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Nina Boyarchenko
Domenico Giannone
Anna Kovner

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Abstract

We study the relationship between bank capital ratios and the distribution of future real GDP growth. Growth in the aggregate bank capital ratio corresponds to a smaller left tail of GDP—smaller crisis probability—but at the cost of a smaller right tail of growth outcomes—smaller probability of exuberant growth. This trade-off persists at horizons of up to eight quarters, highlighting the long-range consequences of changes in bank capital. We show that the predictive information in bank capital ratio growth is over and above that contained in real credit growth, suggesting importance for bank capital beyond supplying credit to the nonfinancial sector. Our results suggest that coordination between macroprudential and monetary policy is crucial for supporting stable growth.

Key words: capital ratios, growth-at-risk, quantile regressions, threshold regressions

Boyarchenko: Federal Reserve Bank of New York, CEPR (email: nina.boyarchenko@ny.frb.org). Kovner: Federal Reserve Bank of New York (email: anna.kovner@ny.frb.org). Giannone: Amazon.com (email: giannond@amazon.com). The authors thank Patrick Adams, Beryl Larson, and Eric Qiang for providing excellent research assistance. This publication and its contents are not related to Amazon and do not reflect the position of the company and its subsidiaries. The views expressed in this paper are those of the authors and do not necessarily represent the position of the Federal Reserve Bank of New York or the Federal Reserve System.

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1 Introduction

“Higher levels of bank capital mitigate the risk and adverse effects of a financial crisis but raise the cost of intermediation in normal times.”

[Seven questions for Janet Yellen on financial stability](#), Brookings, 2019.

Since the financial crisis, the theoretical macro-finance literature¹ has argued for the importance of bank capital in reducing downside risk of future economic growth. We offer an empirical counterpart to that work by studying the empirical relationship between realized bank capital growth and future real GDP growth. We find that increased bank capital predicts lower downside risk to the economy but also lower probability of explosive growth. Notably, while increasing capital cuts off the expected tails of the predicted GDP growth distribution, it has limited effects on the median.

A key contribution of our work is to consider the relationship between capital and the full distribution of economic outcomes, rather than just the relationship at the mean or in the left tail. In this way, we are able to evaluate simultaneously both the potential benefits of capital increases – through the reduction of downside risk – and the potential costs – through the reduction of either mean growth or upside risk to growth. We find that capital ratio growth helps predict the distribution of real GDP growth, even after controlling for real credit growth. Higher capital ratio growth is associated with reduced downside and upside risks to growth, with little effect on median outcomes. Thus, the trade-off from higher capital ratio growth is lower upside growth potential (the cost) against lower downside risk (the benefit). This trade-off varies with the forecast horizon, with the benefit from reduced downside risk increasing with the forecast horizon (and persisting for up to 8 quarters), so that the net benefit of higher capital ratio growth is clearly positive in the short run and is likely somewhat more substantial at longer horizons.

¹See e.g. He and Krishnamurthy (2012); Brunnermeier and Sannikov (2014); Gertler and Kiyotaki (2015); Adrian and Boyarchenko (2012) and the literature within.

Figure 1. GDP growth and lagged capital growth. This figure plots average four-quarter-ahead real GDP growth and realized one year average capital ratio growth. Observations shaded in red correspond to NBER recession quarters. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. Lines show the regressions estimated at the 5th and 95th percentiles as well as the median and median estimated regression lines.

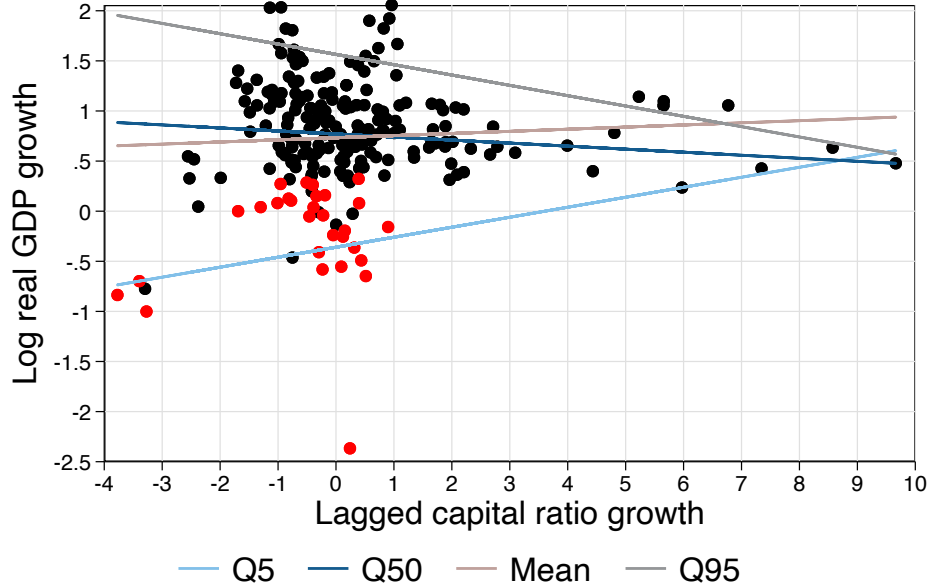


Figure 1 illustrates our baseline result, which shows the scatter plot of average four-quarter-ahead real GDP growth against realized one year average capital ratio growth, together with the (univariate) quantile regression lines for the 5th, 50th, and 95th quantiles and the OLS regression line. While the bottom fifth quantile of future real GDP growth is positively associated with capital ratio growth (as can be seen in the positive slope of the Q5 line), the top fifth quantile is negatively associated with capital ratio growth (seen from the negative slope of the Q95 line), and the median is mostly unaffected by capital ratio growth (seen from the flat median line and the flat OLS line).

We focus on understanding the overall effect of capital ratio growth on the distribution of real GDP growth. However, we also explore these results in an expanded model which includes real credit growth as a predictor. Even after controlling for real credit growth, we

find that increases in bank capital robustly predict increases in the left tail of real GDP growth and decreases in the right tail of real GDP growth. In this expanded model, the estimated coefficients on capital ratio growth have the interpretation of capturing the direct impact capital ratio growth on the predicted conditional moments of future real GDP growth over and above the indirect impact of capital that occurs through credit. Our work thus contributes also to the empirical literature (see e.g. Schularick and Taylor, 2012; Brunnermeier, Palia, Sastry, and Sims, 2017; Greenwood and Hanson, 2013, and the literature within) on the relationship between credit growth and real outcomes. By considering the full distribution of the relationship between capital, credit and outcomes, we add insights both to the work of Brunnermeier et al. (2017), which looks at the mean relationship between credit and outcomes, Jordà, Schularick, and Taylor (2013), which focuses on the relationship between credit and GDP conditional on recessions, and Jordà, Richter, Schularick, and Taylor (2017), which considers the duration of recessions conditional on capital growth.

When credit growth is high, it shifts the GDP distribution to the right but at the cost of expanding the left tail. Our results suggest that capital growth can play a key role as it is associated with less risk on the downside, although also sacrificing the right tail as well. This result is intuitive. As has been highlighted in prior literature (Mian and Sufi, 2009; Schularick and Taylor, 2012; Krishnamurthy and Muir, 2017), a build-up of credit makes the economy vulnerable to future shocks. Higher bank capital mitigates these risks by reducing the amount of deleveraging that banks need to do during a downturn. At the same time, in the right tail of the growth distribution, higher bank capital raises the overall cost of funding for banks, limiting their ability to fund exuberant economic growth.

However, the result that there is no strong relationship between capital and GDP at the median is surprising. Micro evidence finds that increases in capital requirements are associated with contractions in bank credit supply, at least over the short to medium run (Behn, Haselmann, and Wachtel, 2016; Gropp, Mosk, Ongena, and Wix, 2019; Fraise, Lé, and Thesmar, 2020; De Jonghe, Dewachter, and Ongena, 2020). Identifying the effect of

capital on bank credit supply is difficult because higher loan demand can increase capital endogenously via higher profits and retained earnings. These studies hold demand entirely constant by comparing lending to the same firm by banks facing different capital requirements. While magnitudes vary, all find significant negative quantity or positive price effects from higher capital requirements.

Our results suggest that these micro effects do not add up to a large aggregate GDP effect. This could be due to a number of factors. First, banks are not the only providers of credit to non-financial corporations. In fact, in the U.S., bank loans represented only 35 percent of total credit extended to non-financial corporations in 2019, with debt instruments such as commercial paper and corporate bonds representing the other 65 percent. Thus, any aggregate decreases in bank loans could simply be offset by increases in debt instrument issuances. Second, banks do not necessarily ration credit proportionally across the full distribution of borrowers. If increases in capital lead banks to reduce credit provision to less productive, riskier borrowers, the impact on average growth is likely to be small, while reducing both the downside to growth due to bank exposure to riskier borrowers and the upside to growth that arises from the possibility of these riskier projects actually paying off. Consistent with this hypothesis, we find that higher realized capital ratio growth does reduce both the median and the top fifth percentile of future real credit growth, suggesting that higher capital ratios may induce banks to reduce excessive credit provision. Finally, periods of economic expansion can correspond to both credit and capital growth, with banks building capital through retained earnings without sacrificing credit provision.

A caveat to the lack of impact of higher capital on aggregate average growth is that we would not expect this relationship to hold if capital were increased infinitely. The estimates in this paper correspond to capital ratio ranges between 5.5 and 12.9 percent, which are substantially lower than the 20 – 25 percent capital ratios² observed pre-WWII. In addition, although it is plausible that in the U.S. market-intermediated credit substitutes somewhat

²See Mitchell (1984) and Walter (2019).

for decreases in bank-intermediated credit, corporate bond and other market debt issuance is supported to some extent by banks. Many nonbank financial intermediaries are intimately related to banks, either because major corporate bond underwriters are g as subsidiaries of regulated bank holding companies or because banks finance nonbank financial intermediaries.

A potential caveat to the analysis could that capital may be endogenous, which would suggest that increases in bank capital follow recessions. As we will see in Figure 3c, however, that does not appear to be a feature of the U.S. data. In fact, the fraction of periods with capital increases is similar across recessionary and expansionary sub-samples. This likely reflects the fact that changes in capital are also determined by changes in bank regulation which are not directly correlated with changes in GDP. Further, historical bank capital regulation in the U.S. was focused around capital standards where the binding ratio was often not an equity measures, which meant that even in the boom of the 2000s, bank equity capital was falling.

The rest of the paper is organized as follows. We describe the dataset construction in Section 2. Section 3 describes the baseline relationship between capital and the conditional distribution of future growth, and Section 4 explores the robustness of those results. We explore the joint relationship between capital, credit and growth in Section 5. We draw policy conclusions in Section 6. Additional results are relegated to the Appendix.

2 Data

2.1 Real outcomes

We measure real outcomes using average log real GDP growth over h quarters, defined as

$$\Delta \log \text{GDP}_{t,t+h} \equiv \frac{\log \text{GDP}_{t+h} - \log \text{GDP}_t}{h}.$$

Figure 2a plots the time series of log real GDP, and Figure 3a the time series of quarter-over-quarter log real GDP growth. We focus primarily on average four-quarter-ahead ($h = 4$) growth, as reflecting the medium term evolution of real outcomes most likely to be relevant for decisions of both economic agents and policy makers.

2.2 Credit data

We measure credit as the sum of the open market paper, corporate bonds, and total loans on the liabilities-side of the domestic non-financial sector’s balance sheet in Flow of Funds Table L.100. This departs from the measures used in the literature in two ways. First, we include both loans and debt instruments, instead of focusing on credit provision through loans only. This is a particularly salient point for the U.S. as debt securities represent an increasing fraction of total non-financial borrowing. Second, we focus on debt *borrowed* by the domestic non-financial sector rather than non-financial sector debt *held* by the domestic banking sector, reflecting the gradual shift to greater provision of credit by non-bank financial intermediaries. Using the broad measure of domestic non-financial credit thus allows us to understand the relationship between capital, credit, and real GDP more generally.

We convert the nominal credit series to real terms using the CPI. Figure 2b plots the resultant times series of (log) total real credit extended to the domestic non-financial sector. As with real GDP, we compute the quarter-over-quarter growth rate of log real credit to remove trends in the series. The growth rate of log real credit is plotted in Figure 3b.

2.3 Bank capital data

There a number of trade-offs between compiling a long, consistent time series of data on bank capital and having the right data to understand the relationship between capital, capital requirements and real economic outcomes. The metric most commonly used and for which the longest, consistent time series exist across different countries is the aggregate

ratio of equity to assets.³ We depart from that approach to capture the current regulatory requirements and the extent of intermediation by nonbanks. First, we supplement the panel of commercial banks with data on Bank Holding Companies (BHCs) beginning in 1975. In this way, we sacrifice consistency in panel composition in order to capture more nonbank intermediaries such as broker dealers.⁴ Second, we paste together different measures of equity and assets in order to approximate current capital requirements which are based on Common Equity Tier 1 (CET1) (series begins in 2014) and risk weighted assets (begins in 1996).⁵

The resulting series is shown in Figure 2c. For comparison, a time consistent series constructed only with commercial banks and using total equity over assets is shown in Appendix Figure A.1a. Bank business models and regulatory requirements have changed dramatically over the last century. Therefore, rather than examining levels, we compute year-over-year (i.e. four quarter) growth rate of the capital ratio

$$\Delta \text{capital ratio}_{t-4,t} = 100 \times \frac{\text{capital ratio}_t - \text{capital ratio}_{t-4}}{4 \times \text{capital ratio}_{t-4}},$$

plotted in Figure 3c.⁶ When estimating our regressions, we omit observations corresponding to definitional breaks in the data: between Q1 1996 and Q4 1996 (transition to risk-weighted assets); between Q2 2001 and Q4 2001 (Tier 1 Capital replaced with proxy for CET1); and between Q1 2014 and Q3 2014 (transition to CET1).

³For example, Jordà et al. (2017) construct a series approximating Tier 1 capital which they normalize by total assets. Prior to 1984, they approximate the difference between equity capital and Tier 1 capital to be constant at 1.9%.

