How do Capital Requirements Affect Loan Rates? Evidence from High Volatility Commercial Real Estate *

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Abstract

We study how bank loan rates responded to a 50% increase in capital requirements for a subcategory of construction lending, High Volatility Commercial Real Estate (HVCRE). To identify this effect, we exploit variation in the loan terms determining whether a loan is classified as HVCRE and the time that a treated loan would be subject to the increased capital requirements. We estimate that the HVCRE rule increases loan rates by 35 basis points for HVCRE loans, indicating that a one percentage point increase in required capital raises loan rates by about 8.8 basis points.

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1 Introduction

How does the stringency of bank capital requirements affect the interest rates charged to borrowers? Requiring banks to increase equity funding, which has a higher required return than debt, could increase bank funding costs and cause borrowing to become more expensive for bank customers. However, the effects could be minimal if either cost increases do not pass through to borrowers, or if changes to capital structure have an offsetting effect on required returns (Modigliani and Miller, 1958). As the previous literature on this topic predominantly relies on calibrated models of bank funding, estimates of the likely costs of increased capital requirements vary widely, often reflecting different assumptions about this Modigliani-Miller offset (see Dagher et al. (2016) for a review).

This paper provides an empirical estimate of how changes in capital requirements impact loan rates in the U.S. using a quasi-experiment. Specifically, we use loan-level data from U.S. bank stress tests to identify how loan rates respond to a 50% increase in capital requirements for a subcategory of commercial real estate (CRE) loans. Using both a difference-in-differences (diff-in-diff) estimate exploiting variation in the time that a treated loan would be subject to the increased capital requirements, and a triple-difference approach additionally exploiting variation in categories of CRE loans which are and are not subject to the change in capital requirements, we demonstrate that increased capital requirements have a moderate effect on bank loan rates.

The planned increase in capital requirements was announced as part of the Basel III regulatory framework in June 2012. Bank regulators proposed designating non-1-4 family acquisition, development, and construction (ADC) loans without sufficient borrower contributed capital as "High Volatility Commercial Real Estate" (HVCRE) and increased the risk weight on these loans from 100% to 150%. As banks face a regulatory minimum ratio of total capital to risk weighted assets of 8 percent, this rule implies that after the implementation in 2015 banks need to fund 12 percent of an HVCRE loan with equity, compared to 8 percent before 2015. Thus, if a greater portion of the life of a loan occurs after 2015 then banks will have a greater average capital requirement should the loan fall into the HVCRE category. This enables us to identify the effect of the HVCRE rule with a diff-in-diff approach, comparing how the increased interest rate charged on high loan-to-value (LTV) loans varies by the exposure of the loan to the post-implementation period. Our headline result is that the increased capital requirement caused banks to raise interest rates on HVCRE loans by about 35 basis points. Alternatively put, a 1 percentage point increase capital requirements results in about a 8.8 basis point increase in loan rates, an estimate around the middle of the range of values offered in the prior literature (Dagher et al., 2016).

One might be concerned that our results are due to banks being averse to making long maturity, high LTV construction loans for reasons besides the HVCRE regulation. We address this concern in two ways. First, we use a triple-difference methodology exploiting the fact that not all types of CRE loans were subject to the HVCRE rule. Namely, loans for the construction of 1-4 family residential properties and non-ADC commercial real estate loans continued to have a 100% risk weight following the implementation of the rule, regardless of LTV. This enables us to use these untreated loan categories as additional controls groups. We show that the increase in interest rates for high LTV loans which are exposed to the post-implementation date only occurs for the non-1-4 family ADC loans which were subject to the HVCRE rule.

Second, we run a placebo test on the sample of loans originated before the announcement of the HVCRE rule. As banks were unaware that loans meeting the HVCRE criteria would go on to have greater capital requirements, these loans should not have the same difference in pricing. When we run the diff-in-diff and triple-difference specifications in this pre-announcement sample, we find no effects. This indicates that the increase in loan rates is indeed a result of the HVCRE rule.

Next, we test which banks respond to the HVCRE rule. Banks for whom risk-based capital constraints are slack should be less affected by the change in risk weights (see Greenwood et al. (2017)). Instead, it should be the banks closer to a risk based constraint which would need to raise additional equity in order to fund an HVCRE loan as a result of the rule. We show that the increase in interest rates in response to the HVCRE rule is driven entirely by banks which are closer to their Tier 1 risk-based capital constraint.

As an extension, we also test for effects of the rule on non-price terms. While there might be a concern that a higher required return on HVCRE loans would induce banks to shift lending towards riskier loans within that category, we find little evidence that this occurred. There is an economically insignificant effect of the HVCRE rule on bank risk taking as measured by banks' estimated probability of loan default. Furthermore, the rule does not seem to have changed the propensity of banks to originate CRE loans in more volatile housing markets. While it is possible that there was a change in the riskiness of loans unobservable in the data, we only observe significant changes in loan pricing.

