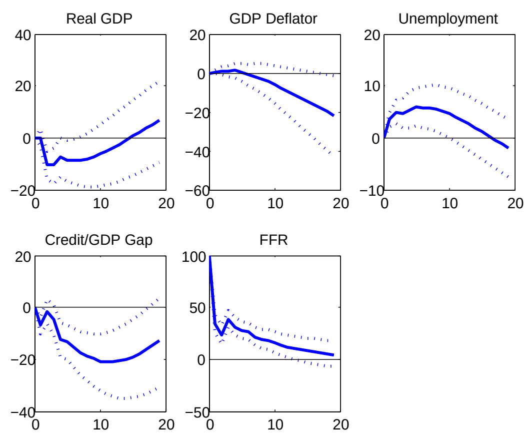


Figure 7: Credit shock when using credit-to-GDP as a measure of vulnerability

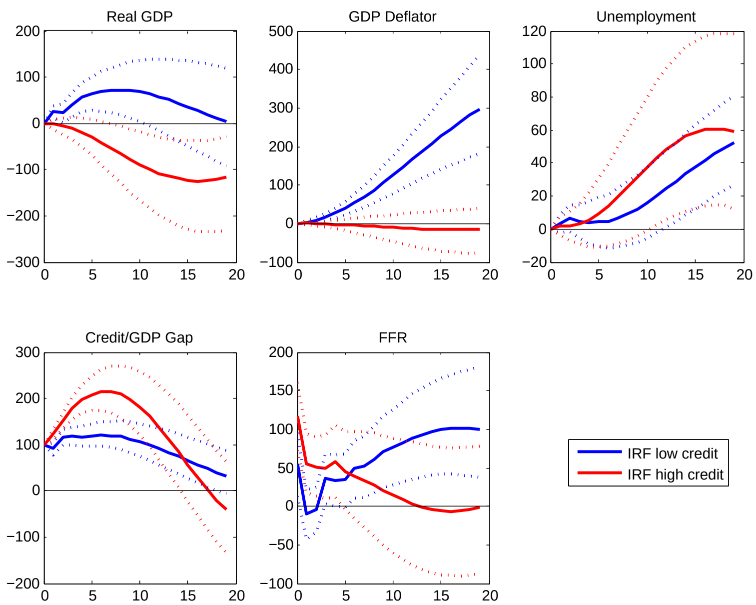


Figure 8: Monetary policy when using the credit-to-GDP gap as a measure of vulnerability

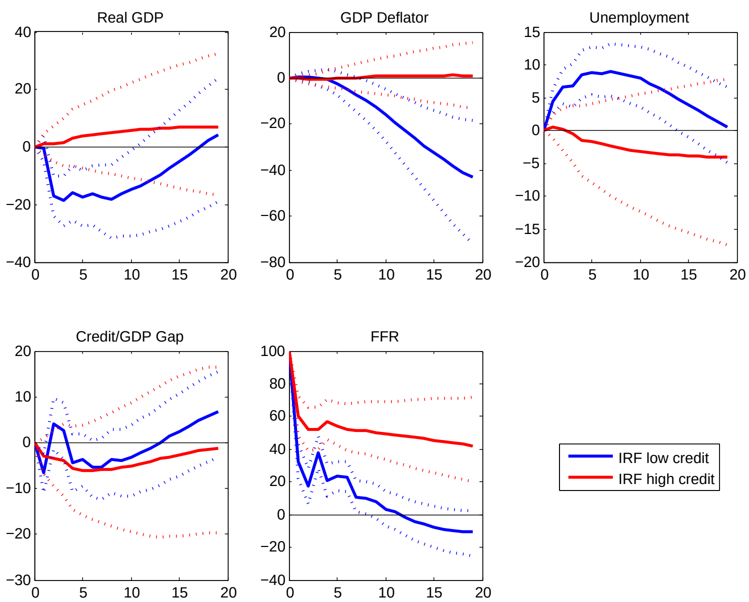


Figure 9: Credit shock using the credit-to-GDP gap as a measure of vulnerability with monetary policy response shut off