⁴We do this by aggregating U.S. regulatory data on BHCs filing the Y-9C with data from call reports on commercial banks without a top holder, and commercial banks with top holders that do not file the Y-9C. This measure will capture broker dealers that are subsidiaries of bank holding companies, however it will not include stand alone broker dealers. This series is not a consistent panel in the following ways: 1) Y-9C reporting cutoff increases to 500 million in assets in 2006, 1 billion in 2015, and 3 billion in 2018 2) broker-dealers and other financial intermediaries are added to sample as institutions become BHCs after financial crisis (e.g. Goldman Sachs and Morgan Stanley), 3) addition of thrifts to series as thrifts begin to file call reports in 2012.

⁵Prior to 1996 we use Total Equity Capital. After 1996, we use Tier 1 Risk Based Capital. In 2001 we begin to approximate Tier 1 Common Equity, and starting in 2014 we use CET1. We use total assets through 1996 and RWA thereafter as the denominator.

⁶Appendix Figure A.1b plots the year-over-year growth rate of the time consistent series constructed only with commercial banks and using total equity over assets.

2.4 Sample

We use the longest available sample for our estimation, which is constrained by the availability of capital ratio data. Our main estimation sample thus starts in Q1 1961 (since our capital ratio data is available starting Q1 1960). Though we report predicted quantiles for all the available dates in our sample, we exclude 2020 observations from our estimation for two reasons. First, the declines in real GDP in Q1 and Q2 2020 due to the COVID-19 pandemic fall conceptually outside of the parameters of our study: it is hard to argue that higher bank capital ratios could have prevented the pandemic. Second, the unprecedented scope of public policy response to the pandemic may overturn the historical relationships between bank capital and credit growth, and credit growth and real GDP growth, with multiple Federal Reserve facilities supporting credit provision to the non-financial sector.

2.5 Caveats

When evaluating the relationship between bank capital and macroeconomic outcomes, there is no obvious right measure of capital to use. Bank capital may impact aggregate growth through a lending channel – equity allows banks access to uninsured debt and thus limits the effects of a fall in deposits on lending. To the extent that there are regulatory capital requirements and an imperfect market for bank equity, there is an additional capital channel where banks reduce lending in downturns in order to meet regulatory requirements, since raising new equity is costly. In the first case, solvency is the limiting factor, suggesting a capital ratio measure such as equity to assets. The second channel lends itself to a capital measure that analyzes capital in excess of regulatory constraints.⁷ The question is particularly salient when trying to compile a long time series of data and variation over time not just on the level of capital requirements, but the type of capital requirement. For example, the financial crisis revealed ex-post that investors valued common equity ratios as a measure of

⁷We leave aside questions about whether it is the aggregate amount of bank capital that matters, or if it matters how the capital is distributed across banks.

solvency in contrast to capital requirements which were binding on total capital, a measure which included loss absorbing capital other than equity such as subordinated debt with a long maturity.

In the analysis, we present results based on changes in equity ratios with adjustments to build a long time series that converges to CET1 / risk weighted assets. By using changes we hope to both capture the way in which marginal additional capital affects GDP as well as to estimate counterfactuals that approximate changes to capital requirements.⁸ This implicitly assumes that changes to capital requirements are the same as changes to actual capital. If changes to bank buffers to regulatory capital are state dependent, for example, drawing relationships between this analysis and capital requirements is more difficult. For example, the assumption that capital ratios change with capital requirements seems plausible if capital requirements increase, but may be less plausible requirements they are lowered in a recession as envisioned by the Countercyclical Capital Buffer (CCyB).⁹ We do not have a long enough time series to estimate if the coefficients on changes in bank capital ratios are symmetric.

Finally, the relationships documented between capital and real outcomes may reflect omitted variables rather than a causal link between capital and GDP. Several material factors have changed over time along with bank capital including: nonbank provision of credit, the amount of bank supervision and the amount of bank competition. Additional possible omitted variables include changes in the separation of ownership and control as banks are increasingly publicly traded (Jensen and Meckling, 1976) as well as changing economies of scale (Hughes and Mester, 2013). To the extent that these changes are correlated with changes in bank capital, our results will be biased.

⁸We estimate an alternative version using capital ratios in levels, and demeaning to adjust for regime and definitional changes. Those results are qualitatively similar.

⁹It is worth noting that the micro evidence that establishes a negative relationship between bank lending and bank capital is primarily established with data points on increases in bank capital, not decreases.

3 Non-linear relationship between capital and growth

We are interested in studying the relationship between capital ratio growth and the full conditional distribution of real GDP growth. We follow Adrian, Boyarchenko, and Giannone (2019) in characterizing the conditional distribution of future real GDP growth using quantile regressions. In particular, for each horizon h , we parametrize the τ quantile of average log real GDP over h quarters as

$$Q_\tau(\Delta \log \text{GDP}_{t,t+h}) = \alpha_{\tau,h} + \beta_{\tau,h}^g \Delta \log \text{GDP}_{t-1,t} + \beta_{\tau,h}^k \Delta \text{capital ratio}_{t-4,t} + \epsilon_{\tau,h,t}, \quad (1)$$

with $\beta_{\tau,h}^k$ – the relationship between one year realized capital ratio growth and the τ^{th} quantile of average log real GDP over the next h quarters – our coefficients of interest. Here and in the rest of the paper, we focus mostly on the conditional distribution of four quarter average log real GDP growth but study how the relationship between capital ratio growth and future real GDP growth changes across horizons in Section 3.2.

3.1 Baseline results

We begin by estimating as a baseline the relationships between capital ratio growth and the distribution of average real GDP growth over the following four quarters. Table 1 reports the estimated coefficients from the Q5 (Table 1a), Q50 (Table 1b) and Q95 (Table 1c) quantile regressions of four quarter average log real GDP growth on lagged real GDP growth and lagged capital ratio growth. Consider first the estimates for Q5 regression, which captures the evolution of downside risks to growth. Table 1a shows that the capital ratio growth is positively related to the left tail of future real GDP growth: when past capital ratio growth is higher, the bottom fifth percentile of four quarter ahead average log real GDP growth is less negative. The estimated quantile coefficient on capital ratio growth is both statistically and economically significant, with a one percentage point increase in capital

ratio growth corresponding to a 0.08 improvement in the left tail of log real GDP growth over the following year (or, approximately, a 1 percentage point improvement in the left tail of real GDP growth). Comparing our baseline specification with the specification that only uses realized real GDP growth to predict the distribution of future real GDP growth (Column 1), we see that including capital ratio growth more than doubles the pseudo R^2 of the Q5 regression, again highlighting the economic significance of capital ratio growth in predicting downside risks to future real GDP outcomes.

In contrast, Table 1b shows that capital ratio growth does not help with predicting the median of future real GDP growth, neither from the perspective of having a statistically significant coefficient nor from the perspective of increasing the pseudo R^2 of the quantile regression. As we discussed in the introduction, this result is perhaps surprising in the context of micro studies that have documented the negative effects of higher capital requirements on credit provision at individual banks.¹⁰ This may reflect that bank credit provision do not necessarily translate one-for-one into decreases in overall growth. We will come back to the question of the joint relationship between capital ratios, credit and growth in Section 5.

Turning to the right tail of real GDP growth outcomes, Table 1c shows that higher capital ratio growth is negatively related to the right tail of future real GDP growth: when capital ratio growth is higher, the top fifth percentile of four quarter average log real GDP growth is less positive. Although the estimated coefficient on capital ratio growth just misses out on being statistically significant, the estimated effect is economically significant, with a one percentage point increase in capital ratio growth corresponding to a 0.11 decline in the right tail of log real GDP growth over the following year (or, approximately, a 1.1 percentage point decline in the right tail of real GDP growth). That is, higher capital ratio growth improves downside risk to future real GDP growth but at the cost of (more than) one-for-one decrease in upside risk to future real GDP growth. Including capital ratio growth also more than

¹⁰Notice that, although not statistically significant, the estimated Q50 coefficient on realized capital ratio growth is negative, so that increases in capital ratio growth do correspond to decreases in median future real GDP growth.

doubles the pseudo R^2 of the Q95 regression (Column 1 vs Column 2), though, as has been noted in prior literature, the predictability of the top fifth quantile of average four-quarter-ahead real GDP growth is significantly smaller relative to the predictability of the bottom fifth quantile.

We evaluate more broadly the non-linear relationship between the predictor variables and future real GDP growth in Figure 4, which plots the estimated quantile coefficients across quantiles from the regression of average four quarter real GDP growth on lagged log real GDP growth and capital ratio growth. The figure also plots the 95 percent confidence bounds around the estimated coefficients, computed from 1000 bootstrapped samples. Considering first the estimated coefficients on lagged real GDP growth (left-most column), we see that the relationship between lagged GDP growth and future real GDP growth is mostly linear: the estimated coefficients are roughly equal across quantiles. Including additional predictors does not change the shape of the coefficients across quantiles, and does not decrease the significance of lagged real GDP growth in predicted median average four quarter ahead real GDP growth. In contrast, the right-most column of the figure shows that the relationship between lagged capital ratio growth and future real GDP growth is non-linear in both the left and the right tail of the real GDP growth distribution, with the coefficients on lagged capital ratio growth decreasing monotonically with the quantile and becoming negative around the 70th percentile. Thus, higher capital ratio growth does not improve the average real GDP growth outlook but does reduce uncertainty around the mean predicted growth.

Putting these estimates together, Figure 5 plots the predicted in-sample and out-of-sample distributions of average four quarter real GDP growth, together with the realized average four quarter real GDP growth.¹¹ The estimated distributions perform well in tracking realized outcomes, with the left tail (lower quantiles) of the predicted distributions more volatile than the right tail. In general, we see that the out-of-sample distribution tracks

¹¹We estimate expanding-window out-of-sample distributions, with the first out-of-sample distribution predicted using 10 years of data (up to Q1 1971). Distribution plotted in quarter t is the predicted distribution for average log real GDP growth between quarters $t+1$ and $t+4$. Realized four quarter average is the realized average log real GDP growth between quarters $t+1$ and $t+4$.

the in-sample distribution but, historically, has more uncertainty around the median (wider distance between the top and bottom fifth percentile).

Importantly, the out-of-sample distribution is more pessimistic about the predicted average real GDP growth during the global financial crisis than the in-sample distribution, with both a lower bottom fifth percentile and a lower top fifth percentile, suggesting that the real time distribution does not understate downside risks to the economy. Abrupt, regulation-driven increases in capital ratios lead to noticeable narrowing of the distribution, especially of the out-of-sample distribution, as can be seen in the early 1990s following the introduction of Basel I and in the 2010s following the recapitalization of the U.S. banking system in the wake of the financial crisis. This highlights that, while the out-of-sample estimates are remarkably close to the in-sample estimates, they are only valid over the range of capital ratio growth realizations “observed” by the estimator. As in any predictive model, the relationship between capital ratio changes and the conditional distribution of future growth outcomes may thus be substantially different for capital ratio changes substantially outside those experienced since the 1960s.

An alternative way of understanding the implications of changes to the capital ratio for the predicted real GDP growth distribution is to evaluate how the conditional distribution changes when we consider counterfactual realizations of capital ratio growth. Figure 6 considers a counterfactual exercise as of Q3 2007, where the counterfactual assumes capital ratio growth one standard deviation higher (-0.8% vs -1.7% realized; capital ratio 8.0% vs 7.7% realized). This counterfactual exercise can be interpreted as answering the question of what would the distribution of possible real GDP growth outcomes would have looked like if banks had paid out less dividends in Q3 2007, so that the banking system would have entered the 2007–2009 financial crisis with 30 basis points higher capital ratios. Figure 6 shows that the counterfactual distribution is significantly improved, with even the bottom fifth percentile of average real GDP growth four and eight quarters out positive.

3.2 Intertemporal trade-off

Overall, Table 1 and Figure 4 suggest a contemporaneous trade-off between the tails of the GDP growth distribution: Higher capital ratio growth reduces both the possibility of extreme negative and positive growth outcomes. We now investigate whether there is an additional intertemporal trade-off, plotting the estimated Q5, Q50, and Q95 coefficients across predictive horizons in Figure 7. Consider first the quantile coefficients on capital ratio growth, plotted in the bottom right corner. While the estimated fifth quantile coefficient on lagged capital ratio growth is relatively flat across horizons, the estimated ninety-fifth quantile coefficient decreases over horizons. Thus, the cost from increased capital ratio growth is highest for shorter predictive horizons, while the benefit is relatively constant across horizons. The figure thus shows that it is important to take into account the nonlinear relationship between lagged capital ratio growth and future real GDP growth even over longer horizons. The Q5 coefficient on capital ratio growth does not converge to the Q95 coefficient even up to 8 quarters ahead, and both coefficients remain different from 0. In contrast, the relationship between lagged GDP growth and future GDP growth appears linear, regardless of the horizon, and the estimated coefficients appear to be converging to 0.

3.3 Connection to the “growth-at-risk” literature

A number of recent papers (see e.g. Adrian et al., 2019; Adrian, Grinberg, Liang, and Malik, 2018; Ghysels, Iania, and Striaukas, 2018; Kiley, 2018, and related literature) study the conditional distribution of future real GDP growth and other economic outcomes as a function of an index of realized financial conditions. Our paper contributes to that literature by taking a step back from realized financial conditions to theoretically-suggested economic fundamentals that shape those financial conditions; namely, bank balance sheet health as captured by bank capital ratios. Our goal is not to necessarily provide a better predictor for the conditional distribution of future real GDP growth than aggregate financial conditions,

but rather to evaluate the fundamental mechanism proposed in theoretical macro-finance literature. If bank capital ratios are the primary determinant of financial conditions, which would be consistent with the findings of empirical intermediary asset pricing literature (see e.g. Adrian, Etula, and Muir, 2014a; Adrian, Moench, and Shin, 2014b, and the literature within), it would not be surprising to find that financial conditions are a better predictor of the conditional distribution of real outcomes as they would be more directly connected to real outcomes. Understanding the role that bank capital plays would, however, remain important in that scenario, corresponding to the fundamental mechanism generating the predictability of real outcomes by financial conditions. In addition, bank capital ratios can be affected through macroprudential regulation such as countercyclical capital buffers, while it may be harder to target the various components of an index of financial conditions.