Our paper most relates to work studying how capital requirements affect bank loan rates. In a review of this literature, Dagher et al. (2016) notes that the predicted impact of a one percentage point increase in capital requirements varies widely, ranging from around 2 basis points up to about 20 basis points. Our estimated effect of 8.8 basis points puts us around the middle of that range. The lack of consensus in the literature partially reflects the fact that most the other papers on this topic are calibration exercises working off different models of bank funding. The estimates at the low end of the range, such as Kashyap et al. (2010), tend to follow Modigliani and Miller (1958) and assume that reductions in the required return on equity as banks deleverage offsets the effect of banks shifting to a more expensive funding source. In contrast, the papers producing estimates at the higher end of the range, such as Slovik and Cournède (2011), tend to assume that costs of debt and equity are fixed, and thus increasing equity substantially raises costs. Our work uses a quasi-experiment to obtain estimates of the impact of capital requirements, thus eliminating the need to make assumptions about the extent of Modigliani and Miller (1958) offsets or loan rate pass through.[1]

There is also extensive empirical work studying how capital requirements affect lending behavior, generally finding that tighter capital constraints reduce banks loan volumes in the U.S. (Peek and Rosengren, 1997) and Europe (Gambacorta and Mistrulli, 2004; Aiyar et al., 2014; Fraisse et al., 2015).[2] Our work contributes to this literature along two primary dimensions. First, we utilize loan-level data, allowing us to exploit within bank-quarter variation whereas most of the other evidence comes from bank-level panels. Second, our analysis emphasizes the impact on loan pricing while most the other work studies volumes. If demand for bank loans is relatively inelastic, the small effects on lending often identified in these empirical studies does not rule out the possibility of significant changes in bank funding costs and loan rates. An analysis of loan pricing is needed to get a full picture of how capital requirements affect the supply of bank credit.

[1]Kisin and Manela (2016) also estimates the cost of capital requirements from a calibrated model, however they take the unique approach of studying the cost that banks paid to utilize a pre-crisis loophole which effectively reduced the risk-weight on their assets. They found the cost of capital requirements to be minimal.

[2]There is also a related literature that studies the effect of bank *capitalization* on lending behavior. Santos and Winton (2013) show better capitalized banks in the U.S. with more capital charge higher rates in the syndicated loan market. Bernanke et al. (1991) and Berrospide and Edge (2010) show that better capitalized banks have faster loan growth, however the estimated effect is small. Carlson et al. (2013) confirm the small effects on lending, but qualify findings in this literature by demonstrating that the effects of capitalization are nonlinear and state dependent.

The closest papers to ours methodologically are Behn et al. (2016) and Benetton et al. (2017), both of which exploit variation in loan risk weighting induced by the Basel II implementation of internal ratings-based capital requirements. Behn et al. (2016) show that higher risk weights resulted in decreased lending to German firms, with no effect on interest rates. Benetton et al. (2017) find that higher risk weights resulted in significantly higher mortgage rates in the United Kingdom. We differ from these studies in two ways. First, we study a different market, as we analyze ADC loans in the US. Second, we study Basel III rules which went into effect late in the recovery from the Global Financial Crisis, and thus may be more reflective of the banking environment in the steady state than Basel II rules whose implementation coincided with the crisis.

The rest of the paper proceeds as follows. Section 2 provides background on the HVCRE rule. Section 3 describes our data and empirical strategy. Section 4 discusses the results, and Section 5 concludes.

2 Background on HVCRE Rule

Housing market distress played a central role in the early stages of the financial crisis. While mortgage losses, particularly through mortgage backed securities, are often emphasized, losses on CRE loans, particularly those for construction and land development, played an out-sized role in imposing losses on the banking sector. For example, Friend and Nichols (2013) show that banks with a heavy concentration in CRE failed at a rate of 22.9%, while only 0.5% of other banks failed.[3]

Motivated by these significant losses, when US bank regulators announced the new pro-

[3] A bank is considered concentrated in CRE if either ADC loans are at least 100% of risk-based capital or the total CRE portfolio is at least 300% of risk-based capital, in addition to a CRE loan growth criteria.

posed rules for risk weighted capital requirements, there was a particular emphasis on requiring banks to increase capital for risky ADC loans. As part of the new Basel III regulatory framework, regulators created the new loan category of HVCRE. HVCRE was defined as a credit facility to finance the acquisition, development or construction of property unless the facility either financed the construction of a 1-4 family residential property, or if the project met certain requirements pertaining to the LTV ratio and borrower contributor capital.[4] In order to require that banks hold capital commensurate with the elevated risk that these loans carry, the new rule set the risk weight on HVCRE loans at 150%, instead of 100% as it had been previously. The risk weight for other CRE loans, namely non-ADC CRE loans and ADC loans meeting the exemption from the HVCRE rule, remained at 100%.