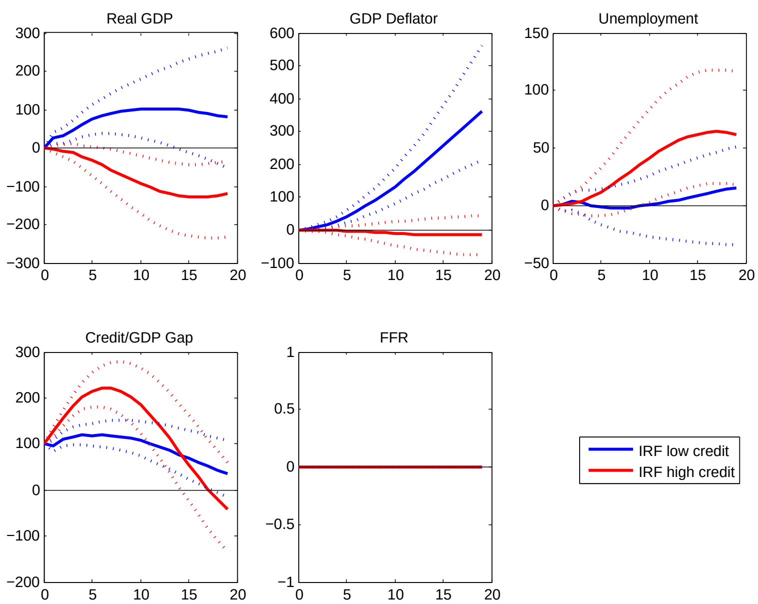


Figure 10: Shock to the level of credit when using the credit-to-GDP gap as a measure of vulnerability

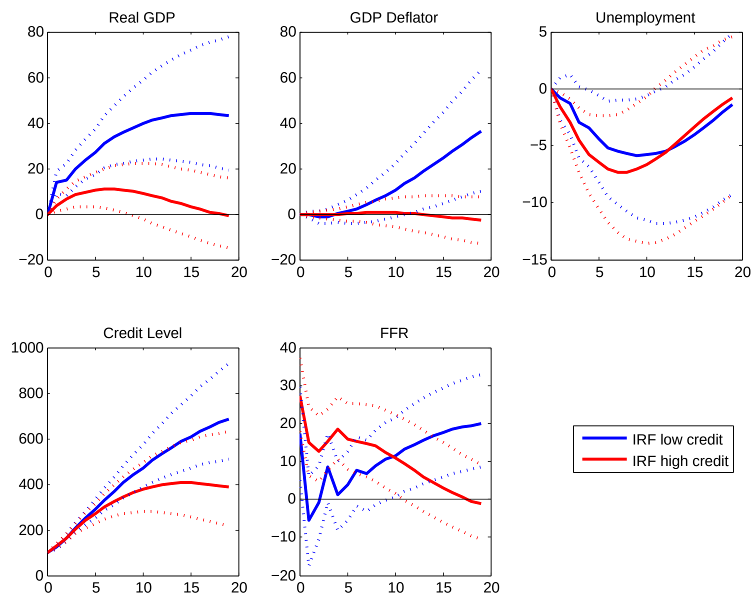


Figure 11: Shock to monetary policy in a system with the level of credit, using the credit-to-GDP gap as a measure of vulnerability

