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The Relative Importance of Macroeconomic Shocks, Regional Shocks and Idiosyncratic Risk on Large and Small Banks

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Abstract
Mandatory stress testing has been acclaimed by banking regulators as a key response to preventing future financial crises. Each year banks in the United States with over $50 Billion in assets must perform a Comprehensive Capital Analysis and Review (CCAR) . Banks with over $10 Billion are subject to Dodd-Frank Act Stress Testing (DFAST). This study examne the relative importance of international or national macroeconomic shocks, state-level shocks, and idiosyncratic shocks on mortgage rate charge-offs for the universe of all banks for the 2002-2014 period. We find tha banks with over $10 billion in assets have charge-off rates that are very sensitive to macroeconomic shocks, while those aggregate shocks have almost no power to explain the charge-off rates of smaller banks. The results suggests that bank stress tests are appropriately targeted at only the largest banks whose assets are most responsive to macroeconomic shocks.

Smaller bank portfolio performance is driven by idiosyncratic shocks of the sort identified in traditional bank examination. State-level shocks are as or more important in explaining small bank charge-off rates as are national shocks. The findings also support the view that the largest banks are subject to added risk compared to small banks because of the high correlation between large bank loan performance and aggregate shocks, implying that large banks require larger capital reserves.

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Key Words: Stress test; charge-off rate, macroeconomic shocks, delinquency rate; bankruptcy; systemic risk, idiosyncratic risk; capital reserve

JEL:G21; E37; E42

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1. Introduction

Mandatory stress testing has been acclaimed by banking regulators as a key response to preventing future financial crises. Each year the largest banks in the United States must perform these tests which in large part rely on statistical models to determine capital adequacy.[1] Current stress testing practices rely heavily on statistical models to evaluate bank performance under adverse hypothetical economic scenarios. The bank stress tests consist of two distinct exercises: The Comprehensive Capital Analysis and Review (CCAR) and the Dodd-Frank Act Stress Testing (DFAST). Both rely on similar processes, data, supervisory exercises, and requirements (Board of Governors of the Federal Reserve System, 2014 June 25). CCAR is a yearly exercise conducted by the Federal Reserve to determine whether the largest functioning bank holding companies present in the United States have sufficient capital to continue operations throughout times of economic and financial market stress, whether they have adequate, forward-looking risk management strategies, and whether the bank's planned dividend payments or common stock repurchases will leave it with adequate capitalization (Board of Governors of the Federal Reserve System, 2015). DFAST is a complementary exercise to CCAR operated by the Federal Reserve. This exercise "serves to inform the Federal Reserve, the financial companies, and the general public, how these institutions' capital ratios might change during a hypothetical set of adverse economic conditions as designed by the Federal Reserve" (Board of Governors of the Federal Reserve System, 2015).

[1] The original Federal Reserve CCAR stress test was applied to the 19 largest banks with assets exceeding $100 billion. The 2017 round of Federal Reserve run stress tests included 34 bank holding companies with assets of at least $50 billion. In addition, the Dodd-Frank Act Stress Testing (DFAST) requires that all federally regulated financial institutions with assets in excess of $10 billion conduct annual company-run stress tests.

These stress tests were first applied following the sharp deterioration in U.S. bank asset values in 2008. U.S. housing prices fell 32% between July 2006 and March 2009.[2] As shown in Figure 1, residential mortgage delinquency rates, that had averaged 1.9% before the recession, rose to an average of 8.2% between 2007-2013. Delinquency rates were still twice their prerecession levels in 2016. Commercial loan delinquency rates rose to almost 9% by 2010 but quickly fell and are now below their long-run averages. Agriculture loans only modestly weakened in quality and actually helped to moderate overall loan delinquency rates for banks in rural areas.

As the quality of loans weakened, an increasing share of loans were written off. Figure 2 shows the time path of charge-offs. The rate of charge-offs was atypically high for 6 years and only returned to prerecession levels in 2014. The slow reduction of charge-off rates for home mortgages was exacerbated by a tendency for younger borrowers and less creditworthy borrowers to increase both their home equity debt and nonmortgage debt as home prices rose which made it difficult for those borrowers to meet their obligations when the housing prices fell (Brown, Stein and Zafar, 2015).

The FDIC closed an average of 58 banks per year since 2008 compared to fewer than 4 bank closures per year between 2000 and 2007.[3] As shown in Figure 3, the bank failures during this past recession were an order of magnitude larger than what was experienced in the 2001 recession and the failures persisted well into the recovery. The number of failures did not fall back to prerecession levels until 2016, reflecting the protracted period of atypically high delinquency and charge-offs.

[2] S&P/Case-Shiller 20-City Composite Home Price Index
[3] FDIC Failed Bank List is available from https://www.fdic.gov/bank/individual/failed/banklist.html

The incidence of bank failure was even larger among the largest banks. Gorton (2015) quotes Ben Bernanke as testifying that 12 of the 13 most important U.S. financial institutions were within 2 weeks of failing in 2008. In the end, 13 of the 25 largest institutions failed, required government assistance to avoid failure, merged to avoid failure, or changed their business structure to avoid failure.[4]

The surge in bank failures led to rising concerns that the failure of a few large banks could cause the failure of the entire financial system. Macroeconomic factors explained about 60% of the variation in net quarterly charge-off rates for a sample of 101 - 156 banks with assets of at least $10 billion (Kapinos and Mitnik, 2016). But if stress tests are useful for large banks, would they also be useful for smaller banks? Or is large bank loan performance atypically tied to macroeconomic shocks while small bank loan performance is tied to idiosyncratic shocks?