The initial proposed rule was released in June 2012, to go into effect starting on January 1, 2015. The final rule, which was released in July 2013, mostly followed the initial proposal, although it allowed exemptions for agricultural loans and community development loans. Critical for our empirical strategy, there was no grandfathering in of earlier originated loans. Namely, any ADC loan which failed to meet the conditions to be exempt from the HVCRE designation would be subject to a 50% increase in the amount of capital required to fund the loan starting on January 1, 2015. Thus loans originated after June 2012 and maturing after January 2015 would be priced by banks with the understanding that having an LTV exceeding supervisory limits would result in greater capital requirements in the future.

[4] A non-1-4 family ADC loan is not considered to be HVCRE if the following conditions hold: (i) the LTV ratio doesn't exceed supervisory limits, (ii) the borrower contributed capital in the form of cash, marketable assets or out of pocket development expenses is at least 15% of the real estate's appraised "as completed" values, and (iii) the contributed capital is contractually required to remain in the project until the facility is sold, paid off or converted to permanent financing. The supervisory LTV limits are 65% for loans backed by raw land, 75% for land development, 80% for non-residential construction, and 85% for construction for property improvement, as is laid out in the Code of Federal Regulations.

3 Data and Empirical Strategy

Data The primary source of data used in this paper is the loan-level data that large banks report for use in the Federal Reserve's supervisory stress tests, formally Schedule H.2 of the FR Y-14Q data. This schedule provides data on the loan characteristics of banks' commercial real estate portfolio for CRE loans with the committed exposure of at least $1 million. Most important to this study are the data on a loan's interest rate, loan-to-value ratio, purpose (e.g. construction or acquisition) and the dates of origination and maturity. The reporting panel consists of banks with at least $50 billion in assets who are subject to the Comprehensive Capital Analysis and Review (CCAR).[5]

Empirical Strategy The basic empirical strategy is to study how the interest rate markup on high LTV construction loans varies by how long the loan is subject to the increased capital requirement from the HVCRE rule. Loans with a high LTV will not qualify for the exemption from the HVCRE designation and thus will have a higher cost of funding for the bank if the life of the loan significantly covers the post January 1, 2015 period where HVCRE loans have the 150% risk weight.

More concretely, suppose banks fund loans with capital and deposits subject to a minimum ratio of total capital to risk weighted assets of 8%. For simplicity, assume that deposits are available at a zero interest rate, while banks have a required return on equity of r^e. This means that HVCRE loans after the implementation date have a cost of capital of $(0.08 \times 1.5 \times r^e)$ while non-HVCRE construction loans or HVCRE construction loans before

[5] Banks with at least $50 billion have to fill out the form FR Y-14Q each quarter, which requires them to provide an array of information including loan-level data from different portfolios. A bank must provide this information if they have $50 billion in total consolidated assets as measured by the average over the previous four quarters on their FR Y-9C forms.

the implementation date have a 100% risk weight and a cost of capital of $0.08 \times r^e$. Thus a loan i from bank b originated at time t with a maturity M_i will have an average cost of capital:

$$\text{Funding Cost}_{i,b,t} = \frac{1}{M_i}\sum_{\tau=t+1}^{t+M_i} 0.08 r_b^e + 0.04 r_b^e \mathbb{1}_{\text{Post HVCRE}_\tau} \mathbb{1}_{\text{HVCRE loan}_i}$$
$$= 0.08 r_b^e + 0.04 r_b^e \mathbb{1}_{\text{HVCRE loan}_i} \left(\frac{1}{M_i}\sum_{\tau=t+1}^{t+M_i} \mathbb{1}_{\text{Post HVCRE}_\tau}\right).$$

That is, the impact of the HVCRE rule will depend on the percentage of the life of the loan occurring after the implementation date ($\frac{1}{M_i}\sum_{\tau=t+1}^{t+M_i} \mathbb{1}_{\text{Post HVCRE}_\tau}$) and whether or not the construction loan meets the conditions to be classified as an HVCRE loan ($\mathbb{1}_{\text{HVCRE loan}_i}$).