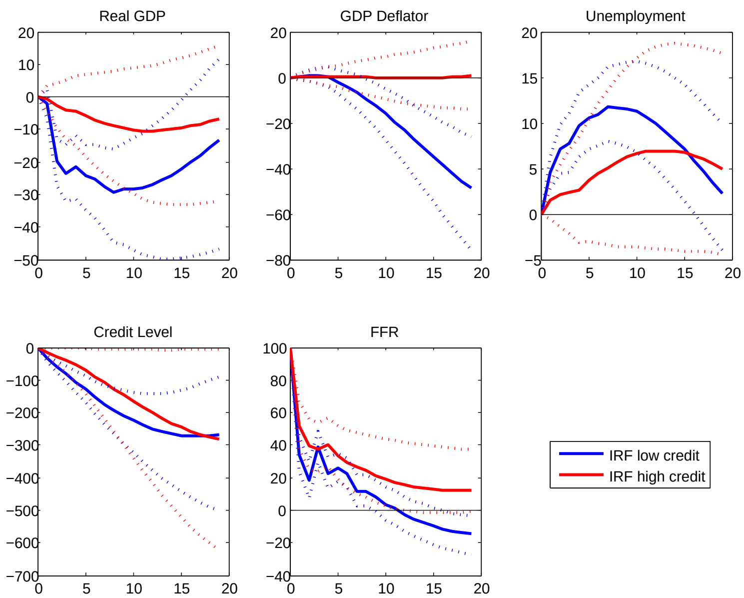


Figure 12: Credit shock using potential GDP to estimate the credit-to-GDP gap

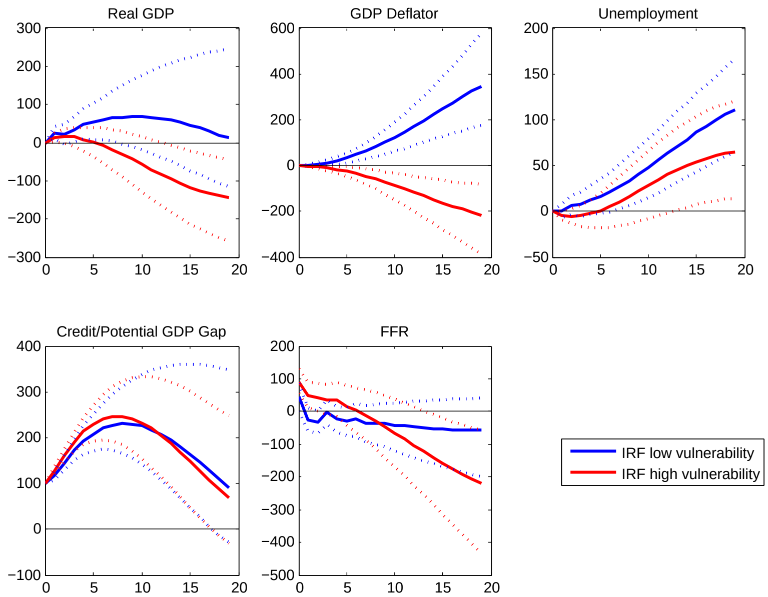


Figure 13: Response to a shock to household credit in a system with the credit-to-GDP gap disaggregated between household and business credit.