This paper measures how much of the variation in mortgage charge-off rates can be attributed to international and national macroeconomic shocks if bank stress tests were applied to all banks in the United States rather than the few largest bank. We also examine how the bank's geographic market affects its exposure to regional shocks by assessing the importance of state-level shocks relative to the aggregate shocks. We conduct variance-decompositions on the annual mortgage charge-off rates on an average of 6,349 banks including the universe of all banks in operation over the period 2002-2014. We find that as the bank increases in size, it's loan quality becomes increasingly tied to macroeconomic shocks. Less than 1% of the variation in mortgage charge-off rates can be explained by aggregate international or national shocks across all banks. But for banks with assets of $10 billion or more, 85% of the variation in annual mortgage charge-offs can be explained by those aggregate shocks. Hence, the current

[4] Gorton (2015), p. 979.

application of stress tests to the largest banks is appropriate as only those largest banks have asset quality that varies with those shocks.

For the vast majority of banks, state-level shocks are more important for explaining mortgage charge-off rates than are national or international shocks. Up to 6% of the variation in mortgage charge-offs is attributable to state shocks in the years after the Great Recession. However, the great majority of the variation in the quality of the loan portfolios of all but the very largest banks is attributable to idiosyncratic shocks, suggesting that only traditional bank examination can identify the weakness of the loan portfolios of the smaller banks.

The finding that the asset quality of large banks is particularly correlated with macroeconomic shocks has several implications for systemic risk management. First, it is difficult to diversify risk when the bank portfolio is already driven by its correlation with the national and international economies. That exposes the largest banks to a source of risk not faced by smaller banks whose portfolios are typically uncorrelated with macroeconomic fluctuations. Second, extreme aggregate shocks will be more common than microeconomic sectoral or regional shocks. In fact, aggregate shocks may have fat tails, even when the sub-aggregates are normally distributed (Acemoglu, Ozdaglar, and Tahbaz-Salehi, 2017). As a result, large banks may be atypically exposed to extreme shocks.

If banks are not adequately capitalized to absorb these shocks, then large banks will be at greater than normal risk of failure. This is in line with current policy which requires the largest banks to hold more equity capital.[5] Uniform equity capital requirements across all banks would

[5] The Supplementary Leverage Ratio applies to any U.S. top-tier bank holding company (BHC) with at least $700 billion in total consolidated assets or at least $10 trillion in assets under custody (covered BHC) and any insured depository institution subsidiary of these BHCs. https://www.occ.treas.gov/news-issuances/news-releases/2013/nr-ia-2013-109a.pdf

then prove inadequate for these largest banks, consistent with the atypically high failure rate experienced for the largest banks in the Great Recession. On the other hand, the smallest banks in the sample with deposits concentrated in a single state also had atypically high risk of nonperforming loans. These results suggest that equity capital requirements should continue to reflect the differential risk of default related to bank size.

2. Literature Review

Stress tests were implemented to address the needs of several different groups. Foremost was the need for regulators and policy-makers to assess the fragility of the banking system and the possible need for intervention. The recession showed that bank capital reserves were inadequate to cover losses. Swagel (2015) stated that Treasury officials had been urging financial firms to have greater capital reserves but they lacked the regulatory authority to mandate higher reserve ratios. In his recounting of the crisis, Timothy Geithner (2014) expressed regret that the Federal Reserve Bank should have required greater reserve ratios. Egan, Hortaçsu and Matvos (2017) simulation model suggests that capital requirements below 18% can lead to excessive bankruptcies in adverse economic conditions.

But traditional bank examination does not assess the adequacy of reserves in the event of a large adverse economic shock. Stress tests were different from bank examinations in that they were applied simultaneously to many banks to project future capital needs rather than current capital needs (Morgan, Peristiani and Savino, 2014). As a result, effective stress tests allow regulators to assess proactively rather than retroactively what policies to implement to prevent failure from occurring or whether a firm must be seized to maintain operations. They may also be used to recommend legislative action to prepare for possible bailouts, as the FDIC must now seek Congressional approval before making broad debt guarantees (Swagel, 2015).

A second group that benefits from the stress tests are investors. While publicly available data on banks is retrospective, the stress test process reveals important information to the public regarding a bank's ability to weather future shocks. Banks that were shown to have insufficient capital in the first stress tests experienced the largest decline in returns. Moreover, stock prices for the largest 50 banks not subject to the stress tests also responded to the public release of information, presumably because of presumed correlation in the observed capital gaps for the largest banks and unobserved capital adequacy for the next largest banks (Morgan, Peristiani and Savino, 2014).

The spillover benefits from the stress tests to the economy at large included the improved confidence in the U.S. financial system. As reviewed by Gorton (2015), to be successful in restoring confidence, stress tests need to be transparent, they must be released at a point when market uncertainty about the banking system is high, and they must be accompanied by government assurances of support for the most vulnerable banks. During the crisis, stress tests helped alleviate uncertainty regarding the amount of the capital gap individually and in aggregate, whether the government would nationalize or provide a capital infusion, and whether the government had the capability of stabilizing the sector.