4 Robustness

In this section, we explore the robustness of the relationship between realized capital ratio growth and the conditional distribution of future real GDP growth. We supplement the out-of-sample robustness exercise in Section 3 with two additional exercises: alternative measures of capital ratio growth and an alternative estimation approach.

4.1 Alternative measures of capital ratio growth

In Table 2, we report the estimated coefficients from quantile regression (1) for Q5, Q50, and Q95 of average four-quarter-ahead real GDP growth, expanded to include additional lags of capital ratio growth:

$$Q_\tau(\Delta \log \text{GDP}_{t,t+h}) = \alpha_{\tau,h} + \beta_{\tau,h}^g \Delta \log \text{GDP}_{t-1,t} + \sum_{l=1}^5 \beta_{\tau,l,h}^k \Delta \text{capital ratio}_{t-4l,t-4(l-1)} + \epsilon_{\tau,h,t},$$

with the number of lags included increasing as we move across columns in the table. Consistent with one year capital ratio growth predicting tails of the conditional distribution of

real GDP growth at longer horizons, including additional lags of capital ratio growth, if anything, increases both the point estimate and the statistical significance of the estimated coefficient on capital ratio growth over the last year (capital ratio growth from $t - 4$ to t) for both the Q5 and the Q95 regression. In our preferred longer-lag specification in Column (6), which includes the average capital ratio growth rate from year 5 to year 1 (capital ratio growth from $t - 20$ to $t - 4$), capital ratio growth over both the short and long run increases the bottom fifth quantile (smaller left tail) and decreases the top fifth quantile (smaller right tail) of the conditional distribution of future real GDP growth. For the bottom fifth quantile, adding the longer-run capital ratio growth increases the pseudo R^2 from 13% to 23%, while including the longer-run capital ratio growth in the Q95 regression increases the pseudo R^2 from 3% to 9%.

Overall, Table 2 confirms our baseline result: Higher realized capital ratio growth predicts a decrease in both the left and the right tail of the conditional distribution of average real GDP growth over the next four quarters but does not reliably predict changes in the median of the distribution. Additionally, in Appendix A, we show that our results are robust to using a different measure of capital ratio altogether: a time consistent series constructed only with commercial banks and using total equity over assets.

4.2 Alternative estimation approach

As argued in Adrian et al. (2019), quantile regressions provide a simple way for characterizing the entire conditional distribution. We now show that our results are genuine features of the data and are robust to the specific estimation method. Instead of quantile regression we estimate a distribution regression, which characterizes the conditional distribution through threshold regressions (Foresi and Peracchi, 1995). For a given threshold κ , we estimate a logistic regression for the probability of average four quarter ahead real GDP growth falling

at or below the threshold:

$$\mathbb{P}_t(\Delta \log GDP_{t,t+h} \leq \kappa) = \frac{\exp \{ \alpha_{\kappa,h} + \beta_{\kappa,h}^g \Delta \log GDP_{t-1,t} + \beta_{\kappa,h}^c \Delta \text{capital ratio}_{t-4,t} + \epsilon_{\kappa,h,t} \}}{1 + \exp \{ \alpha_{\kappa,h} + \beta_{\kappa,h}^g \Delta \log GDP_{t-1,t} + \beta_{\kappa,h}^c \Delta \text{capital ratio}_{t-4,t} + \epsilon_{\kappa,h,t} \}}.$$

Just as we can trace out the inverse cumulative distribution function by varying the quantile for which the quantile regression is estimated, estimating threshold regressions for different choices of κ traces out the cumulative distribution function and thus serves as a natural alternative estimation procedure. The relation between quantile regression and distribution regression is studied in Peracchi (2002) and Chernozhukov, Fernandez-Val, and Melly (2013).

Figure 8 plots the estimated coefficients across thresholds, together with heteroskedasticity-robust standard errors around the point estimate. Consistent with past real GDP growth having a linear relationship with four-quarter-ahead future real GDP growth, the coefficient on real GDP growth is roughly constant across cutoffs. Turning to the coefficients on capital ratio growth, the bottom right panel of Figure 8 shows that the estimated coefficients increase from negative to positive values as the threshold increases. This is again re-casting of our baseline result: Higher capital ratio growth lowers the probability of average four-quarter-ahead real GDP growth falling below a low threshold (below 25 - 50 bps) and lowers the probability of average four-quarter-ahead real GDP growth falling above a high threshold (above 100 - 125 bps). Thus, the threshold-regression estimation approach confirms that higher capital ratio growth predicts smaller left and right tails of the conditional distribution of future real GDP growth.

5 Capital, credit and growth

The previous sections establish that higher capital ratio growth robustly predicts decreases in both the left and the right tail of the conditional distribution of future real GDP growth but has little relationship to median growth. One potential channel through which capital affects growth is through credit provision, with higher bank capital ratio growth supporting

credit provision through both the making of loans and the underwriting of corporate debt instruments. We investigate this channel in this section.

5.1 Nonlinear relationship between capital and credit

Consider first the relationship between the conditional distribution of future credit growth and current capital ratio growth. As with the conditional distribution of future real GDP growth in Section 3, we parametrize the τ quantile of average log real GDP over h quarters as

$$Q_\tau(\Delta \log \text{credit}_{t,t+h}) = \alpha_{\tau,h} + \beta_{\tau,h}^g \Delta \log \text{GDP}_{t-1,t} + \beta_{\tau,h}^c \Delta \log \text{credit}_{t-1,t} \\ + \beta_{\tau,h}^k \Delta \text{capital ratio}_{t-4,t} + \epsilon_{\tau,h,t}.$$

Table 3 reports the estimated coefficients from the Q5, Q50, and Q95 quantile regressions of one, four and eight quarter average log real credit growth. Starting with the Q5 quantile regressions in Table 3a, short-run capital ratio growth does not reduce the left tail of future real credit growth while longer-run (capital ratio growth from years 5 to 1) capital ratio growth does, consistently across all three predictive horizons. That is, higher longer-run capital growth corresponds to less severe credit growth declines in downturns.

Tables 3b and 3c show, however, that the reduction in the left tail of the conditional distribution of future credit growth comes at the cost of a reduction in both the median and the right tail. Higher capital ratio growth over the past year predicts lower median real credit growth in the future, at up to 8 quarters out. Similarly, higher capital ratio growth over both the short-run and the long-run predicts lower Q95 of real credit growth in the future, at up to a year out. Appendix Table A.1 shows that higher capital ratio growth corresponds in particular to lower median bank credit growth and, more specifically, to lower median growth of loans provided to households.

Thus, overall, Table 3 shows that, consistent with the micro evidence in Behn et al. (2016);

Gropp et al. (2019); Fraisse et al. (2020); De Jonghe et al. (2020), higher capital ratio growth does correspond to lower modal credit growth in the future, shifting the distribution of future credit growth to the left and contracting the distribution around its mode. Taken together with the lack of a relationship between capital growth and the median of the conditional distribution of real GDP growth in the future, this is consistent with banks reducing credit provision to less productive firms when capital ratios rise.

5.2 Nonlinear relationship between credit, capital and growth

We now study whether capital ratio growth contains information about the conditional future distribution of real GDP growth beyond its impact on credit growth. In particular, we expand quantile regression specification (1) to include credit growth

$$Q_\tau(\Delta \log \text{GDP}_{t,t+h}) = \alpha_{\tau,h} + \beta_{\tau,h}^g \Delta \log \text{GDP}_{t-1,t} + \beta_{\tau,h}^c \Delta \log \text{credit}_{t-l,t} \\ + \beta_{\tau,h}^k \Delta \text{capital ratio}_{t-4,t} + \epsilon_{\tau,h,t},$$

for different choices of the horizon l over which credit growth is computed. Table 4 reports the estimated coefficients from the Q5, Q50, and Q95 quantile regressions, controlling for average credit growth over the previous quarter (Column 2), previous year (Column 3), previous 5 years (Column 4), and future year (Column 5). Across all these alternative specification, higher capital growth consistently predicts a smaller left tail and a smaller right tail of the conditional distribution of future real GDP growth. Thus, the capital ratio growth contains predictive information about the conditional distribution of future real GDP growth beyond predicting the distribution of credit growth outcomes. In other words, the results in Table 4 and, in particular, in Column (5) of Table 4, highlight that capital ratio growth reduces downside risk to real GDP growth over and above that generated by declines in future credit growth, suggesting that bank capital plays an additional role in the economy beyond supporting credit provision.

5.3 Linear relationships between credit, capital and growth

We conclude this section by relating our results to prior literature, examining the linear relationship between real outcomes, real credit growth and capital growth. This linear approach to studying the relationship between variables of interest is closely related to the approaches undertaken in Brunnermeier et al. (2017) and Jordà et al. (2017).

Credit, capital, and recessions Consider first the relationship between real credit and capital growth and the incidence of recessions. Similarly to Schularick and Taylor (2012) and Jordà et al. (2017), we estimate a logit model for the one-quarter-ahead probability of NBER recessions as a function of lags of log real credit growth and capital growth

$$\mathbb{P}(\text{Recession}_t) = \frac{\exp \left\{ \alpha + \sum_{l=1}^5 \beta_{l,c} \Delta \log \text{credit}_{t-1-l,t-l} + \sum_{l=1}^5 \beta_{l,k} \Delta \text{capital ratio}_{t-4-l,t-l} + \epsilon_t \right\}}{1 + \exp \left\{ \alpha + \sum_{l=1}^5 \beta_{l,c} \Delta \log \text{credit}_{t-1-l,t-l} + \sum_{l=1}^5 \beta_{l,k} \Delta \text{capital ratio}_{t-4-l,t-l} + \epsilon_t \right\}}.$$

Notice that, if recessions occurred whenever one year real GDP growth dropped below a constant cut-off, this recession logit would correspond exactly to the threshold regressions in Section 4.

Table 5a reports the estimated coefficients of the logit regression excluding and including the capital growth terms, respectively. Consider first the estimated coefficients of the logit regression with only real credit growth as predictors. Column (1) confirms the basic result of Schularick and Taylor (2012): while higher credit growth decreases the probability of a recession in the short-run (at the year-quarter horizon), higher credit growth increases the probability of recessions in the long-run (at the one to five year horizon). Considering the predictive power of capital growth for future recessions, Column (2) of Table 5a shows that higher capital growth decreases the probability of recessions in both the short- and the long-run. Comparing the pseudo R^2 across Columns (1) and (2), we see that capital growth has somewhat better predictive power, corresponding to a pseudo R^2 of 20% relative to the 15% pseudo R^2 from the regression with credit growth. Finally, Column (3) shows that,

controlling for capital growth, the long-run effect of credit growth is no longer statistically-significant, while the effect of capital growth is only slightly attenuated when controlling for credit growth. That is, as with Table 4, Table 5a suggests that capital ratio growth contains information about tail real GDP growth outcomes over and above that contained in real credit growth.

This is in contrast to the results in Jordà et al. (2017), who do not find a relationship between bank capital levels and financial crises. There are important differences, however, between their exercise and ours. First, Jordà et al. (2017) focus on predicting *financial crises* rather than recessions, using a long-history cross-country panel to overcome the small sample of financial crises in any individual country. We focus on predicting NBER recessions as there are only two financial crises in our sample, only one of which corresponds to a recession.¹² Second, reflecting the higher frequency of the data available in our sample for the U.S., we use quarterly observations, while Jordà et al. (2017) use annual observations. Thus, it is possible that the one-quarter ahead predictive power of capital growth for recessions that we document in Column (2) of Table 5 is masked in the annual regressions of Jordà et al. (2017). Finally, we measure credit as total credit borrowed by the domestic non-financial sector through loans and corporate bonds. In contrast, Jordà et al. (2017) measure credit as the loans made to the non-financial sector that are held by banks. This is a particularly salient distinction for the U.S., both as corporate bonds represent an increasingly important source of funding for U.S. corporations and as non-bank financial institutions hold an increasingly larger share of non-financial sector overall debt. Similarly, as we discussed above, while Jordà et al. (2017) measure capital as the ratio of (approximate) Tier 1 capital to total assets for the entire sample, we use a subperiod-specific but regulation consistent definition of the capital ratio.

¹²In addition, from a theoretical perspective (see e.g. He and Krishnamurthy, 2012; Brunnermeier and Sannikov, 2014; Adrian and Boyarchenko, 2012), it is not clear that bank capital should only matter for predicting financial crises and not recessions more generally.

Credit, capital, and average growth As argued by Brunnermeier et al. (2017), conditioning on recessionary episodes may overstate the detrimental role of credit for growth – and, by extension, understate the benefits of capital growth – as such an approach overlooks any benefits of credit in fueling economic expansions. To that end, we estimate a linear relationship between four quarter average log real GDP growth and lags of log real GDP growth, log real credit growth, and capital growth

$$\begin{aligned}\Delta \log \text{GDP}_{t,t+4} = & \alpha + \sum_{l=1}^5 \beta_{l,g} \Delta \log \text{GDP}_{t-1-l,t-l} + \sum_{l=1}^5 \beta_{l,c} \Delta \log \text{credit}_{t-1-l,t-l} \\ & + \sum_{l=1}^5 \beta_{l,k} \Delta \text{capital ratio}_{t-4-l,t-l} + \epsilon_t.\end{aligned}$$

Table 5b reports the estimated coefficients of the OLS regression excluding and including the capital growth terms, respectively. Considering once again the specification without capital growth first, Column (1) shows that real credit growth is positively related to future real GDP growth in the short-run and negatively related to future real GDP in the long-run. That is, higher credit growth is associated in the longer-run with higher recession probabilities and lower average growth but positive growth outcomes in the shorter-run. Adrian et al. (2018) find a similar reversal in the estimated relationship between credit and real GDP growth across forecast horizons.