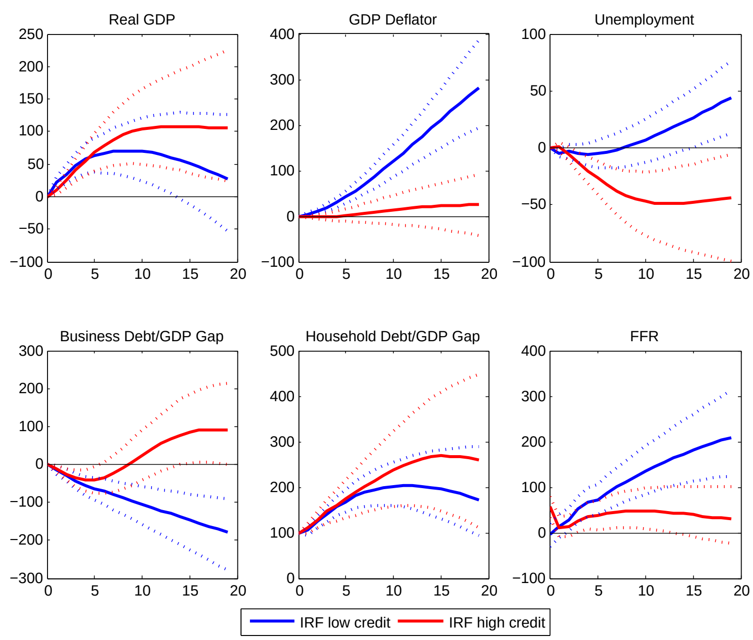


Figure 14: Response to a shock to business credit in a system with the credit-to-GDP gap disaggregated between household and business credit.

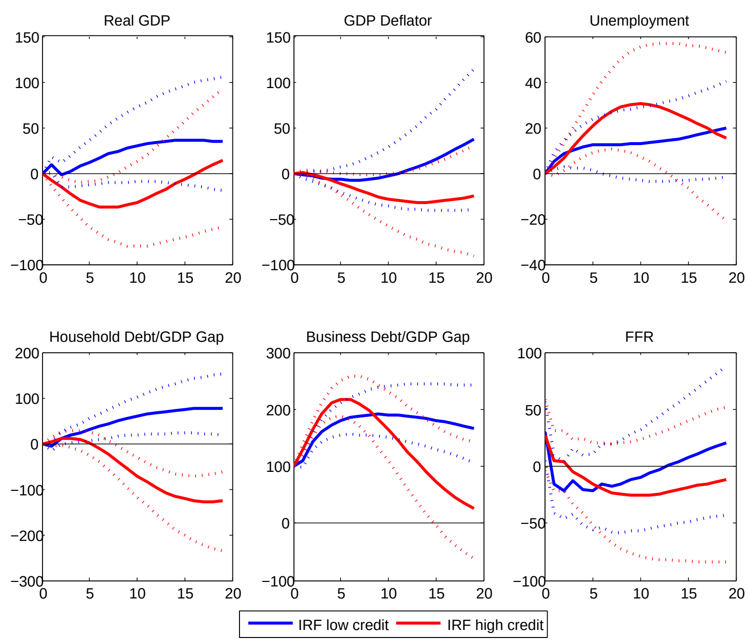


Figure 15: Impulse response to a monetary policy shock when the sample is divided into periods of increasing credit-to-GDP gap (red lines) and decreasing credit-to-GDP gap (blue lines).

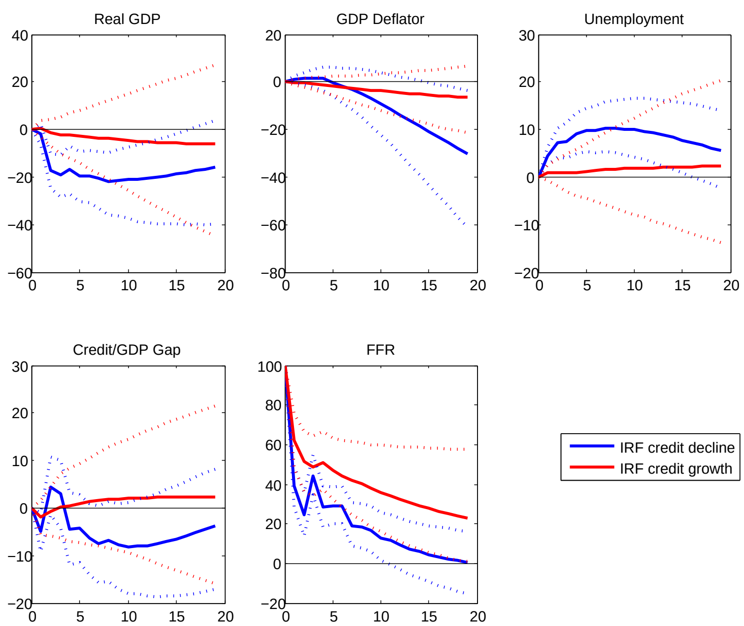


Figure 16: Impulse responses to a shock to our constructed measure of risk appetite (ALLM)