This facilitates a diff-in-diff approach to estimating the effects of the new HVCRE rules on the pricing of acquisition, development and construction loans. Our treatment variable is an indicator for whether the LTV on the loan exceeds the supervisory limit, which is 0.75 for loans for the purpose of "land acquisition and development" and 0.8 for other ADC loans.[6]

Instead of the normal "Post" variable indicating dates after a policy goes into effect, we have a continuous variable representing the percentage of the loan's life which occurs after the implementation date. Intuitively, a loan originated after the announcement of the HVCRE rule which matures only shortly after the implementation date should be minimally affected, as the risk weight would be 100% for most of the life of the loan. However, longer-lived loans or loans originated closer to the implementation date would be more impacted by the rule.

[6]Data restrictions prevent us from exactly identifying HVCRE loans, as loan categories in the FR Y-14Q data do not perfectly match up with the categories which define the regulatory LTV limits and we lack data on contributed capital. We believe this is the closest indicator for whether a loan would be classified as HVCRE available with the data. Results are little changed by just using a threshold of 0.8 for all loans.

The baseline specification is:

$$r_{i,b,t} = \beta(\text{High LTV}_{i,b,t} \times \text{Pct. HVCRE}_{i,b,t}) + \gamma \text{X}_{i,b,t} + \tau_{b,t} + \varepsilon_{i,b,t}, \quad (1)$$

where $r_{i,b,t}$ is the interest rate on loan i originated at time t by bank b. The variable High $\text{LTV}_{i,b,t}$ is an indicator, taking the value of one if the loan to value ratio on the loan is above the limit for the HVCRE rule, while Pct. $\text{HVCRE}_{i,b,t}$ is the percentage of the life of the loan occurring after the implementation date. We include loan-level controls ($\text{X}_{i,b,t}$) and bank-quarter fixed effects ($\tau_{b,t}$). Standard errors are clustered at the bank-quarter level. In extensions, we also replace $r_{i,b,t}$ with various other characteristics or non-price loan terms, such as the estimated probability of default, or the house price volatility in the zip code.

The variable $\text{X}_{i,b,t}$ includes the non-interacted treatment variables High $\text{LTV}_{i,b,t}$ and Pct. $\text{HVCRE}_{i,b,t}$, as well as the following loan level controls: the annual volatility of zipcode level house prices, the logarithm of the committed exposure and indicator variables specifying whether the loan rate is fixed or floating, whether the loan is for a multifamily property, whether the value used in LTV ratio corresponds to the "as completed" value, and whether the borrower is rated BBB or higher.[7] In our more parsimonious specification, we include these controls linearly. In our preferred fully-interacted specifications, $\text{X}_{i,b,t}$ also includes the interactions of High $\text{LTV}_{i,b,t}$ and Pct. $\text{HVCRE}_{i,b,t}$ with the other controls.

We run this analysis for the sample of ADC loans which were originated between the announcement of the rule in June 2012 and the implementation of the rule in January 2015. We exclude loans for the construction of 1-4 family properties, as these loans do not qualify for the increased capital requirements.

[7] Information on variable construction can be found in Appendix A.

An estimate of $\beta > 0$ would indicate that high LTV construction loans (i.e. loans missing the exemption for the HVCRE designation) require higher interest rates for loans more exposed to the period with higher capital requirements, consistent with the HVCRE rules increasing the cost of construction loans.

A second complementary approach exploits another source of variation: that non-1-4 family ADC loans were subject to the HVCRE rule, while 1-4 family ADC loans and other types of CRE loans were not. This allows us to estimate the effects of the HVCRE rule using the following triple-difference specification:

$$
\begin{aligned}
r_{i,b,t} &= \beta(\text{High LTV}_{i,b,t} \times \text{Pct. HVCRE}_{i,b,t} \times \text{Non-1-4 family ADC}_{i,b,t}) \\
&\quad + \gamma \text{X}_{i,b,t} + \tau_{b,t} + \varepsilon_{i,b,t}. \qquad (2)
\end{aligned}
$$

In this specification, the variables are the same as in (1) except there is an additional interaction with an indicator for whether the loan is a non-1-4 family ADC loan and $\text{X}_{i,b,t}$ is expanded to include all lower level interactions of the three treatment variables and the interaction of the loan controls with the non-1-4 family ADC loan indicator.

We run this analysis for two samples of CRE loans. First, we run this for all ADC loans originated between the announcement and the implementation of the rule. Here, β reflects the increase in interest rates for high LTV loans exposed to the post-HVCRE period for non-1-4 family ADC loans relative to the increase for 1-4 family construction loans. We also run this analysis on the sample of all CRE loans, thus comparing the response of non-1-4 family ADC loans to that of non-ADC CRE loans. Although this sample's loan characteristics differ further from our baseline sample as compared to the sample consisting of just ADC loans, the larger sample allows for more precision in our estimated difference in the effects between the treated and untreated category of CRE loans.