Turning to the impact of capital growth on average real GDP growth, Columns (2) and (3) show that capital ratio growth is not related in a statistically significant way to future real GDP growth and, indeed, does not improve the explanatory power of the linear regression. Thus, while capital ratio growth is informative about the possibility of extreme negative outcomes of real GDP growth, looking here at average realizations, it has little predictive power even in the short-run. This again echoes our results from Section 3: higher capital ratio growth corresponds to a smaller left tail of future real GDP growth but has little impact on the center of the conditional growth distribution.

6 Conclusion

In this paper, we documented that higher capital ratio growth corresponds to a narrowing of the conditional distribution of future real GDP growth around the median. Capital ratio growth supports future real GDP growth over and above its effect of credit growth, suggesting a broader role of bank capital in the economy beyond fueling credit growth.

To understand the implications of our results for countercyclical capital policies, we review the theoretical justifications for countercyclical capital buffers. In financial intermediary general equilibrium models, countercyclical capital requirements act by reducing the cyclical nature of banks' ability to take on leverage and thus serve two roles. First, during expansions, countercyclical capital requirements are raised to reduce banks' ability to expand assets and take on greater leverage. During expansions, higher capital requirements thus serve to restrain over-exuberant lending. Second, during contractions, countercyclical capital requirements are lowered, reducing banks' need to shrink their balance sheets thus moderating reductions in bank loans.

In terms of our empirical set up, the activation of a countercyclical capital requirement would lead to higher capital ratios (positive capital ratio growth), reducing both the left and the right tail of the real GDP growth distribution. On the other hand, the release of the buffer during downturns would lead to lower capital ratios (negative capital ratio growth), making the future distribution of real GDP growth more fragile. Of course this latter effect assumes that changes to capital requirements lead to changes in bank capital ratios, which may not be a realistic assumption if bank managers choose to maintain higher capital during recessions as a projection of strength to investors. An additional caveat to this comes from the fact the estimated relationships between capital growth and GDP growth are based on historical data.

More broadly, our results highlight the complex interactions between bank capital ratios and public policies aimed at supporting economic growth. Our results show that capital ratio

growth has predictive power for the tails of future real GDP growth even after controlling for realized future credit growth. Thus, policies that support credit growth may be ineffectual in preventing economic downturns if they are not accompanied by regulations to ensure that financial intermediaries are well capitalized.

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Table 1: Predicting GDP tail outcomes. This table reports the coefficients from a quarterly quantile regression of average four quarter log log real GDP growth on lags of log real GDP growth and bank equity ratios. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. Bootstrapped standard errors included in parentheses below the point estimates.

(a) Q5		
	(1)	(2)
Constant	-0.35 (0.17)**	-0.39 (0.09)***
Lag log real GDP growth	0.27 (0.11)**	0.23 (0.10)**
Y1 lag capital ratio growth		0.08 (0.03)***
Pseudo R^2	0.06	0.13
N. obs	230	230
(b) Q50		
	(1)	(2)
Constant	0.59 (0.05)***	0.59 (0.06)***
Lag log real GDP growth	0.22 (0.05)***	0.22 (0.05)***
Y1 lag capital ratio growth		-0.02 (0.02)
Pseudo R^2	0.06	0.06
N. obs	230	230
(c) Q95		
	(1)	(2)
Constant	1.56 (0.12)***	1.53 (0.11)***
Lag log real GDP growth	0.05 (0.09)	0.11 (0.09)
Y1 lag capital ratio growth		-0.11 (0.07)
Pseudo R^2	0.01	0.03
N. obs	230	230

Table 2: Predicting GDP tail outcomes: alternative measures of capital growth. This table reports the coefficients from a quarterly quantile regression of average four quarter log real GDP growth on lags of log real GDP growth, real credit growth and bank equity ratios. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. Bootstrapped standard errors included in parentheses below the point estimates.

(a) Q5

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.39 (0.10)***	-0.33 (0.09)***	-0.35 (0.07)***	-0.33 (0.07)***	-0.30 (0.06)***	-0.32 (0.06)***
Lag log real GDP growth	0.23 (0.10)**	0.22 (0.12)*	0.18 (0.12)	0.16 (0.12)	0.09 (0.12)	0.10 (0.11)
Annual growth	0.08 (0.03)***	0.08 (0.03)**	0.09 (0.03)***	0.10 (0.03)***	0.11 (0.03)***	0.11 (0.02)***
Y2 growth		0.04 (0.04)	0.01 (0.05)	0.02 (0.05)	0.03 (0.04)	
Y3 growth			0.05 (0.04)	0.05 (0.03)	0.07 (0.03)**	
Y4 growth				0.04 (0.04)	0.05 (0.03)*	
Y5 growth					0.07 (0.03)***	
Y5-Y1 growth						0.18 (0.03)***
Pseudo R^2	0.13	0.14	0.17	0.20	0.23	0.22
N. obs	230	226	222	218	214	214

(b) Q50

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.59 (0.06)***	0.56 (0.06)***	0.54 (0.06)***	0.53 (0.06)***	0.55 (0.05)***	0.56 (0.06)***
Lag log real GDP growth	0.22 (0.05)***	0.24 (0.05)***	0.25 (0.05)***	0.24 (0.05)***	0.24 (0.06)***	0.21 (0.05)***
Annual growth	-0.02 (0.02)	-0.02 (0.03)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.02 (0.02)
Y2 growth		0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	
Y3 growth			0.03 (0.03)	0.02 (0.03)	0.04 (0.03)	
Y4 growth				0.01 (0.02)	0.02 (0.03)	
Y5 growth					-0.05 (0.03)	
Y5-Y1 growth						0.01 (0.02)
Pseudo R^2	0.06	0.07	0.07	0.06	0.07	0.06
N. obs	230	226	222	218	214	214

(c) Q95

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	1.53 (0.11)***	1.47 (0.11)***	1.50 (0.10)***	1.50 (0.12)***	1.51 (0.11)***	1.50 (0.11)***
Lag log real GDP growth	0.11 (0.09)	0.14 (0.10)	0.12 (0.09)	0.13 (0.09)	0.11 (0.10)	0.15 (0.10)
Annual growth	-0.11 (0.07)	-0.12 (0.05)**	-0.14 (0.06)**	-0.07 (0.06)	-0.13 (0.07)*	-0.11 (0.07)
Y2 growth		-0.04 (0.05)	-0.05 (0.05)	-0.10 (0.06)	-0.07 (0.06)	
Y3 growth			-0.09 (0.07)	-0.02 (0.08)	-0.03 (0.09)	
Y4 growth				-0.07 (0.05)	-0.06 (0.07)	
Y5 growth					0.01 (0.06)	
Y5-Y1 growth						-0.04 (0.06)
Pseudo R^2	0.03	0.07	0.08	0.09	0.09	0.08
N. obs	230	226	222	218	214	214

Table 3: Predicting credit tail outcomes. This table reports the coefficients from a quarterly quantile regression of average four quarter log real credit growth on lags of log real GDP growth, real credit growth and bank equity ratios. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. Bootstrapped standard errors included in parentheses below the point estimates.

(a) Q5

	1Q		4Q		8Q	
	Baseline	With longer lags	Baseline	With longer lags	Baseline	With longer lags
Constant	-1.13 (0.16)***	-1.21 (0.15)***	-0.82 (0.14)***	-0.87 (0.13)***	-0.66 (0.09)***	-0.56 (0.08)***
Lag log real GDP growth	0.36 (0.25)	0.36 (0.25)	0.34 (0.12)***	0.30 (0.11)***	0.13 (0.12)	0.15 (0.08)*
Lag log real credit growth	0.40 (0.18)**	0.52 (0.19)***	0.51 (0.10)***	0.58 (0.11)***	0.34 (0.09)***	0.29 (0.08)***
Annual growth	-0.03 (0.07)	0.03 (0.07)	0.01 (0.05)	0.05 (0.05)	0.03 (0.03)	0.04 (0.02)*
Y5-Y1 growth		0.20 (0.06)***		0.17 (0.06)***		0.20 (0.03)***
Pseudo R^2	0.22	0.26	0.31	0.35	0.22	0.32
N. obs	230	214	230	214	227	211

(b) Q50

	1Q		4Q		8Q	
	Baseline	With longer lags	Baseline	With longer lags	Baseline	With longer lags
Constant	0.62 (0.19)***	0.59 (0.21)***	0.28 (0.11)**	0.22 (0.11)**	0.45 (0.09)***	0.45 (0.10)***
Lag log real GDP growth	0.41 (0.09)***	0.37 (0.10)***	0.31 (0.09)***	0.34 (0.09)***	0.23 (0.08)***	0.22 (0.08)***
Lag log real credit growth	0.15 (0.10)	0.15 (0.13)	0.45 (0.07)***	0.41 (0.07)***	0.37 (0.06)***	0.30 (0.06)***
Annual growth	-0.22 (0.07)***	-0.24 (0.08)***	-0.07 (0.04)*	-0.08 (0.03)**	-0.07 (0.04)*	-0.09 (0.03)***
Y5-Y1 growth		0.07 (0.07)		0.06 (0.05)		0.06 (0.04)
Pseudo R^2	0.19	0.19	0.32	0.30	0.24	0.23
N. obs	230	214	230	214	227	211

(c) Q95

	1Q		4Q		8Q	
	Baseline	With longer lags	Baseline	With longer lags	Baseline	With longer lags
Constant	1.57 (0.15)***	1.60 (0.13)***	1.26 (0.08)***	1.23 (0.07)***	1.49 (0.14)***	1.41 (0.15)***
Lag log real GDP growth	0.45 (0.12)***	0.28 (0.13)**	0.16 (0.05)***	0.12 (0.06)**	0.11 (0.07)	0.13 (0.10)
Lag log real credit growth	0.27 (0.11)**	0.40 (0.11)***	0.44 (0.05)***	0.48 (0.04)***	0.29 (0.08)***	0.30 (0.10)***
Annual growth	-0.22 (0.11)**	-0.23 (0.09)***	-0.15 (0.06)**	-0.11 (0.04)***	0.07 (0.09)	0.06 (0.09)
Y5-Y1 growth		-0.12 (0.07)*		-0.02 (0.03)		0.02 (0.08)
Pseudo R^2	0.15	0.19	0.29	0.35	0.17	0.21
N. obs	230	214	230	214	227	211

Table 4: Predicting GDP tail outcomes, controlling for credit growth. This table reports the coefficients from a quarterly quantile regression of average four quarter log real GDP growth on lags of log real GDP growth, real credit growth and bank equity ratios. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. Bootstrapped standard errors included in parentheses below the point estimates.

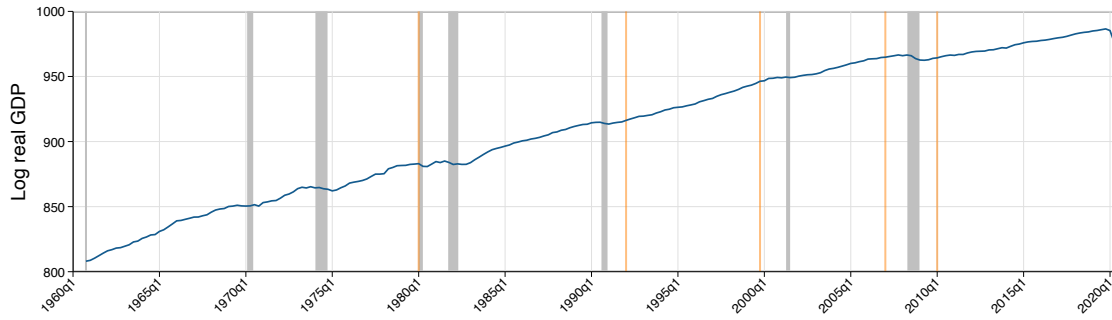
(a) Q5					
	(1)	(2)	(3)	(4)	(5)
Constant	-0.39 (0.09)***	-0.50 (0.09)***	-0.67 (0.10)***	-0.09 (0.19)	-0.46 (0.09)***
Lag log real GDP growth	0.23 (0.10)**	0.14 (0.05)***	0.08 (0.12)	0.11 (0.10)	0.11 (0.09)
Y1 lag capital ratio growth	0.08 (0.03)***	0.12 (0.02)***	0.18 (0.03)***	0.15 (0.03)***	0.13 (0.02)***
Q1 lag log real credit growth		0.32 (0.06)***			0.17 (0.10)
Y1 lag log real credit growth			0.51 (0.11)***	0.34 (0.13)**	
Y5-Y1 lag log real credit growth				-0.44 (0.15)***	
Realized log real credit growth					0.29 (0.09)***
Pseudo R^2	0.13	0.31	0.25	0.27	0.42
N. obs	230	230	230	214	230
(b) Q50					
	(1)	(2)	(3)	(4)	(5)
Constant	0.59 (0.06)***	0.49 (0.06)***	0.45 (0.07)***	0.54 (0.07)***	0.31 (0.08)***
Lag log real GDP growth	0.22 (0.05)***	0.15 (0.05)***	0.15 (0.05)***	0.15 (0.05)***	-0.01 (0.05)
Y1 lag capital ratio growth	-0.02 (0.02)	0.04 (0.03)	0.03 (0.03)	0.02 (0.02)	0.07 (0.02)***
Q1 lag log real credit growth		0.15 (0.04)***			-0.06 (0.05)
Y1 lag log real credit growth			0.19 (0.06)***	0.14 (0.05)**	
Y5-Y1 lag log real credit growth				-0.08 (0.05)	
Realized log real credit growth					0.52 (0.05)***
Pseudo R^2	0.06	0.11	0.10	0.08	0.27
N. obs	230	230	230	214	230
(c) Q95					
	(1)	(2)	(3)	(4)	(5)
Constant	1.53 (0.11)***	1.45 (0.15)***	1.35 (0.15)***	1.53 (0.25)***	1.09 (0.09)***
Lag log real GDP growth	0.11 (0.09)	0.05 (0.11)	0.06 (0.10)	0.15 (0.11)	-0.16 (0.09)*
Y1 lag capital ratio growth	-0.11 (0.07)	-0.05 (0.08)	-0.04 (0.08)	-0.10 (0.05)*	0.06 (0.06)
Q1 lag log real credit growth		0.11 (0.11)			-0.07 (0.08)
Y1 lag log real credit growth			0.18 (0.12)	0.03 (0.15)	
Y5-Y1 lag log real credit growth				-0.14 (0.19)	
Realized log real credit growth					0.60 (0.09)***
Pseudo R^2	0.03	0.05	0.05	0.07	0.26
N. obs	230	230	230	214	230

Table 5: Linear relationship between capital and real outcomes. This table reports the coefficients from a quarterly logit regression of NBER recession indicators on lags of real credit growth and bank equity ratios (Table 5a), and from a quarterly linear regression of average four quarter log real GDP growth on lags of log real GDP growth, real credit growth and capital ratio growth (Table 5b). Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Heteroskedasticity-robust standard errors included in parentheses below the point estimates.