But if these benefits follow from stress tests, why should the stress test be reserved for just the largest banks? The most obvious reason is that the failure of a very large bank would generate losses for many other financial institutions, creating a possibility of cascading failures at these other financial institutions. Related is the possible need for government or central bank intervention into large banks. In fact, the 8 largest institutions that received government bailouts in the crisis received $125 billion as a group, half the total capital injected into the banking system as a whole (Swagel, 2015). Focusing stress testing on the largest banks increases the

likelihood of discovering weaknesses early enough to act in the banks generating the greatest systemic risk.

But are large banks also more likely to fail and hence in the greatest need for stress tests? If 13 of the largest 25 financial institutions failed in the Great Recession, is it because large financial institutions took on more risk or are they more vulnerable to cyclical shocks? If the latter, an additional reason to apply the stress tests on the large banks is that they are atypically vulnerable to macroeconomic shocks. Smaller banks would then be more subject to the idiosyncratic shocks more commonly identified by traditional bank examination.

There are several reasons why large banks are more exposed to general versus idiosyncratic shocks. Because of their size, large banks are exposed to all sectors and to both foreign and domestic economic fluctuations. A bank whose assets span the economy is more diversified in one sense in that individual sectoral or geographical shocks will be less likely to affect bank financial performance, but the bank's asset quality will be more sensitive to aggregate macroeconomic fluctuations.

The greater correlation between easily observed macroeconomic shocks and large bank returns means that large banks have the disadvantage of visibility. Large banks also face a disadvantage if they have to sell assets in response to short-term financial weakness because they may be large enough to bid down the value of the assets, a problem smaller banks would not face. Borrowing from the Federal Reserve's discount window is easily observed. Large banks were so averse to revealing that signal to their investors that they paid 44 basis points more than the discount window rate for short-term credit (Armantier et al, 2015). The asset quality of the largest banks was sufficiently observable that investors anticipated the results of the stress tests before the results were released (Morgan, Peristiani and Savino, 2014). The sensitivity of large

banks to macroeconomic fluctuations could make them too big not to fail. Perhaps that vulnerability is why their risk management strategies did not sufficiently anticipate the cost of extreme events to their portfolios and left them undercapitalized as a result.[6]

3. Methodology and Data

Our hypothesis is that the loan portfolios of large banks are more susceptible to aggregate shocks than are smaller banks. To test this, we need to develop measures of aggregate shocks that are common across all banks. To be complete, we allow aggregate shocks to originate at the international, national, or state levels. We use mortgage charge-off rates as our indicator of bank loan performance. Mortgages have two important advantages. Virtually all banks are exposed to the mortgage market, and so we do not have selection on which banks are included in the analysis. And mortgages are subject to local market conditions, and so loan performance is affected by both global and local economic fluctuations. Finally, charge-off models are a common loss forecasting method used by banks, especially smaller banks like those that dominate our sample (McPhail and McPhail, 2015).

Charge-offs can be measured by net or gross measures. Gross charge-offs aggregate all losses, but not all charge-offs are permanently lost. Some fraction of loans are subsequently paid. Net charge-offs off-set gross charge-offs by any recoveries: collections made on loans previously viewed as write-offs. The two measures are:

$$Gross\ Charge-off\ rate = \frac{12\ month\ Charge-off}{Total\ unpaid\ balance\ at\ t-12}$$

$$Net\ Charge-off\ rate = \frac{12\ month\ Charge-off\ -Recoveries}{Total\ unpaid\ balance\ at\ t-12}$$

[6] Large banks would also be vulnerable to fat tailed risks that occur in the aggregate, even if individual sectors face normally distributed shocks (Acemoglu, Ozdaglar, and Tahbaz-Salehi (2017).

Typically, charge-off rates are positive, meaning that charge-offs are greater than recoveries. A negative value for net charge-offs indicates that recoveries are greater than charge-offs. This can occur, for example, when exiting a crisis period during which time a portfolio may realize large recoveries from prior defaults while in the same quarter experiencing fewer charge-offs on new defaults. In our sample of banks, 9.7% of the net charge-offs were negative, but the fraction of negative net rates was as low as 6.4% in 2008 and as high as 16.6% in 2014.

We explain bank charge-off rates for mortgages using the following model:

$$(1) \qquad M_{ijt}^{k} = \alpha_{ik} + \alpha_{tk} + \alpha_{jk} + \alpha_{jtk} + \alpha_{ijtk}; k = G, N$$

where M_{ijt}^{G} is the gross mortgage charge-off rate for bank *i* in state *j* in year *t* and M_{ijt}^{N} is the corresponding net charge-off rate. α_{ik} is a bank specific fixed effect; α_{tk} is a time specific fixed effect that is common across all banks in year *t* which would include national and international economic shocks, federal regulations, interest rates and other common economic factors influencing bank profitability; α_{jk} are state-specific fixed factors and α_{jtk} are state-specific cyclical factors common to all banks in the state, and α_{ijt} are the remaining time-varying effects influencing bank write-offs in year *t.* α_{ik} can be further decomposed into known bank specific effects, such as bank size and bank concentration, and unknown bank specific effects.[7]

4. Results for Large Banks versus Small Banks

Our first objective is to measure the share of the variance in bank loan performance, M_{ijt}^{G} and M_{ijt}^{N}, that can be explained by international, national or state specific shocks. The national and international factors change every year but are common across all the banks in our data.