This triple-difference methodology addresses the concern that banks just charge higher interest rates on longer maturity, high LTV loans in general. Were this the case, high-LTV loans maturing further after 2015 would have higher interest rates for 1-4 family construction loans and non-construction CRE loans as well the non-1-4 family ADC loans which were impacted by the HVCRE rule. This effect would show up in the interaction of High $\text{LTV}_{i,b,t}$ and Pct. $\text{HVCRE}_{i,b,t}$ instead of the triple interaction. The triple interaction term differences out the effect of these variables on untreated loan categories and thus may remove a potential bias.

4 Empirical Analysis

Data Properties We present summary statistics for our variables of interest and controls in Table I, which includes data on loans from 30 bank holding companies. The top panel shows the summary statistics for our baseline sample of non-1-4 family ADC loans which were originated between the June 2012 announcement of the HVCRE rule and the January 2015 implementation. The middle panel shows the same statistics for the sample of 1-4 family ADC loans originated during this period, which are used as the primary control group in the triple difference specification. The bottom panel shows the statistics for the non-1-4 family ADC loans originated between January 2010 and the announcement date, which we use in our placebo tests.

The interest rate in the baseline sample of non-1-4 family ADC loans averages 3.35 percent whereas the other samples have average interest rates around 4 percent. This may partly reflect longer loan maturities in the baseline (median of 3 years instead of 1.5 or 2) and a lower estimated probability of default. The median committed exposure of about $5 million is somewhat higher than in the pre-announcement sample and over double that of the 1-4 family ADC sample.

In the baseline sample, 16% of loans have an LTV exceeding the HVCRE threshold, compared to 21% and 10% in the pre-announcement and 1-4 family samples. Due to longer maturities, on average 56% of the life of the loan occurs after the implementation of the HVCRE rule in the baseline sample, compared to 44% in the 1-4 family construction sample. On average, 40% of the life of the loans in the pre-announcement sample occurs after the announcement date.[8]

Main Results We present our main results for how the HVCRE rule impacted bank loan rates in Table II. In the first three columns, we use our diff-in-diff specification exploiting variation in loan-to-value ratios and the extent to which a loan is exposed to the period after the implementation of the HVCRE rule. In the last four columns, we present our triple-difference estimates, expanding the sample to additionally include 1-4 family ADC loans (columns 4 & 5) and non-ADC CRE loans (columns 6 & 7), and testing for a differential effect on the non-1-4 family ADC loans which were impacted by the rule.

In our diff-in-diff specification, the key variable of interest is the interaction between whether the loan LTV exceeds the limit for being exempted from the HVCRE rule (High LTV) and the percentage of the loan extending past the implementation date (Pct. HVCRE). In the most parsimonious specification with just the treatment variables, loan controls, and quarter fixed effects, we get a coefficient of 0.55 on the interaction term. This means that a high LTV loan is expected to carry an interest rate which is 55 basis points (bp) higher as a result

[8]For the pre-announcement sample in our placebo regressions, we use exposure to the post-announcement period instead of the post-implementation period. This ensures that the relationship between loan maturity and loan exposure to the post-HVCRE period remains roughly similar between the baseline sample and the placebo sample.

of the HVCRE rule.

In the second column, we add bank-quarter fixed effects, which do not meaningfully change the estimates. However, when we interact the loan controls with the two treatment variables in the third column, the magnitude of the effect drops to 35bp. This drop is predominantly due to the interaction of the fixed rate dummy with the variable Pct. HVCRE. Since fixed rate loans disproportionately have higher LTVs and are more expensive for longer maturities, this omitted variable likely biases the estimated coefficient on the interaction in the first two columns. Thus the 35bp effect found in our fully-interacted specification is our preferred estimate of the effect of the HVCRE rule.

For the sake of comparing this effect to those found in the rest of the literature, it is useful to translate this estimate into an elasticity between loan rates and capital requirements, instead of risk weights. The estimate implies that the HVCRE rule, which increased the risk weight on treated loans by 50%, increased loan rates by 35bp. Focusing on the 8% minimum required ratio of total capital to risk weighted assets, the HVCRE rule increased the capital needed to fund an HVCRE loan from 8% to 12% of the loan, or four percentage points. This means that a 1 percentage point increase in capital requirements raises loan rates by about 8.8 basis points. In their survey of the literature, Dagher et al. (2016) notes that other estimates of this elasticity generally range between 2bp and 20bp, placing us in the middle of the range of prior estimates.[9]

While our results seem reasonable given the rest of the literature, the sensitivity of our estimates to the selection of controls highlights a weakness in the identification: our treat-

[9]Note that banks face multiple and heterogeneous capital constraints, thus the proper denominator in this exercise by constraint, by bank, and by year. For example, given the common equity tier 1 constraint of 4.5%, banks only experienced an increase of 2.25 percentage points in required common equity to fund an HVCRE loan. Meanwhile, a bank facing the maximum G-SIB surcharge and a fully phased in capital conservation buffer would need a total capital ratio of 13%, making a 50% increase in risk weights increase total required capital by 6.5 percentage points.

ment is not randomly assigned. The LTV of a loan may interact with other characteristics in ways which influence loan pricing independent of risk-weighted capital requirements. For example, longer maturity loans allow for more variation in property values over the life of the loan. This volatility in property values may be especially problematic for high LTV loans, as borrowers would be more likely to end up underwater and default on their loan, justifying a higher interest rate.