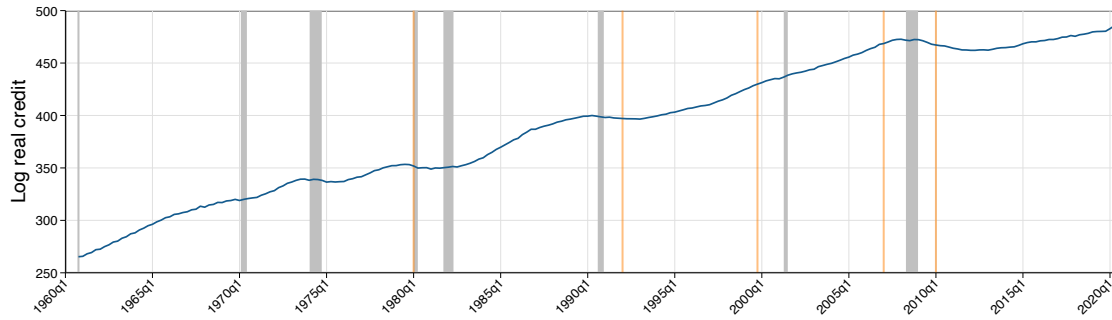
(a) Recession probability				(b) Average growth			
	(1)	(2)	(3)		(1)	(2)	(3)
Constant	-2.55 (0.41)***	-2.41 (0.32)***	-0.92 (0.69)	Constant	0.66 (0.09)***	0.56 (0.14)***	0.53 (0.13)***
L.Y1 log real credit growth	-1.12 (0.22)***		-1.98 (0.39)***	L.Y1 log real credit growth	0.14 (0.06)**		0.21 (0.07)***
L.Y5-Y1 log real credit growth	1.33 (0.34)***	-0.13	-1.13 (0.66)	L.Y5-Y1 log real credit growth	-0.18 (0.08)**		-0.23 (0.13)*
L.Y1 capital ratio growth		-0.52 (0.19)***	-1.01 (0.21)***	L.Y1 capital ratio growth		0.02 (0.03)	0.06 (0.03)**
L.Y5-Y1 capital ratio growth		-1.66 (0.41)***	-1.20 (0.50)**	L.Y5-Y1 capital ratio growth		0.05 (0.03)*	-0.01 (0.04)
Pseudo R^2	0.14	0.19	0.37	Adj. R^2	0.02	-0.01	0.03
N. obs	214	214	214	N. obs	214	214	214

Figure 2. Raw data. This figure plots the time series of log real GDP, log real credit, and aggregate capital ratio, together with NBER recession shadings and capital regulatory regime changes. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Notable breaks in the composition of the panel include changes to the Y-9C reporting cut-off to \$500 million in 2006q1, the change in charter of financial institutions in the wake of the financial crisis in 2009q1 (e.g. Goldman Sachs, Morgan Stanley), and the addition of thrifts to the time series as they begin filing call reports in 2012q1. Notable changes to the definition of capital ratios occur in 1996q2 where the denominator changes from total assets to risk weighted assets and in 2001q1 where the numerator changes to approximate CET1 from total equity capital. Capital regulatory regime changes defined as: 1970q1: Depository Institutions Deregulation and Monetary Control Act, 1992q1: Basel 1, 1999q4: Graham-Leach-Bliley, and 2010q1: Dodd Frank Act.

(a) Log real GDP



(b) Log real credit



(c) Equity capital ratio

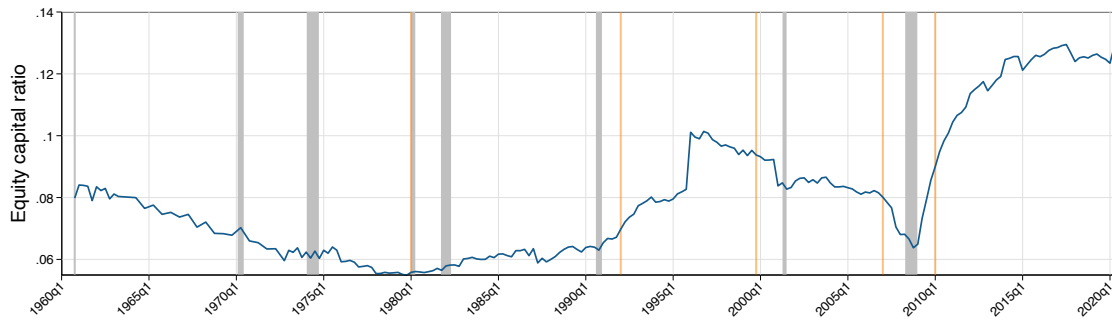
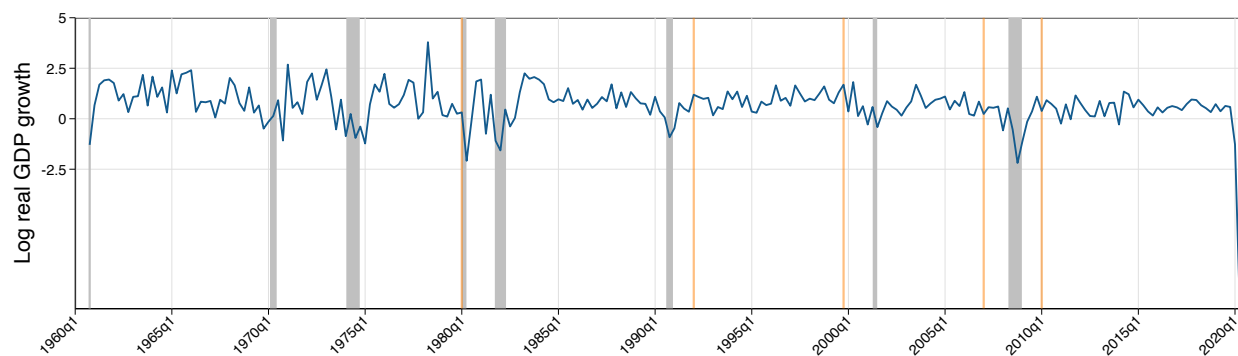
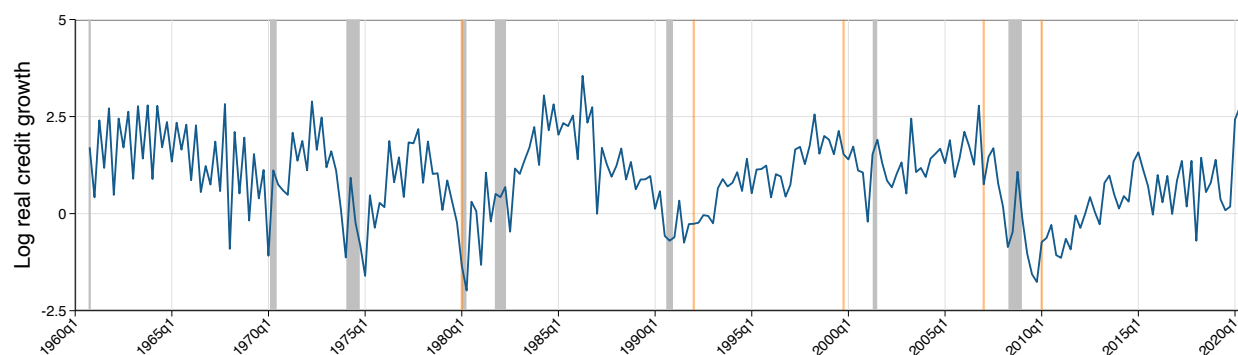


Figure 3. De-trended data. This figure plots the time series of the quarter-over-quarter growth rate of log real GDP and log real credit, and the year-over-year growth rate of equity capital ratio, together with NBER recession shadings and capital regulatory regime changes. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available.

(a) Log real GDP growth



(b) Log real credit growth



(c) Equity capital ratio growth

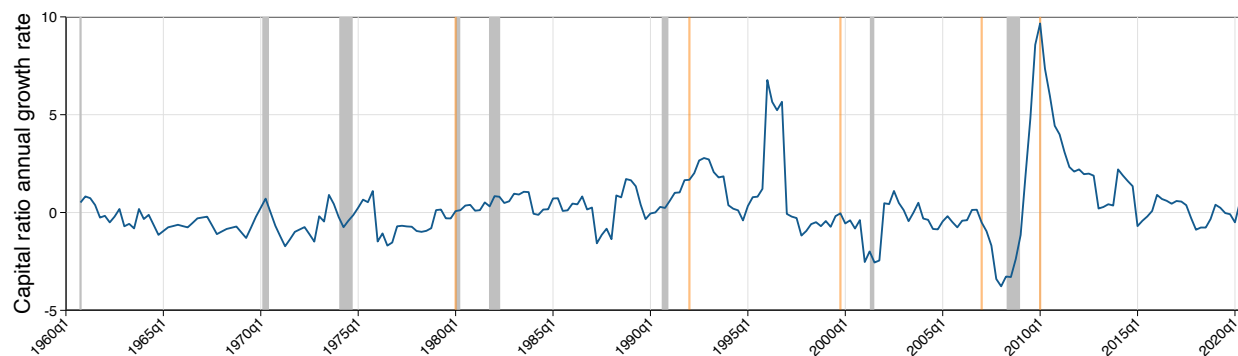


Figure 4. Estimated quantile regression coefficients. This figure plots the estimated coefficients in quantile regression of average four quarter log real GDP growth on lag of log real GDP growth and lagged capital ratio growth. First row corresponds to the model with lagged log real GDP growth only; second row to the full model. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. We report confidence bounds for the null hypothesis that the true data-generating process is a general, flexible linear model for log real GDP growth, and capital ratio growth (VAR with 4 lags); bounds are computed using 1000 bootstrapped samples.

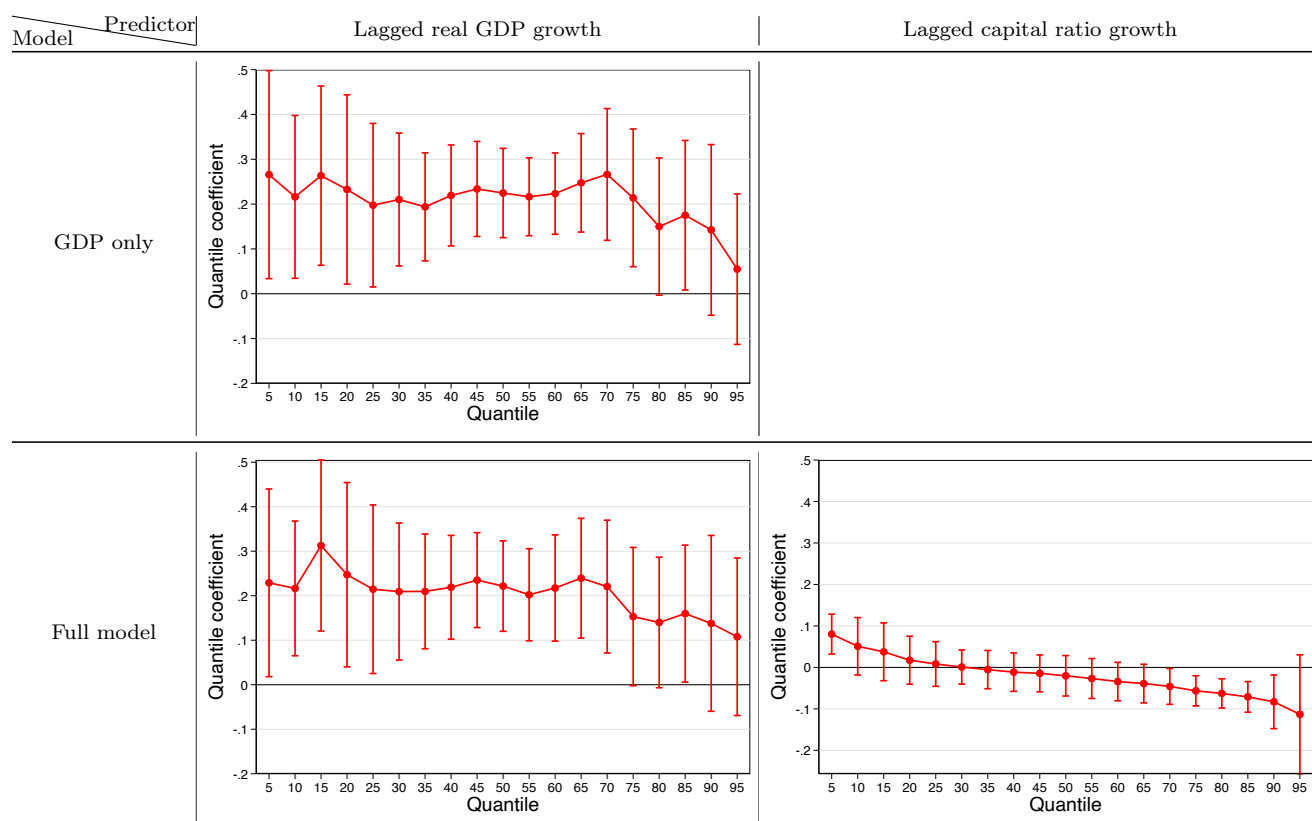


Figure 5. Predicted distributions. This figure plots the time series evolution of the predicted distribution of average four quarter log real GDP growth, together with NBER recession shadings and capital regulatory regime changes. Distribution predicted using lagged log real GDP growth and lagged capital ratio growth. Blue shaded area corresponds to the in-sample (5%, 95%) interquantile range; the red dashed lines correspond to the out-of-sample (5%, 95%) interquantile range. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms.