[7] Rodriguez and Trucharte (2007) propose a model of stress testing that predicts individual borrower default rates, but this data is not publically available.

Consequently, we can capture the ability of these variables to explain variation in bank asset performance as a year-specific fixed effect that captures the effect of common aggregate shocks across our sample of banks.

Banks are also subject to state-specific shocks. Some banks have all their assets in a single state while others have assets spread broadly across states. We define the bank *i*'s exposure to state *j* by $s_{ij} = \frac{A_{ij}}{\sum_{j=1}^{50} A_{ij}}$, where A_{ij} is the bank *i*'s deposits in *state j*. The $s_{ij} \epsilon$ [0,1] with $\sum_{j=1}^{50} s_{ij} = 1$. We can then decompose variation in mortgage charge-offs using the regression

(2) $$M_{ijt}^{k} = \sum_{t=1}^{T} \beta_{tk} D_t + \sum_{j=1}^{50} \beta_{jk} D_j + \varepsilon_{ijtk}; k = G, N$$

In this specification, $\alpha_{tk} = \sum_{t=1}^{T} \beta_{tk} D_t$, $\alpha_{jk} = \sum_{j=1}^{50} \beta_{jk} D_j$, and $\varepsilon_{ijtk} = \alpha_{ik} + \alpha_{jtk} + \alpha_{ijtk}$. We can then measure how much of the variation in M_{ijt}^{k} is due to common year effect and how much is due to state effects. The rest of the variation is due to state-specific temporal effects or idiosyncratic effects specific to the bank.

To show how bank size effects the extent of the bank's exposure to common shocks, we divide the banks into three groups, all banks, all banks with at least $1 billion in assets and all banks with at least $10 billion in assets. With those groups, we have sufficient number of banks in all years to conduct an adequate assessment of how macroeconomic shocks vary in importance to bank asset quality by bank size.

We decided to pick years 3 years apart to avoid clouding our results with serial collinearity in bank charge-off rates. Therefore, our data includes the years 2002, 2005, 2008, 2011, and 2014. Although we do not use every year, the included years match the pattern of

delinquency rates, charge-off rates and bank failures shown in Figures 1-3. There is a dramatic rise in mortgage charge-off rates in 2008 relative to previous years, rising to an average of just under $1 charge-off in every $1000 in mortgage balances. Some banks had amazingly large charge-off rates with the worst exceeding 50%. The changing distributions are shown in Figure 4. The vast majority of banks had very low charge-off rates.

We report the results in Table 1. It is clear that across the average of 6,349 banks, most of the variation in bank charge-off rates is unrelated to macroeconomic or state shocks. Only 1.3% of the variation is due to common shocks across banks and the rest is due to temporary shocks to the economies of the states in which the bank has assets or to factors unique to the bank itself. As we limit the sample to only very large banks, macroeconomic shocks and state shocks become the dominant source of variation in bank charge-offs. For the 1.6% of banks with at least $1 billion in assets, 57% of the charge-off rates are attributable to macroeconomic shocks. An additional 4.3% of the variation is attributable to state fixed effects, leaving 38-39% of the variation that is idiosyncratic to the bank or the state.

For the 0.8% of banks with at least $10 billion in assets, the macroeconomic shocks become even more important, explaining 85% of the variation in mortgage charge-off rates. State fixed effects add 2-2.5% of the variation, leaving around 12.5% of the variation attributable to idiosyncratic factors. Clearly, as banks get larger, the quality of their portfolio becomes more strongly tied to national and state economic shocks, and their charge-off rates are less tied to unobservable bank factors. That means that the asset quality of the largest banks is easier for investors to assess from public information. It also means that the banks that have been subject to stress tests are the banks whose financial performance is most closely tied to the shocks that make up the stress tests.

5. Results Regarding the Application of Stress Tests to All Banks

The previous section demonstrates that macroeconomic shocks are more important for large banks than small banks, but it is useful to assess how well a stress test would function if applied universally rather than selectively. The Federal Reserve's supervisory scenarios in the CCAR use 28 variables which describe domestic and international economic circumstances. Six measures of U.S. economic activity and prices are incorporated including measures of inflation, unemployment, per capita income and aggregate output. Four measures of asset prices are used including housing, commercial property and stock prices and stock price volatility. Six different interest rates varying by maturity and government or private issuance are added. The remaining measures control for changes in foreign country GDP, price levels, and exchange rates. We use a subset of these measures to build a vector of national shocks used to proxy α_{tk}.

We build in state-specific economic shocks, α_{jk} and α_{jtk} by using the national cyclical measures as a guide. Interest rates and inflation are assumed common across states but other cyclical variables vary across states. Our local market equivalent of the U.S. GDP growth rate is the year-over-year rate of change in gross state product lagged one year. The strength of the state housing market is measured by the year-over-year growth in housing prices lagged one year. The strength of the state labor market is measured by the state unemployment rate for the previous year. Results are similar if we alter the lag or we use growth measured over multiple years rather than one year.

Measures of state economic performance measures were downloaded from the Federal Reserve's Economic Database (FRED) housed at the Federal Reserve Bank of St Louis. The vector of state factors includes weighted averages of indicators of the strength of the state economy where the weights are share of bank assets in each state. For example, state

unemployment rates are used as an indicator of the state-specific business cycle with higher unemployment rates signaling weak economic conditions. The relevant bank measure of the unemployment rate is the state share weighted sum of state unemployment rates: $U_{ijt} = \sum_{j=1}^{50} s_{ij} U_{jt}$.