Our triple-difference specification addresses the concern that our results are driven by pricing considerations separate from the HVCRE rule. We study how the increase in interest rates for high LTV loans which are exposed to the HVCRE period differs between non-1-4 family ADC loans, which were impacted by the rule, and other CRE loans, which were not. We take the pricing of either 1-4 family ADC loans (columns 4 and 5) or non-ADC loans (columns 6 and 7) as a control for how the interaction of High $\text{LTV}_{i,b,t}$ and Pct. $\text{HVCRE}_{i,b,t}$ would influence the pricing of CRE loans independent of the regulation. Our estimated effect of the rule on interest rates is then the additional magnitude of this interaction effect for the category of loans subject to the rule, given by the coefficient on High $\text{LTV}_{i,b,t} \times$ Pct. $\text{HVCRE}_{i,b,t} \times$ Non-1-4 family $\text{ADC}_{i,b,t}$.

We find that the increase in interest rates documented in the diff-in-diff specification only occurs for non-1-4 family ADC loans. Columns 4 and 5 run the triple-difference specification for the sample of ADC loans originated between the announcement and implementation of the HVCRE rule. The coefficient on the interaction between the high LTV indicator and the percentage of the loan extending past the implementation, reflecting the effect of these variables on the pricing of one to family construction loans, is virtually zero in both specification. The coefficient on the triple interaction, however, is 0.59 in the specification with bank-quarter fixed effects and loan controls interacted with the non-1-4 family ADC dummy, and 0.33 in the fully-interacted specification, nearly identical to the coefficients of 0.58 and 0.35 found in the diff-in-diff specifications.[10] Although the triple-difference approach substantiates the magnitude of the earlier findings, these estimates are somewhat imprecise due to the fact that the sample includes less than 2000 1-4 family construction loans. As a result, the coefficient on the triple interaction is insignificant in the specification with the more thorough controls.

Columns 6 and 7 run the triple-differences specification for the full sample of CRE loans, and thus uses non-ADC loans as a control category instead of only focusing on construction loans. For these non-ADC loans, we find that high LTV loans which are more exposed to the HVCRE period have *lower* interest interest rates. Consequently, the coefficients on the triple interaction are higher than before at 0.97 and 0.69. This difference is also more precisely estimated, as the sample size expands significantly compared to the specification with only construction loans. However, the control group is also more dissimilar to the treatment category than before, thus we would be hesitant to take this finding as an indication of a downward bias in the earlier estimates.

Placebo Test Thus far we have shown that banks increase interest rates on high LTV, non-1-4 family ADC loans that are more exposed to the period in which the loan would carry higher capital requirements. The fact that this increase in pricing is found solely in the category of CRE loans which are subject to HVCRE rule, and not in other construction loans or other CRE loans, indicates that this increase in pricing is the result of the rule itself, instead of some other characteristic impacting the pricing of CRE loans. One might be concerned however that there is some characteristic of long maturity high LTV loans which impacts the pricing

[10]The fully interacted specification includes bank-quarter fixed effects and interacts the loan controls with the three treatment variables used in the triple interaction.

specifically of non-1-4 family ADC loans and is thus not addressed in the triple-difference approach.

To address such lingering concerns about omitted variables, in Table III we estimate the models on the period before the announcement of the HVCRE rule. If the relationship between maturity and LTV reflects a fundamental risk in ADC loans instead of the influence of the HVCRE capital requirements, then the same effect should exist for loans originated before the HVCRE rules were announced. However, if the effects are driven by the HVCRE rule, then loans originated before the announcement of the rule should have no difference in pricing, as banks would be unaware that high LTV loans would carry greater capital requirements in the future.

Specifically, Table III presents the same estimates as Table II except for loans originated in the two and a half years prior to the announcement of the rule, instead of prior to the implementation of the rule. We also change Pct. HVCRE to measure the percentage of the loan extending beyond the announcement date instead of implementation date in order to keep the relationship between maturity and Pct. HVCRE roughly constant between the samples.