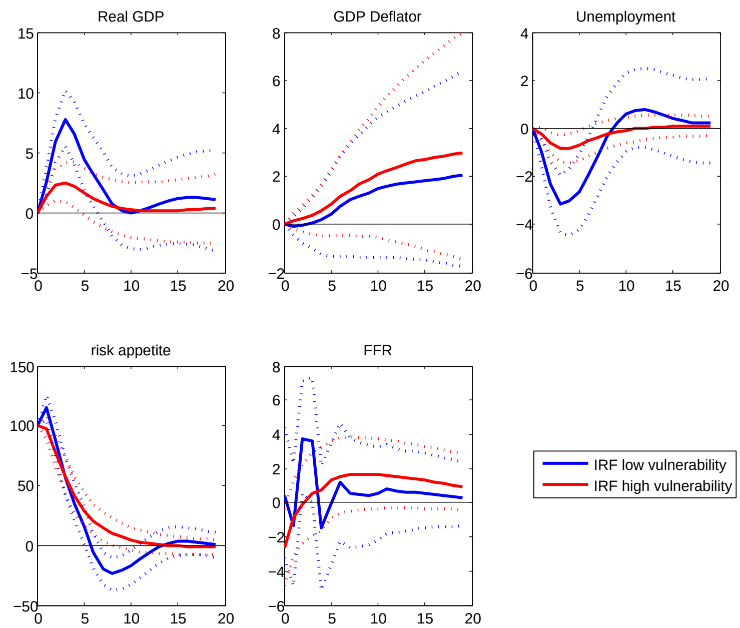


Figure 17: Impulse responses to a shock to the negative excess bond premium (EBP)

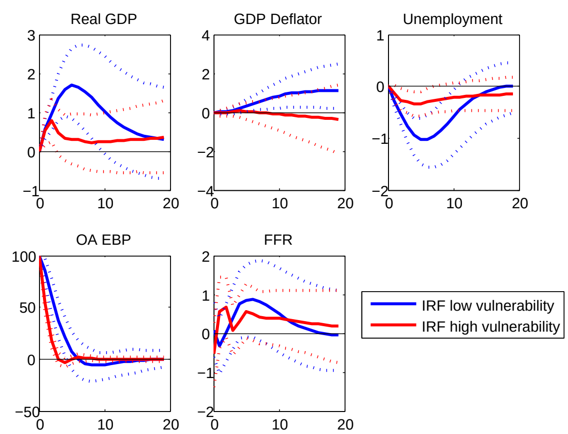


Figure 18: Impulse responses to a shock to our constructed measure of risk appetite, ALLM (in a system containing the credit-to-GDP gap where high/low vulnerability periods are defined using the aggregate credit-to-GDP gap).