Our vector of known bank-specific factors includes two measures of bank portfolio strategies. The first is the value of total bank assets, taken as a measure of bank size. While one would have expected larger banks would have better risk management strategies, we have already seen that larger banks are more exposed to aggregate shocks. The second is bank concentration by state. Banks may be entirely concentrated in one state or may have exposure to many states. The latter banks are better diversified. We can create the following *Herfindahl – Hirschman Index* to explain bank state concentration:$\sum_{j=1}^{50} s_{ij}^2$. The index can range from 0.02 (a bank with exactly 2% of its deposits in every state) to 1 (a bank with 100% of its deposits in a single state). When regressed with our independent variables, we can see how much of the bank's performance is exposed at the state and national level. In addition, we can also find how much of the variance is due to idiosyncratic bank policies.

Table 2 reports the sample means by year included in our analysis. The time variation in the data reveals some interesting trends. Banks face fluctuations in state or regional markets and many have all their assets in a single state. The Herfindahl Index measuring bank concentration in a single state averaged 0.99 in 2002 and was still 0.95 by 2014 after considerable consolidation during and after the recession. Hence, the smallest banks are exposed to state-level shocks as opposed to national or international shocks. But even the largest banks have relatively concentrated deposits. Banks with over $10 billion in assets have an average Herfindahl index of 0.2 which is the equivalent of sharing deposits evenly across 5 states. More commonly, the

largest banks report a disproportionate share of their deposits from one or two states then small shares scattered across a larger number of states.

As the data show, there is wide variation in economic climate, both across years and across states within individual years. The state-by-state variation in a single year is sometimes greater than the national variation across all years. For example, in 2011, state unemployment rates varied from 3.8% from 13.5% while the national unemployment rate varied from 5.4% to 9.8% over the 5 years. Variation in the growth rates of housing prices and real gross state product are also substantial at any given point in time. Variation from bottom to top of housing price changes is on the order of 20 percentage points and variation in GSP growth rates typically varies by 10 percentage points. In 2008, the percentage change in state housing prices varied between -19% to +3.4% and GSP growth varied from -5.5% to +8.8%.

Table 1 reported the share of variation in mortgage charge-offs that could be explained by international and national time varying factors plus state fixed effects. Only 1.3% of the variation across banks can be attributed to those shocks. If we add in the time varying state effects, we only explain an additional 0.7% of the charge-off rates across banks. For a total explained variance of 2.1% due to macroeconomic shocks sourced at the internal, national or state levels. Most bank asset quality is due to bank policies that are uncorrelated with these common shocks; the idiosyncratic factors that are the subject of traditional bank examination.

It is possible that aggregate shocks do not matter when times are good but they matter a great deal in cyclical downturns.[8] Table 3 displays the share of charge-off variation attributable to state-level economic shocks by year. Before 2008, a period in which banks failed at a rate of 4 per year, state-specific shocks had little impact on mortgage default rates. Only 1-2% of

[8] This is Warren Buffet's observation that you do not know who is swimming naked until the tide goes out.

mortgage charge-off rates were due to state economic shocks. After 2008 as bank failures became more common, state shocks also became more important. But even then, state shocks were responsible for about 6% of the mortgage charge-off rates in 2011 and 2-3% of mortgage charge-off rates in 2014. Across most banks, asset quality is not driven by exogenous factors.

In Tables 4A-B, we add some additional details on the nature of the state and national economic shocks. The results are similar across the two tables and so we focus our discussion on the net charge-off rates in Table 4B. Column 1 shows the relative importance of state and national economic factors. State economic measures perform much as one would expect. Banks in states with high unemployment rates and declining housing prices face rising mortgage charge-off rates. Years with high corporate interest rates and more variable stock prices also lead to more mortgage write offs.

However, the more interesting regressions are in the last column where we add bank attributes. Banks with assets concentrated in 1 or relative few states have higher charge-off rates, presumably because they are less able to diversify risks associated with state economic shocks. However, as banks increase in size measured by assets, they experience higher charge-off rates, perhaps because they are more heavily exposed to undiversifiable macroeconomic shocks. Further analysis is needed to understand whether the realized returns to larger banks justify their exposure to more risky mortgage portfolios.

Our results rely on a top-down modeling approach that is not able to capture the details of bank loan portfolios such as borrower credit scores, loan-to-value ratios, debt-to-income ratios, loan product type, and other borrower characteristics that could be used to predict bank default rates as in Rodriguez and Trucharte (2007). Those factors may interact with the macroeconomic factors in ways that would make the latter more informative in projecting charge-off rates for

smaller banks. If so, our results underestimate the extent to which macroeconomic factors explain charge-off rates. However, it is doubtful that the explanatory power of the macroeconomic shocks will rise to a level that would justify the use of stress tests rather than traditional bank examination for the vast majority of the smaller banks.

6. Conclusion

Idiosyncratic bank policies are responsible for 98% of the variation in bank mortgage charge-off rates on average. Even in recessions, state and national economic shocks explain at most 6% of the variation in the quality of mortgage portfolios. For the 98% of banks with assets below $1 billion, macroeconomic shocks of the sort employed in stress tests are not relevant for assessing the quality of the bank's loan portfolio. While macroeconomic fluctuations rise in importance during recessions, it is still the standard bank examination that would be necessary to evaluate the bank's idiosyncratic risk of default.