The coefficients on the primary interaction terms are much smaller than in the main results and are statistically insignificant in every specification. In the most conservative diff-in-diff specification, which produced a coefficient of 0.35 in the baseline results, we recover a coefficient of 0.06 in the placebo sample. The coefficient on the triple-interaction term is negative and insignificant in the triple-differences specification comparing the pricing of 1-4 family construction loans to non-1-4 family ADC loans. Finally, we obtain a coefficient of 0.10 or lower on the triple interaction term in the specification including the full sample of CRE loans. Recall that the equivalent estimates were 0.69 or 0.97 in the time period after the announcement of the rule. That banks only significantly increase interest rates on treated loans once they are aware of the rule indicates the rule is the cause of the change in pricing as opposed to the fundamentals of the treated loans.

Heterogeneous Effects A second way to validate our methodology is to demonstrate that the increase in interest rates in response to the HVCRE rule disproportionately occurs in the banks that would be most sensitive to changes in risk weights. To understand why banks would differ in their sensitivity to risk weights, consider the variety of capital constraints to which banks are subject. In addition to other capital ratios, banks need to maintain regulatory minimums for both the ratio of Tier 1 capital to average total assets (leverage ratio) and the ratio of Tier 1 capital to risk-weighted assets (Tier 1 risk-based ratio). As the numerators of these constraints are the same, the degree to which each constraint is binding will depend on the composition of the assets of the lenders. Banks with more U.S. Treasuries or other low risk-weighted assets may be closer to their leverage ratio. Since this ratio is determined by assets instead of risk-weighted assets, the HVCRE rule would not impact required capital. In contrast, banks for whom the Tier 1 risk-based ratio is binding will be sensitive to changes in the risk weights. As the risk-based constraint is not slack, an increase in the risk weight on a loan will increase the bank's minimum Tier 1 capital. It is thus these banks which are closer to the risk-based capital ratio who should respond to the HVCRE rule.

To test for this heterogeneous effect, we follow Greenwood et al. (2017) and use quarterly Y9-C filings to measure how close banks are to their capital constraints. Our measure of distance to a risk weighted capital constraint for bank b at time t is $\frac{\text{Common Equity Tier 1}}{\text{Risk Weighted Assets}}_{b,t} - 0.06 - \text{Surcharge}_b$, where Surcharge_b is the bank-specific surcharge over regulatory minimum capital requirements required of global systemically important banks.[11] Using this distance vari-

[11]Since the surcharge is phased in between 2015 and 2019, and the average maturity of a non-1-4 family ADC

able, we then construct a dummy variable, Capital Constrained$_b$, which takes a value of one if the bank's distance to the constraint is less than the loan-weighted median for the quarter. We then repeat our primary analysis, additionally including interactions with the dummy for whether the bank is close to its Tier 1 risk-based capital constraint.

Table IV shows that the previous results are driven almost entirely by the banks which are closer to their Tier 1 capital constraint. The first two columns present the results of interacting our diff-in-diff specification with the capital constrained dummy. Looking at the coefficient on the interaction of the high LTV dummy and the percentage of the loan extending after the implementation of the HVCRE rule, we see that unconstrained banks react little to the HVCRE rules. These banks are estimated as increasing interest rates by -4bp and 7bp in the specifications with and without the fully interacted controls. Both estimates are economically and statistically insignificant. In contrast, constrained banks are estimated as increasing interest rates by 53bp and 86bp in the specifications with and without the fully-interacted controls, with the difference from non-capital constrained banks being significant at the 1% level.

There is a similar pattern when the constrained dummy is incorporated into the triple-difference specification. The coefficient on the triple interaction between the variables High LTV, Non-one to four Family ADC, and Pct. HVCRE, that is the estimated effect of the HVCRE rule on unconstrained banks, is negative in most specifications and never more than 19bp. For the constrained banks, the predicted effect of the HVCRE rule is at least 100bp in every specification, with the difference from the effect on unconstrained banks always significant at the 1% level. In short, the increase in interest rates for non-1-4 family ADC

loan is about five years, we take the surcharge to be half of the fully phased in amount, which would reflect the surcharge for 2017. However, results are little changed when the surcharge is taken to be either 0 or fully phased in. The bank specific G-SIB surcharges are listed here: http://www.fsb.org/wp-content/uploads/2016-list-of-global-systemically-important-banks-G-SIBs.pdf loans demonstrated earlier in the paper is almost entirely driven by loans from banks for whom changes in risk weights would be expected to influence behavior.

Effects on other loan characteristics Finally, we test how loans more impacted by the HVCRE rule vary in terms of riskiness. In Table V, we repeat the previous diff-in-diff analysis replacing the loan interest rate with a measure of the riskiness of the loan. In the first two columns, the dependent variable is bank's internally generated estimate of the loan's probability of default.[12] In the next two columns, the dependent variable is the volatility of house prices in the zipcode of the property. In the last two columns the dependent variable is an indicator for whether the borrower is rated BBB or better.