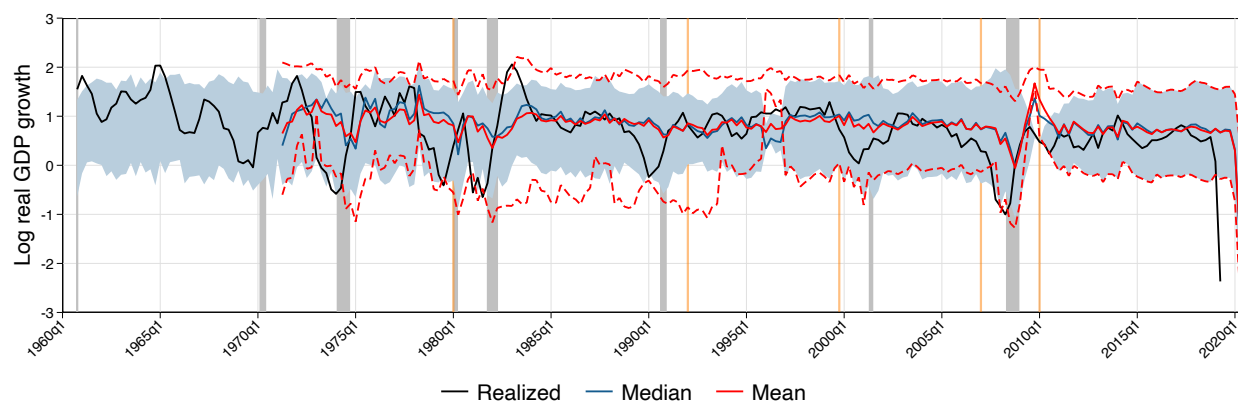
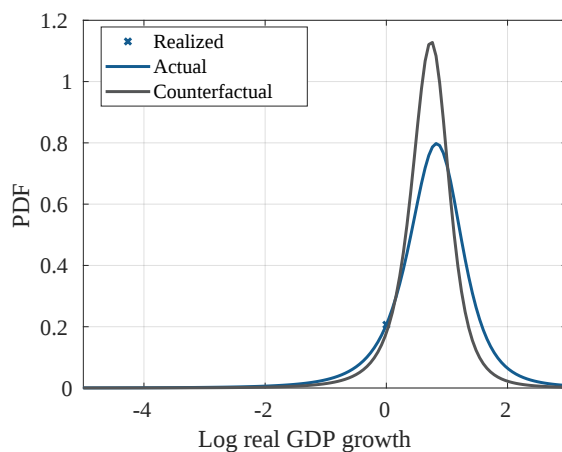


Figure 6. Effect of increasing capital growth ahead of the crisis. This figure plots the actual and counterfactual predicted distributions of average log real GDP growth over H quarters as of Q3 2007. Counterfactual distribution constructed under assumption of capital ratio growth one standard deviation higher than observed. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms.



Horizon	Q5		Median		Q95	
	Actual	Counterfactual	Actual	Counterfactual	Actual	Counterfactual
1Q	-0.83	-0.54	0.72	0.69	2.01	1.71
2Q	-0.49	-0.20	0.69	0.65	1.99	1.66
4Q	-0.40	-0.13	0.76	0.69	1.78	1.40
8Q	-0.18	0.04	0.76	0.70	1.47	1.31

Figure 7. Quantile regression coefficients across horizons. This figure plots the estimated coefficients in quantile regression of average real GDP growth over H quarters on lags of log real GDP growth and lagged capital ratio growth. First row corresponds to the model with lagged log real GDP growth only; second row to the full model. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms.

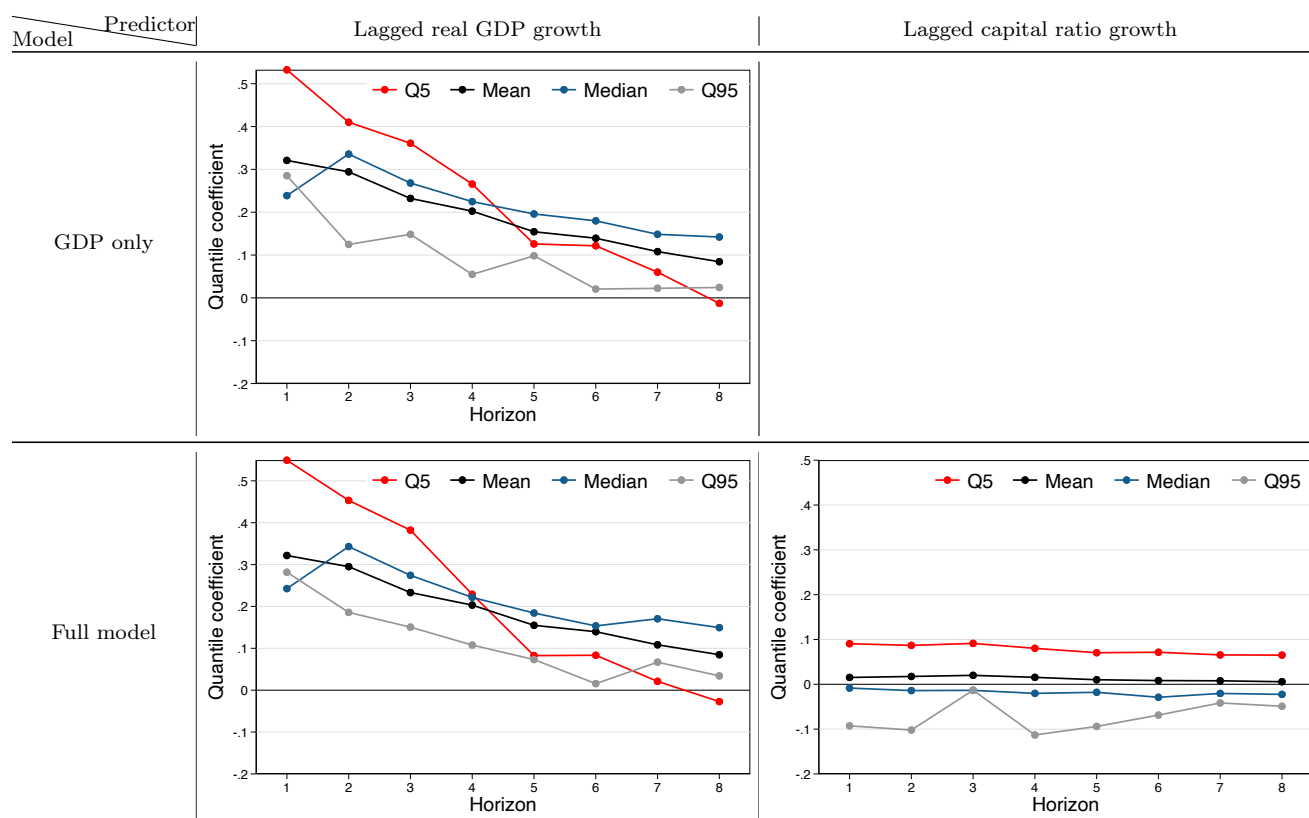
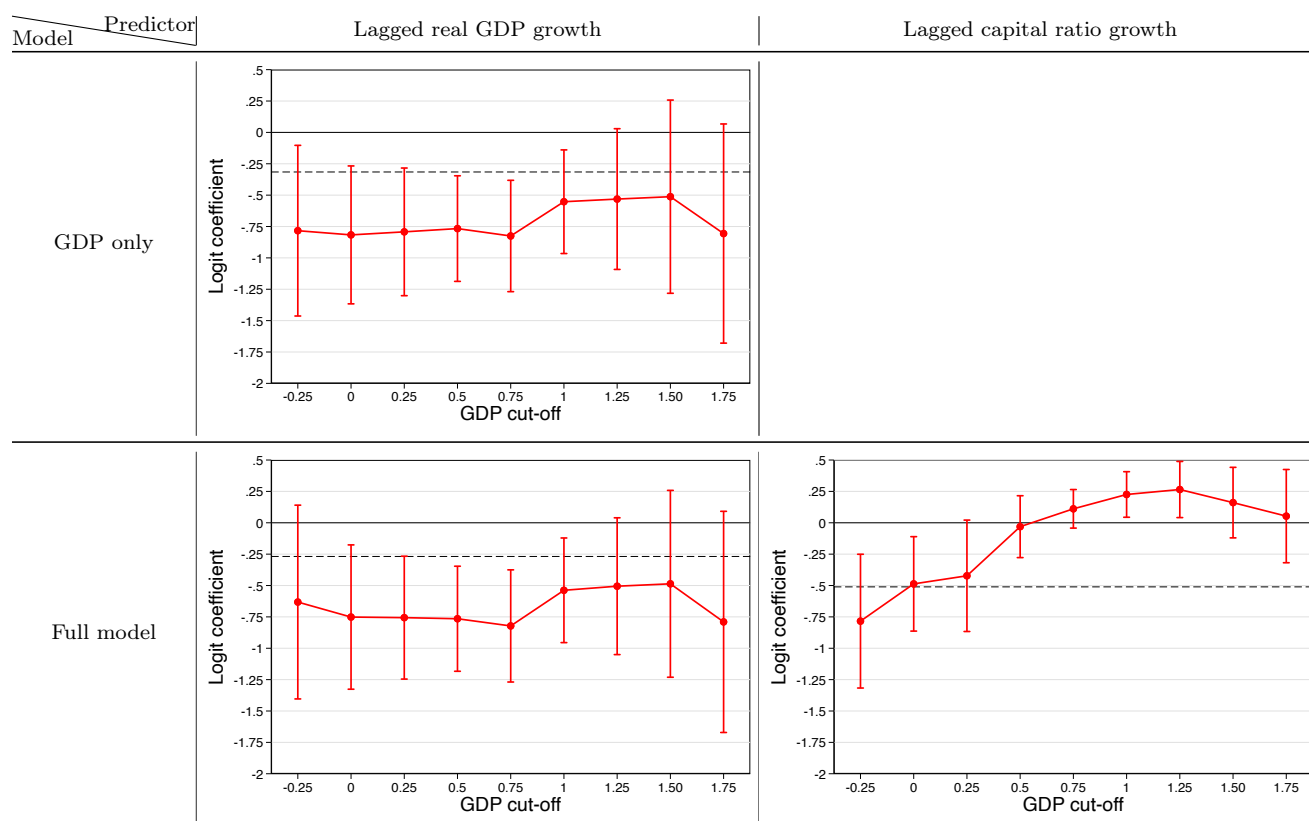


Figure 8. Threshold regression coefficients across thresholds. This figure plots the estimated coefficients in logit regression of average real GDP growth over 4 quarters falling below threshold τ on lags of log real GDP growth and lagged capital ratio growth. First row corresponds to the model with lagged log real GDP growth only; second row to the full model. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. Dashed line corresponds to estimate from a one-year-ahead logit regression of NBER recessions. 95% confidence bands based on heteroskedasticity-robust standard errors plotted as bars around point estimates.



A Additional results

In this appendix, we report additional results using total equity capital over total assets of commercial banks as the measure of the capital ratio. Briefly:

- Figure A.1 plots the time series of the capital ratio and the time series of year-over-year growth rate of the capital ratio for commercial banks
- Table A.3 reports the estimated coefficients from a logit regression of the probability of NBER recessions on lags of log real credit growth and capital ratio growth, and the estimated coefficients from an OLS regression of average four quarter real GDP growth on lags of log real GDP growth, log real credit growth, and capital ratio growth.
- Table A.2 reports the estimates from the Q5, Q50 and Q95 quantile regressions of average four quarter real GDP growth on lagged log real GDP growth, log real credit growth, and capital ratio growth.
- Figure A.3 plots the predicted in-sample and out-of-sample distribution, together with the realized average four quarter real GDP growth. The figure also plots the predicted in-sample and out-of-sample distributions for two alternative models: one that only uses lagged real GDP growth to predicted the distribution of future real GDP growth, and one that uses lagged real GDP growth and lagged real credit growth.
- Figure A.2 plots the estimated quantile coefficients across quantiles from the regression of average four quarter real GDP growth on lagged log real GDP growth, log real credit growth, and capital ratio growth. The figure also plot the confidence bounds for the null hypothesis that the true data-generating process is a VAR(4) for log real GDP growth, log real credit growth, and capital ratio growth.
- Figure A.4 plots 4 quarter-ahead distribution using realized data and using counterfactual realizations of capital ratio growth as of Q3 2007, counterfactual assumes capital ratio growth one standard deviation higher (2.4% vs -1% realized; capital ratio 10.6% vs 10.3% realized)
- Figure A.5 plots the estimated Q5, Q50 and Q95 quantile coefficients across predictive horizons.
- Figure A.6 plots the estimated coefficients from the threshold regressions.

Table A.1: Predicting components of real credit growth. This table reports the coefficients from a quarterly quantile regression of average four quarter log real credit growth on lags of log real GDP growth, real credit growth and bank equity ratios. Total credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity capital ratio transitions from the ratio between total equity capital and total assets to the current capital regulatory standard of T1 Common to Risk Weighted assets as comparable fields in regulatory data become available. Capital ratio growth measured in year-over-year terms. Bootstrapped standard errors included in parentheses below the point estimates.