For the largest banks, however, macroeconomic shocks explain the great majority of the charge-off rates and do provide relevant predictive information on asset quality. These banks represent the majority of all bank assets in the United States and so they are relevant for monetary authorities seeking to limit systemic risk. These banks appear to have greater risk than smaller banks due to their exposure to national or international shocks whose impact cannot be limited by diversification. Moreover, because of the correlation between their asset quality and observable macroeconomic shocks, investor flight is also a bigger potential problem for the largest banks in economic downturns. New rules implemented since the Great Recession require that regulators shift losses onto bondholders, shareholders and other lenders, meaning that investor flight may be even more dramatic in the future. Consequently, their size, importance and

sensitivity to large adverse shocks suggest that regulators continue to require the largest banks to hold relatively more equity capital.

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Table 1: Analysis of variance in bank net mortgage charge-off rates attributable to macroeconomic, state, and idiosyncratic shocks, 2002-2014, by bank size

	All Banks		Banks with over $1 billion in assets		Banks with over $10 billion in assets	
	Net	Gross	Net	Gross	Net	Gross
Total	100.0%	100.0%	100%	100.0%	100%	100.0%
Year Effects α_{tk}	0.7%	0.7%	57.3%	57.1%	85.1%	85.5%
State Effects α_{jk}	0.6%	0.6%	4.3%	4.3%	2.5%	2.0%
Idiosyncratic Bank and State-by-Year Effects ε_{ijtk}	98.7%	98.7%	38.4%	38.6%	12.4%	12.5%
Average Number of banks	6,349		108		57	

Table 2: Means and Ranges for variables using the sample of all banks. Exogenous variables are lagged one year

List of variables	2002	2005	2008	2011	2014
Bank-level data					
Net Charge-off rates for mortgages (x1000) (Range)	.110 (-54.2, 37.6)	.140 (-48.0, 71.9)	.976 (-82.9, 505)	1.40 (-27.0, 192)	.329 (-150, 157)
Gross charge-off rates for mortgages(x1000) (Range)	.208 (-18.5, 29.6)	.223 (-1.75, 72.0)	1.05 (-23.3, 505)	1.53 (-27.1, 192)	.515 (-20.9, 157)
Herfindahl index with 1 indicating all assets in one state (Range)	.99 (.10, 1)	.97 (.094, 1)	.97 (.092, 1)	.96 (.11, 1)	.95 (.094, 1)
The logarithm of bank assets (Range)	12.3 (4.22, 23.3)	12.4 (4.22, 24.3)	12.4 (4.22, 23.7)	12.4 (6.64, 23.1)	12.7 (8.19, 24.9)
State-level data					
State Unemployment Rate* (Range)	4.18 (2.8, 6.3)	5.40 (3.4, 7.6)	4.39 (2.4, 6.9)	8.88 (3.8, 13.5)	6.78 (3.0, 9.8)
State Home Price Growth Rate* (Range)	.052 (.0076, .15)	.091 (.039, .29)	-.022 (-.19, .034)	-.033 (-.14, .043)	.050 (.0070, .18)
Gross State Product Growth Rate* (Range)	.019 (-.021, .13)	.029 (-.0016, .084)	-.003 (-.055, .088)	.020 (-.028, .092)	.022 (-.025, .097)
National-level data					
Chicago Boards Options Exchange Growth Rate*	18.4	13.2	32.2	24.3	15.6
BofA Merrill Lynch US Corporate BBB Effective Yield*	7.8	5.01	5.95	5.54	3.36
10-year Treasury Maturity Rate*	5.16	4.15	4.76	3.73	1.91
3-month Treasury Bill Rate*	5.15	4.15	4.98	0.06	2.33
National Unemployment Rate*	6.3	5.7	5.4	9.8	7.0
Number of Banks (included in analysis)	6,292	6,774	6,940	6,185	5,555

Table 3: Share of annual variation in mortgage charge-off rates that is attributable to state-specific effects

Year	Net rate	Gross rate
2002	1.0%	1.8%
2005	0.6%	0.7%
2008	1.2%	1.2%
2011	5.7%	6.1%
2014	3.2%	2.2%

Table 4A: Regression Models Explaining Bank Gross Charge-off Rates

(t-statistics are in parentheses and significance is marked by * or **)

	Variables	Macro	Year dummies	Macro & State dummies	Year & State dummies
National	**Unemployment Rate**	-0.1032**			
		(2.42)			
	CBOE Options Index	0.033**			
		(4.33)			
	Yield of BBB Corporate Bonds	0.0485			
		(1.47)			
	T Bill Rate	-0.0419*			
		(1.76)			
State	**Unemployment Rate**	0.2158**	0.216**		
		(7.32)	(7.32)		
	GSP Growth Rate	-0.4275	-0.4275		
		(0.19)	(0.19)		
	Housing Price Growth Rate	-4.5867**	-4.5867**		
		(5.25)	(5.25)		
Year	**2005**		-6.63	-3.03	-1.67
			(0.55)	(0.28)	(0.16)
	2008		46.58**	78.96**	81.47**
			(3.76)	(7.42)	(7.66)
	2011		-6.26	127.07**	130.82**
			(0.33)	(11.6)	(11.94)
	2014		-26.2*	22.96**	25.83**
			(1.91)	(2.03)	(2.29)
Bank	**Herfindahl Index**				3.7374**
					(7.23)
	ln (Bank Assets)				0.1371**
					(5.05)
Constant		-0.571*	-0.4506**	1.6218**	-2.6126**
		(1.76)	(2.74)	(8.93)	(3.95)
State effects				√	√
Year Effects			√	√	√
	R^2	**0.0104**	**0.0104**	**0.0133**	**0.0151**
	N	**31746**	**31746**	**31746**	**31746**