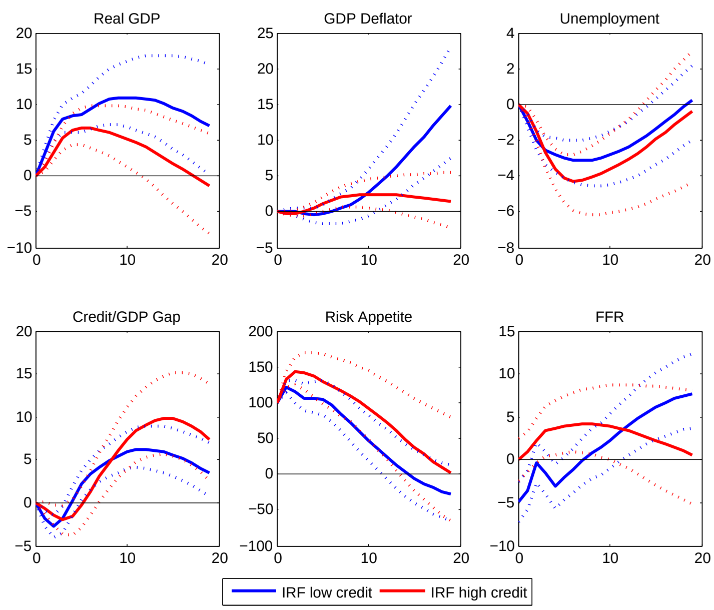


Figure 19: Impulse responses to a shock to our leverage measure, AE

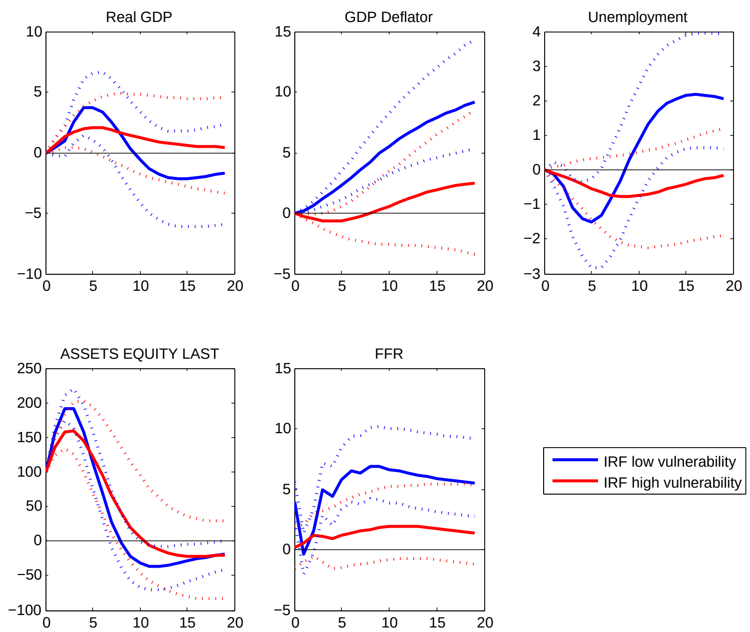


Figure 20: Impulse responses to a shock to runnable liabilities estimated over the full sample.

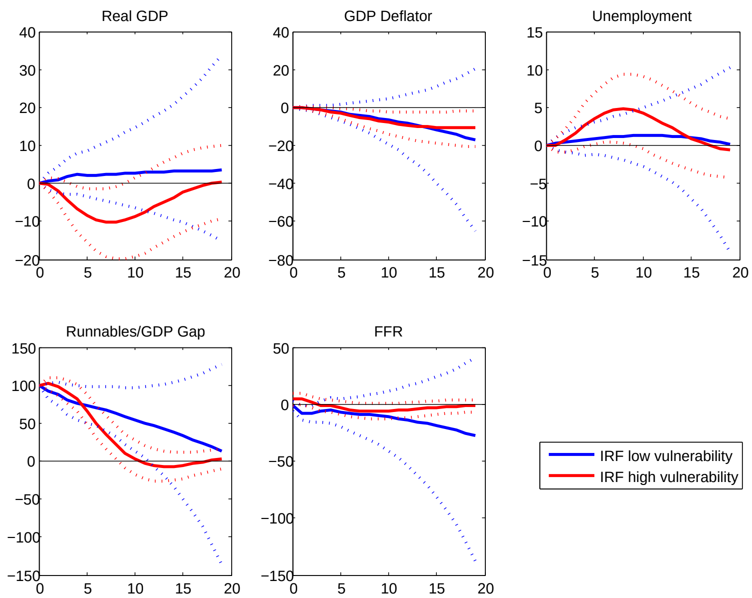


Figure 21: Impulse responses to a shock to runnable liabilities estimated over the sample after the Bankruptcy Amendments Act of 1984 (1985:Q1–2014:Q4).