(a) Q5

	Total	Bank credit	Non-bank credit	HH credit	Business credit	Business loans	Loans held	Bonds held
Constant	-0.82 (0.14)***	-0.89 (0.11)***	-0.90 (0.15)***	-0.92 (0.12)***	-1.26 (0.23)***	-1.50 (0.26)***	-1.82 (0.27)***	-3.59 (0.44)***
Lag log real GDP growth	0.34 (0.13)***	0.36 (0.12)***	0.10 (0.09)	0.23 (0.09)**	0.36 (0.25)	0.41 (0.28)	0.77 (0.26)***	0.31 (0.30)
Lag log real credit growth	0.51 (0.10)***	0.43 (0.10)***	0.47 (0.07)***	0.42 (0.15)***	0.71 (0.12)***	0.56 (0.09)***	0.29 (0.11)**	0.15 (0.08)*
Lag capital ratio growth	0.01 (0.05)	-0.02 (0.04)	0.08 (0.07)	-0.01 (0.04)	0.07 (0.07)	0.06 (0.07)	-0.09 (0.11)	-0.11 (0.21)
Pseudo R^2	0.31	0.33	0.22	0.18	0.32	0.39	0.21	0.09
N. obs	230	229	229	229	229	229	229	229

(b) Q50

	Total	Bank credit	Non-bank credit	HH credit	Business credit	Business loans	Loans held	Bonds held
Constant	0.28 (0.12)**	0.22 (0.13)*	0.44 (0.12)***	0.35 (0.12)***	0.34 (0.13)***	0.25 (0.18)	0.19 (0.15)	0.41 (0.47)
Lag log real GDP growth	0.31 (0.10)***	0.41 (0.10)***	0.13 (0.10)	0.23 (0.11)**	0.27 (0.09)***	0.51 (0.13)***	0.58 (0.13)***	-0.20 (0.43)
Lag log real credit growth	0.45 (0.06)***	0.42 (0.06)***	0.38 (0.06)***	0.45 (0.05)***	0.44 (0.06)***	0.46 (0.06)***	0.32 (0.08)***	0.23 (0.06)***
Lag capital ratio growth	-0.07 (0.04)*	-0.10 (0.04)**	0.07 (0.05)	-0.10 (0.04)***	-0.01 (0.05)	-0.08 (0.06)	-0.03 (0.07)	-0.27 (0.14)**
Pseudo R^2	0.32	0.33	0.18	0.31	0.33	0.32	0.23	0.08
N. obs	230	229	229	229	229	229	229	229

(c) Q95

	Total	Bank credit	Non-bank credit	HH credit	Business credit	Business loans	Loans held	Bonds held
Constant	1.26 (0.09)***	1.45 (0.09)***	1.64 (0.23)***	1.77 (0.12)***	1.34 (0.14)***	1.71 (0.17)***	1.55 (0.12)***	6.71 (0.96)***
Lag log real GDP growth	0.16 (0.05)***	0.28 (0.05)***	0.24 (0.22)	0.15 (0.13)	0.15 (0.08)*	0.19 (0.11)*	0.37 (0.14)***	-0.65 (0.59)
Lag log real credit growth	0.44 (0.06)***	0.27 (0.05)***	0.55 (0.11)***	0.33 (0.07)***	0.43 (0.10)***	0.32 (0.13)**	0.28 (0.06)***	0.11 (0.10)
Lag capital ratio growth	-0.15 (0.06)**	-0.22 (0.05)***	0.08 (0.13)	-0.14 (0.12)	-0.02 (0.07)	-0.27 (0.09)***	-0.14 (0.08)	-1.00 (0.27)***
Pseudo R^2	0.29	0.24	0.20	0.15	0.23	0.22	0.25	0.08
N. obs	230	229	229	229	229	229	229	229

Table A.2: Predicting GDP tail outcomes. This table reports the coefficients from a quarterly quantile regression of average four quarter log real GDP growth on lags of log real GDP growth, real credit growth and bank equity ratios. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity ratio constructed as total equity capital over total assets of commercial banks only. Capital ratio growth measured in year-over-year terms. Heteroskedasticity-robust standard errors included in parentheses below the point estimates.

(a) Q5						
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.35 (0.17)**	-0.34 (0.11)***	-0.65 (0.13)***	-0.55 (0.19)***	-0.06 (0.11)	-0.54 (0.15)***
Lag log real GDP growth	0.27 (0.11)**	0.22 (0.11)**	0.18 (0.06)***	0.11 (0.12)	0.08 (0.09)	0.07 (0.09)
Y1 lag capital ratio growth		0.24 (0.07)***	0.24 (0.06)***	0.27 (0.07)***	0.31 (0.08)***	0.11 (0.11)
Q1 lag log real credit growth			0.35 (0.08)***			0.22 (0.13)*
Y1 lag log real credit growth				0.30 (0.13)**	0.27 (0.12)**	
Y5-Y1 lag log real credit growth					-0.47 (0.14)***	
Realized log real credit growth						0.28 (0.12)**
Pseudo R^2	0.06	0.11	0.26	0.16	0.21	0.35
N. obs	230	230	230	230	214	230
(b) Q50						
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.59 (0.05)***	0.59 (0.06)***	0.52 (0.06)***	0.50 (0.07)***	0.57 (0.06)***	0.40 (0.06)***
Lag log real GDP growth	0.22 (0.05)***	0.22 (0.05)***	0.15 (0.06)**	0.19 (0.05)***	0.15 (0.05)***	0.03 (0.05)
Y1 lag capital ratio growth		-0.00 (0.03)	-0.00 (0.04)	0.01 (0.03)	0.03 (0.03)	-0.01 (0.03)
Q1 lag log real credit growth			0.13 (0.03)***			-0.11 (0.05)**
Y1 lag log real credit growth				0.12 (0.04)***	0.12 (0.04)***	
Y5-Y1 lag log real credit growth					-0.09 (0.05)*	
Realized log real credit growth						0.48 (0.07)***
Pseudo R^2	0.06	0.06	0.10	0.09	0.08	0.24
N. obs	230	230	230	230	214	230
(c) Q95						
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	1.56 (0.12)***	1.50 (0.12)***	1.50 (0.14)***	1.40 (0.16)***	1.57 (0.21)***	1.16 (0.08)***
Lag log real GDP growth	0.05 (0.09)	0.13 (0.09)	0.03 (0.10)	0.04 (0.09)	0.14 (0.11)	-0.10 (0.09)
Y1 lag capital ratio growth		-0.19 (0.07)***	-0.19 (0.09)**	-0.11 (0.10)	-0.24 (0.06)***	-0.02 (0.08)
Q1 lag log real credit growth			0.09 (0.09)			-0.14 (0.08)*
Y1 lag log real credit growth				0.16 (0.14)	-0.06 (0.11)	
Y5-Y1 lag log real credit growth					-0.12 (0.15)	
Realized log real credit growth						0.57 (0.08)***
Pseudo R^2	0.01	0.06	0.07	0.07	0.13	0.25
N. obs	230	230	230	230	214	230

Table A.3: Linear relationship between capital and real outcomes. This table reports the coefficients from a quarterly logit regression of NBER recession indicators on lags of real credit growth and bank equity ratios (Table A.3a), and from a quarterly linear regression of average four quarter log real GDP growth on lags of log real GDP growth, real credit growth and capital ratio growth (Table A.3b). Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity ratio constructed as total equity capital over total assets of commercial banks only. Heteroskedasticity-robust standard errors included in parentheses below the point estimates.

(a) Recession probability				(b) Average growth			
	(1)	(2)	(3)		(1)	(2)	(3)
Constant	-2.55 (0.41)***	-1.90 (0.22)***	-2.23 (0.45)***	Constant	0.66 (0.09)***	0.67 (0.12)***	0.68 (0.12)***
L.Y1 log real credit growth	-1.12 (0.22)***		-1.31 (0.29)***	L.Y1 log real credit growth	0.14 (0.06)**		0.16 (0.06)***
L.Y5-Y1 log real credit growth	1.33 (0.34)***		1.19 (0.41)***	L.Y5-Y1 log real credit growth	-0.18 (0.08)**		-0.19 (0.08)**
L.Y1 capital ratio growth		-0.02 (0.25)	-0.50 (0.25)**	L.Y1 capital ratio growth		-0.01 (0.03)	0.02 (0.04)
L.Y5-Y1 capital ratio growth		-1.09 (0.57)*	-0.38 (0.56)	L.Y5-Y1 capital ratio growth		0.01 (0.08)	-0.06 (0.09)
Pseudo R^2	0.14	0.04	0.17	Adj. R^2	0.02	-0.02	0.02
N. obs	214	214	214	N. obs	214	214	214

Figure A.1. Alternative measure of equity capital ratio. This figure plots the raw time series of the equity capital ratio and the year-over-year growth rate of equity capital ratio, together with NBER recession shadings and capital regulatory regime changes. Equity ratio constructed as total equity capital over total assets of commercial banks only. Source: Authors' calculations from Call Report data. Thrifts begin filing call reports as of 2012q1.

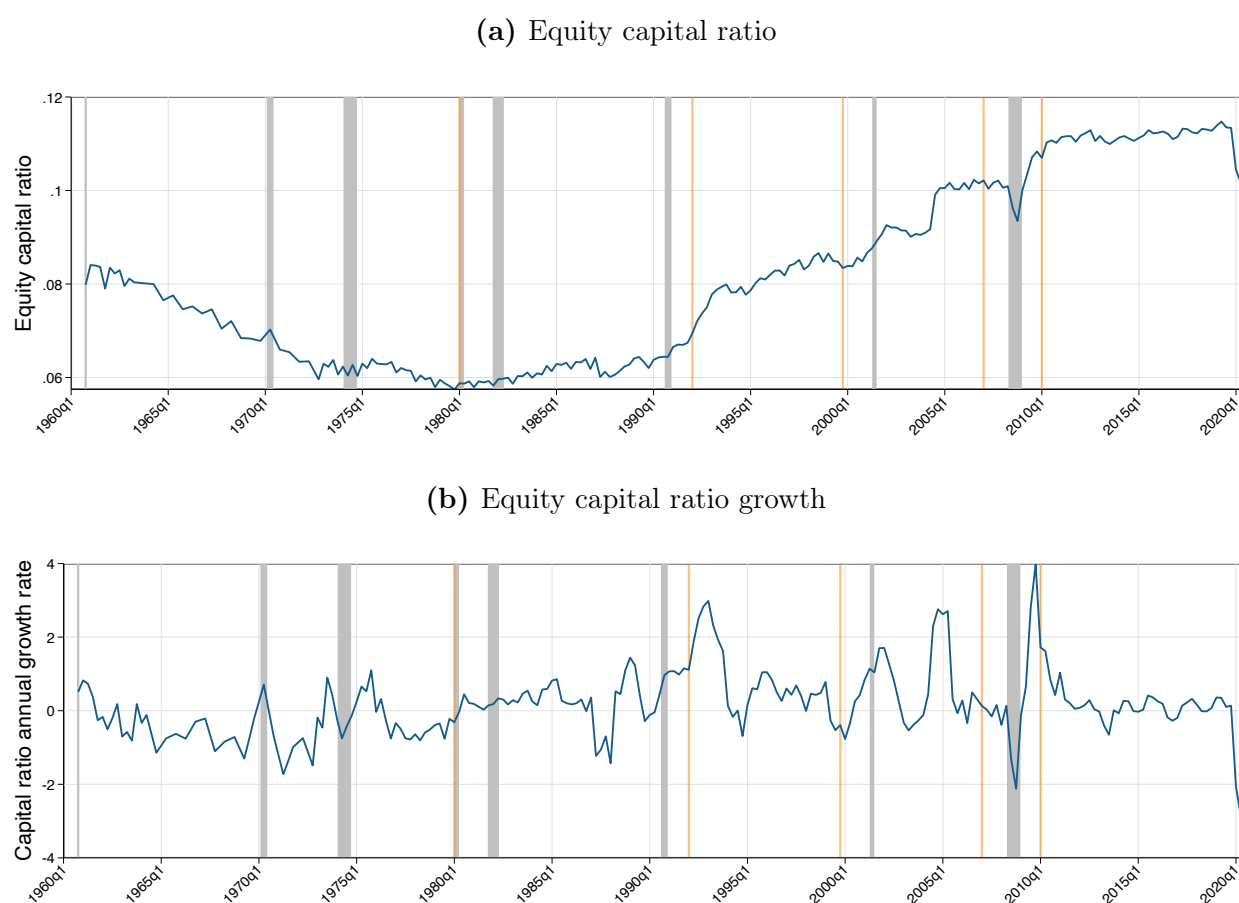


Figure A.2. Estimated quantile regression coefficients. This figure plots the estimated coefficients in quantile regression of average four quarter log real GDP growth on lag of log real GDP growth, log real credit growth, and capital ratio growth. First row corresponds to the model with lagged log real GDP growth only; second row to the model with lagged log real GDP and log real credit growth only; third row corresponds to the full model. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity ratio constructed as total equity capital over total assets of commercial banks in the U.S. economy. Capital ratio growth measured in year-over-year terms. We report confidence bounds for the null hypothesis that the true data-generating process is a general, flexible linear model for log real GDP growth, log real credit growth, and capital ratio growth (VAR with 4 lags); bounds are computed using 1000 bootstrapped samples.