Table 4B: Regression Models Explaining Bank Net Charge-off Rates

(t-statistics are in parentheses and significance is marked by * or **)

	Variables	Macro	Year dummies	Macro & State dummies	Year & State dummies
National	**Unemployment Rate**	-0.1169**			
		(2.66)			
	CBOE Options Index	0.0344**			
		(4.38)			
	Yield of BBB Corporate Bonds	0.0695**			
		(2.03)			
	T Bill Rate	-0.0663**			
		(2.04)			
State	**Unemployment Rate**	0.197**	0.197**		
		(6.48)	(6.48)		
	GSP Growth Rate	-0.9586	-0.9586		
		(0.41)	(0.41)		
	Housing Price Growth Rate	-4.7271**	-4.7271**		
		(5.25)	(5.25)		
Year	**2005**		-0.0198	-0.0162	-0.00146
			(0.16)	(0.15)	(0.01)
	2008		0.4632**	0.807**	0.8344**
			(3.62)	(7.35)	(7.61)
	2011		-0.0257	1.2315**	1.2726**
			(0.13)	(10.90)	(11.26)
	2014		-0.2999**	0.1405*	0.1712
			(2.12)	(1.21)	(1.47)
Bank	**Herfindahl Index**				4.0192**
					(7.54)
	ln(Bank Assets)				0.1544**
					(5.52)
Constant		-0.5513*	-0.4535**	1.5338**	-3.1525**
		(1.65)	(2.67)	(8.19)	(4.62)
State effects				√	√
	R^2	**0.0094**	**0.0094**	**0.012**	**0.0141**
	N	**31746**	**31746**	**31746**	**31746**

Figure 1: Bank Quarterly Delinquency Rates, 2000 – 2016

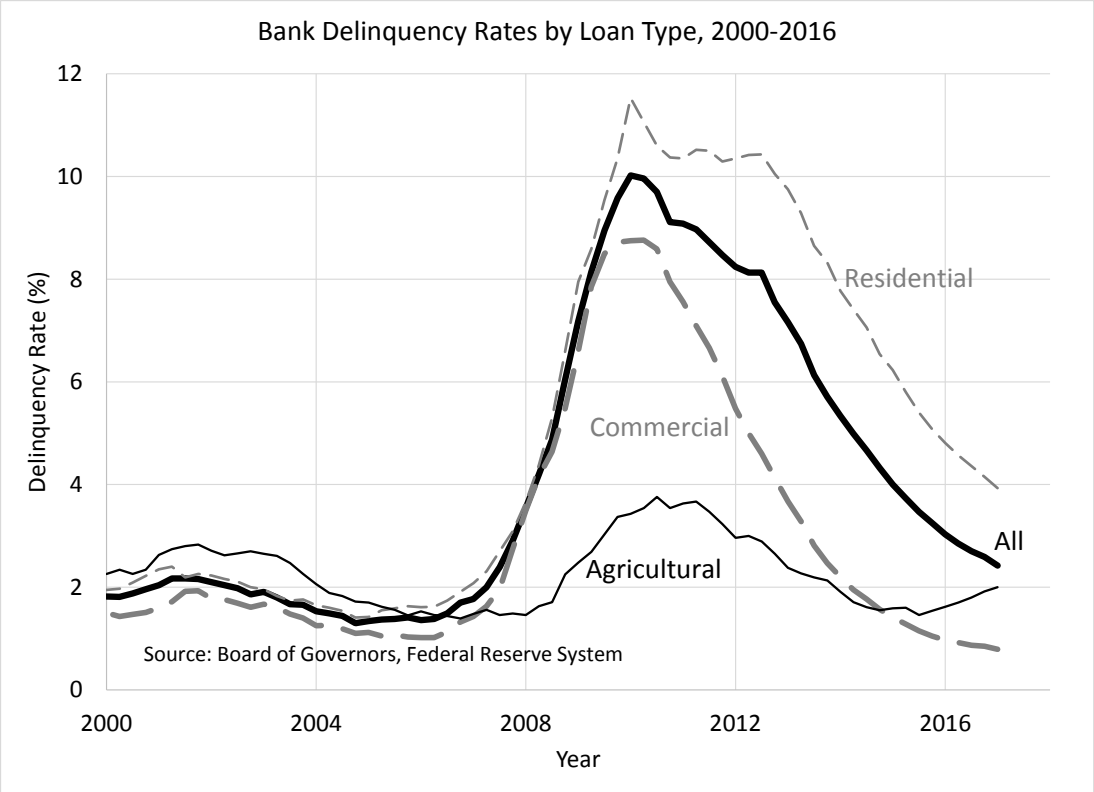

Figure 2 Bank Quarterly Charge-off Rates, 2000 – 2016

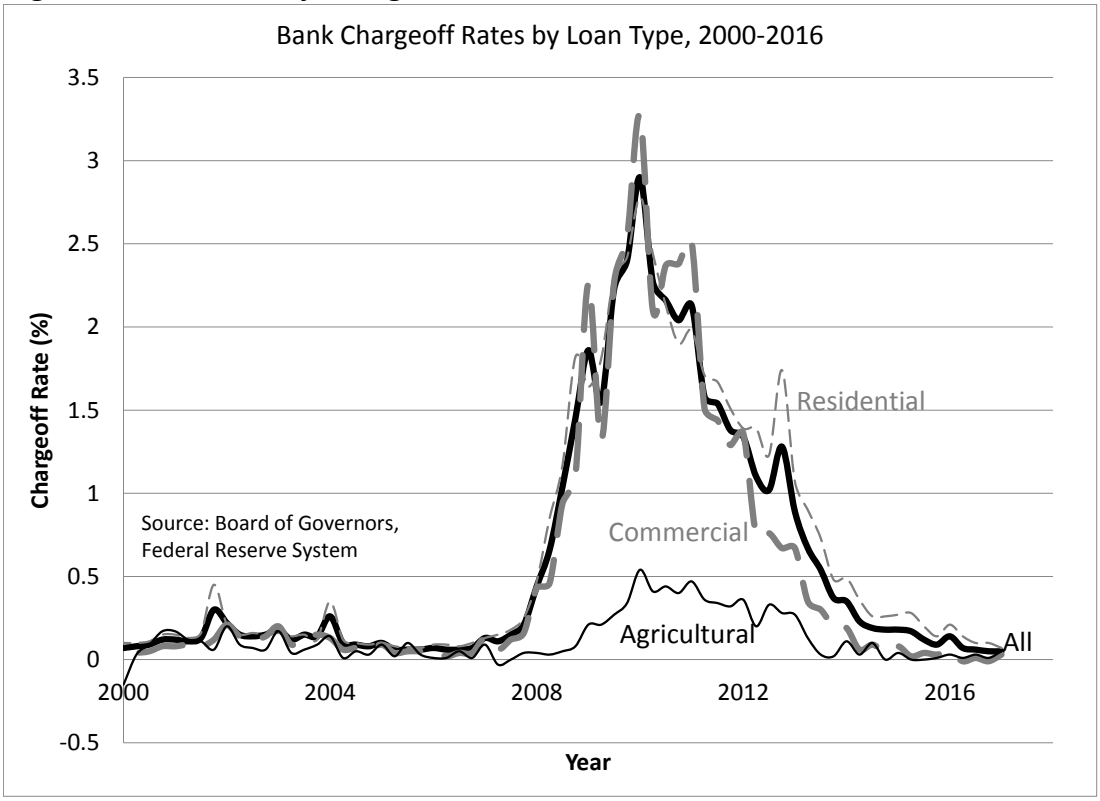

Figure 3: Annual Bank closures in the United States, 2000 – 2016

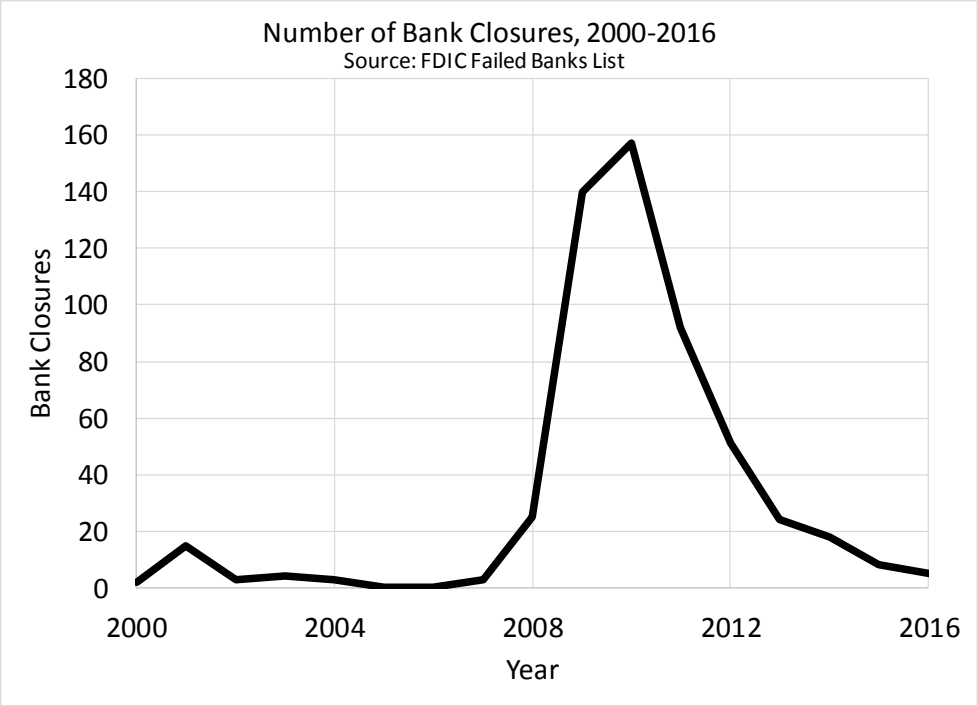

Figure 4: Cumulative Distribution of Bank Net Mortgage Charge-Off Rates, various years