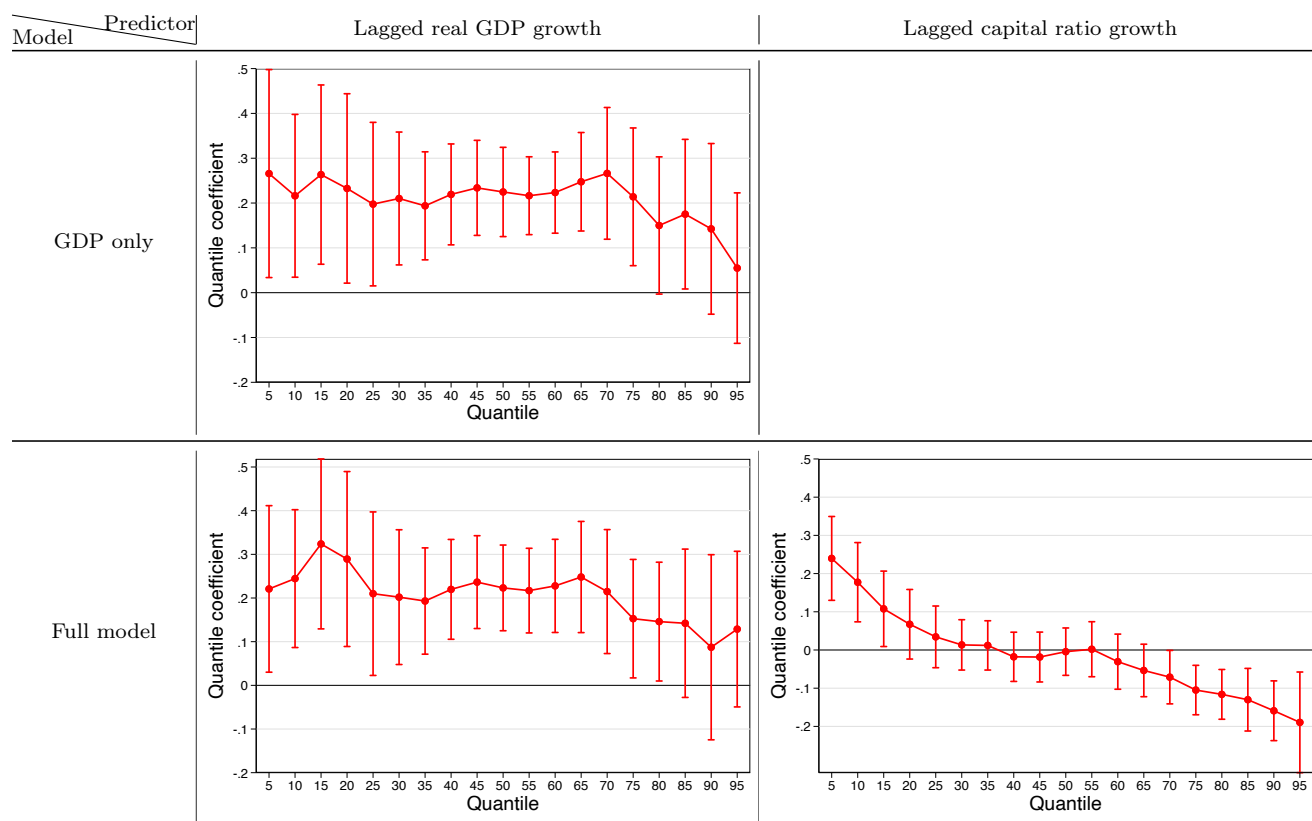
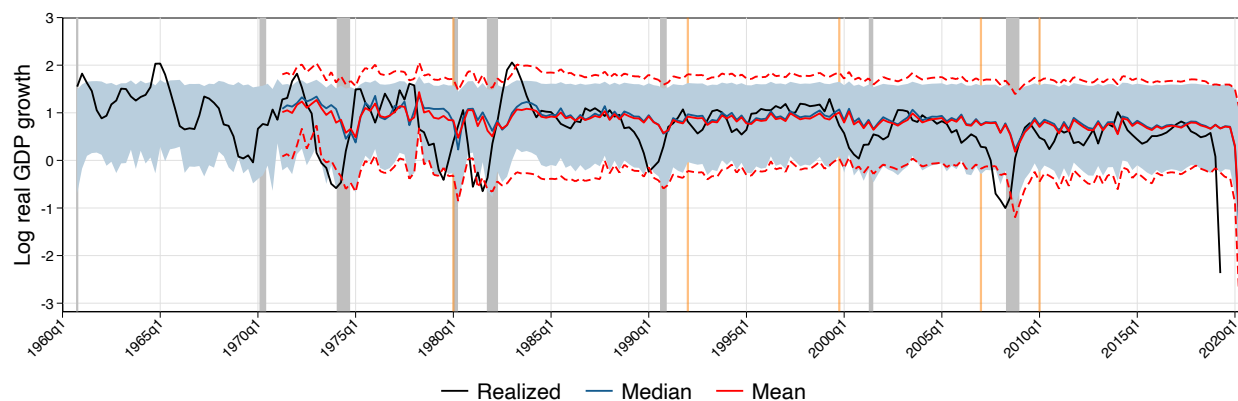
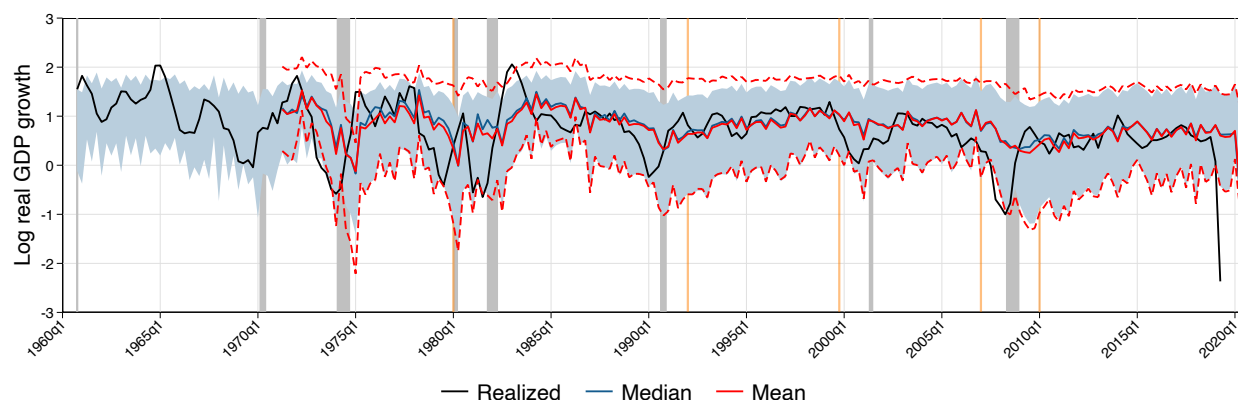


Figure A.3. Predicted distributions. This figure plots the time series evolution of the predicted distribution of average four quarter log real GDP growth, together with NBER recession shadings and capital regulatory regime changes. Blue shaded areas correspond to the in-sample (5%, 95%) interquantile ranges, respectively. Red dashed lines correspond to the out-of-sample (5%, 95%) interquantile ranges. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity ratio constructed as total equity capital over total assets of commercial banks only. Capital ratio growth measured in year-over-year terms.

(a) GDP only



(b) GDP and credit only



(c) Full model

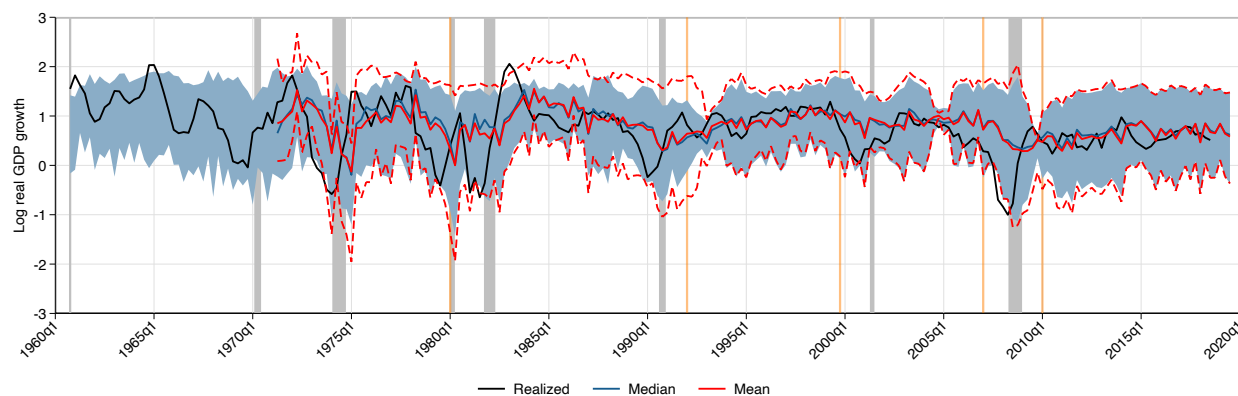
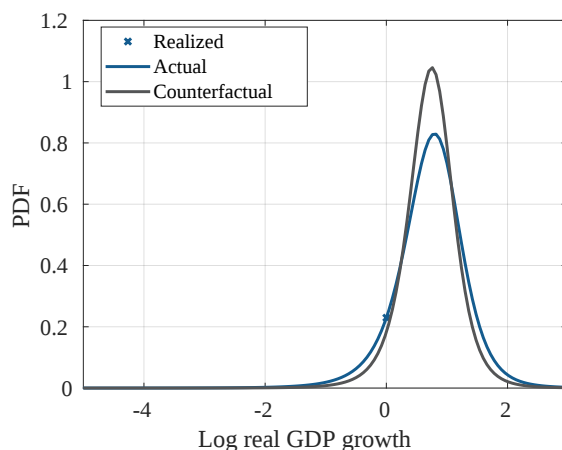


Figure A.4. Effect of increasing capital growth ahead of the crisis. This figure plots the actual and counterfactual predicted distributions of average log real GDP growth over H quarters as of Q3 2007. Counterfactual distribution constructed under assumption of capital ratio growth one standard deviation higher than observed. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity ratio constructed as total equity capital over total assets of commercial banks only. Capital ratio growth measured in year-over-year terms.



Horizon	Q5		Median		Q95	
	Actual	Counterfactual	Actual	Counterfactual	Actual	Counterfactual
1Q	-0.83	-0.54	0.72	0.69	2.01	1.71
2Q	-0.49	-0.20	0.69	0.65	1.99	1.66
4Q	-0.40	-0.13	0.76	0.69	1.78	1.40
8Q	-0.18	0.04	0.76	0.70	1.47	1.31

Figure A.5. Quantile regression coefficients across horizons. This figure plots the estimated coefficients in quantile regression of average real GDP growth over H quarters on lags of log real GDP growth, log real credit growth, and capital ratio growth. First row corresponds to the model with lagged log real GDP growth only; second row to the model with lagged log real GDP and log real credit growth only; third row corresponds to the full model. Credit defined as the sum of non-financial corporate business commercial paper and corporate bonds outstanding and total loans extended to the non-financial sectors in the U.S. economy. Equity ratio constructed as total equity capital over total assets of commercial banks only. Capital ratio growth measured in year-over-year terms.

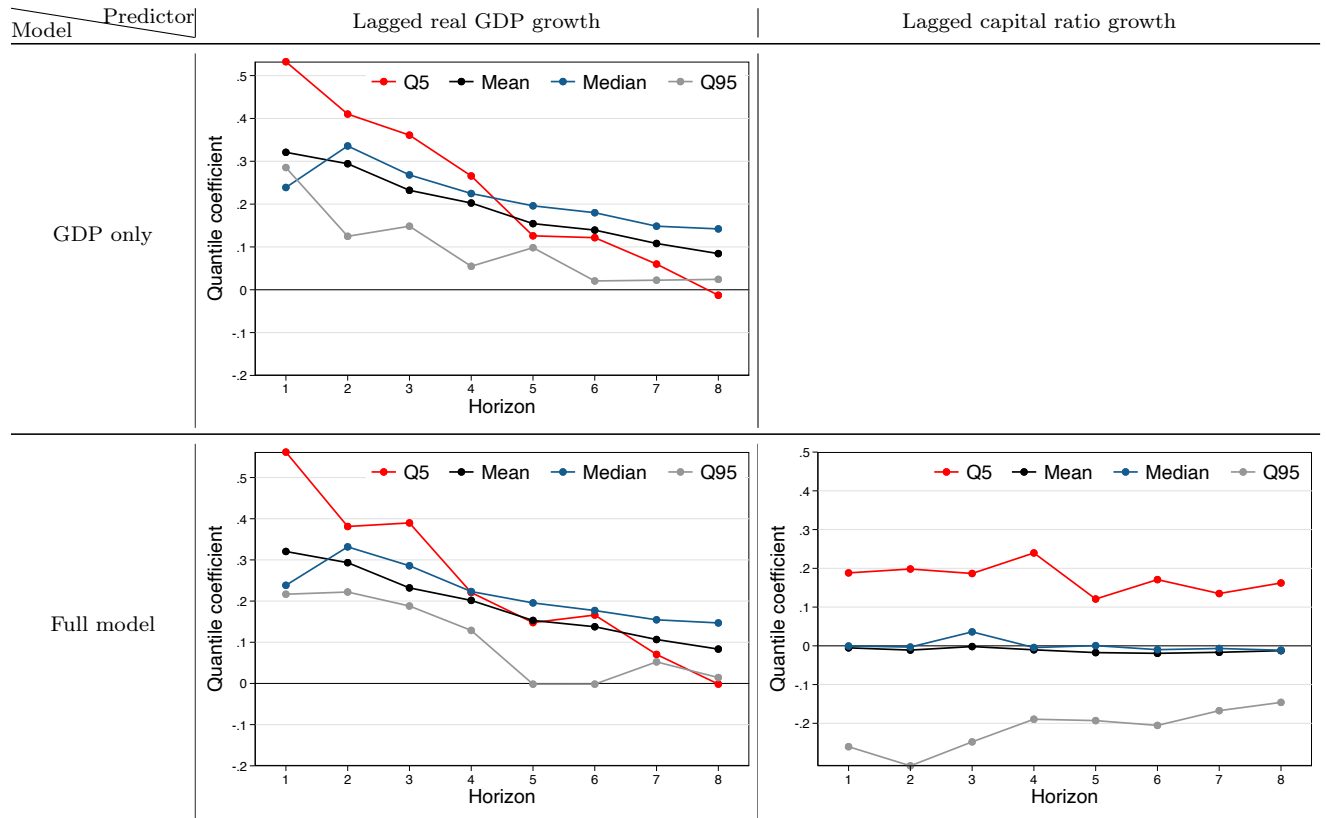


Figure A.6. Threshold regression coefficients across thresholds. This figure plots the estimated coefficients in logit regression of average real GDP growth over 4 quarters falling below threshold τ on lags of log real GDP growth and lagged capital ratio growth. First row corresponds to the model with lagged log real GDP growth only; second row to the full model. Equity ratio constructed as total equity capital over total assets of commercial banks only. Capital ratio growth measured in year-over-year terms. Dashed line corresponds to estimate from a one-year-ahead logit regression of NBER recessions. 95% confidence bands based on heteroskedasticity-robust standard errors plotted as bars around point estimates.