We find little evidence of a relationship between the risk of the loan and extent to which the loan is impacted by the HVCRE rule. High LTV loans which are more exposed to the post-implementation period have a lower probability of default. However, the result is insignificant. In contrast to the lower estimated default risk, loans more impacted by the HVCRE rule are shown to be originated in zipcodes with more volatile house prices and borrowers are less likely to be highly rated. However these results are also insignificant, with the exception of the specification pertaining to the borrower rating with the minimal set of controls.

Overall, there is neither evidence that the increase in interest rates found in our diff-in-diff results reflects elevated risk in treated loans, nor is there evidence that the increased capital requirements induced banks to take on more risk within the HVCRE category to compensate for a higher required return.

[12] Banks that are subject to the advanced approach for regulatory capital must submit the advanced IRB parameter estimate for the loan's year-ahead probability of default. Banks that are not subject to the advanced approach for regulatory capital can report their probability of default estimate corresponding to the Internal Rating on the loan.

5 Conclusion

Our paper studies the effect of a 50% increase in the amount of capital required to fund High Volatility Commercial Real Estate loans. Exploiting variation in whether loan terms qualify a loan to be categorized as HVCRE and the portion of the life of a loan covering the period in which the HVCRE rule is in effect, we estimate that the rule increased the interest rate on treated loans by 35. We rule out alternative explanations for this finding by demonstrating that the effect is only found for non-1-4 family ADC loans, which were subject to the regulation, and not 1-4 family construction loans, which were not. Furthermore, the effect is only found for loans originated after the rule was announced and only found for banks close to the relevant capital constraint.

These estimates imply that a one percentage point increase in required capital raises loan rates by about 8.8 basis points. This elasticity is around the middle of the middle range of existing estimates (see Dagher et al. (2016) for a review of this literature). This is generally consistent with Modigiliani Miller effects partially offsetting the effects of changes in funding composition on funding costs. Namely, calibrations assuming that funding costs are fixed will overstate the effects of capital regulation and estimates assuming that the only cost is a lost tax shield will understate the effects. To put our finding in the context of most the literature using calibrated models of bank funding, in Appendix B we relate our findings to the calibration in Miles et al. (2013). The elasticity of loan rates to capital requirements we find in our studies is consistent with a Modigiliani Miller offset of about 30%.

The estimate is also a useful input into an important policy question: what level of capital requirements is optimal? Evaluating proper capital requirements entails first identifying the costs of more stringent requirements, which come in the form of a higher cost of borrowing for bank customers, and second, weighing these costs against the benefits in the form of greater financial stability. This paper contributes to the first part of this calculation by demonstrating that the effects of increased capital requirements are modest, but not negligible. If there are substantial benefits to increased capitalization of the banking system, as is estimated by Miles et al. (2013), our findings would generally be supportive of recent regulatory efforts to increase capital requirements.

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Appendix A: Data Appendix

The data from the Y-14Q Schedule H.2 was downloaded on January 2, 2018 from the Wholesale Data Mart, which is maintained by staff at the Federal Reserve Bank of Chicago. We drop loans that do not specify a loan purpose (MDRM G073) and that do not specify the line reported on the Y-9C (MDRM K449). Further, we drop loans that do not specify a maturity date (MDRM 9914) or that have a computed time to maturity is less than or equal to 0 or greater than 30 and loans that do not have a interest rate (MDRM 7889) that is greater than 0. Our loan to value measure is constructed by taking loan to value at origination (MDRM K449) when it is nonmissing. When loan to value at origination is missing, we take the committed balance amount (MDRM G074) divided by the value at origination (MDRM M148) if this is nonmissing. A loan is designated as non-1-4 family ADC if it has designated loan purpose of either (1) Construction Build to Suit/Credit Tenant Lease, (2) Land Acquisition & Development, or (3) Construction Other and has a line reported on FR Y9-C not equal to 1 that is not equal to "1-4 family residential construction loans originated in domestic offices." The loan index category is MDRM K462. Interest rates are winsorized at the 1% level.

For computing the standard deviation of annual changes in house prices by zipcode, we download data from the Federal Housing Finance Agency on Annual House Price Indexes by five-digit zip code.[13] We compute the standard deviation of the given year-over-year change in house prices. We then merge the data by zip code into our loan-level dataset.

Appendix B: Derivation of the Modigliani-Miller Offset and Calibration to Miles et. al. (2013)

Most of the existing literature that attempts to estimate how changes in bank capital requirements would impact loan rates takes the following approach: take an estimate of the required returns on bank equity and debt and then make an assumption about the degree to which Modigliani-Miller effects offset changes in the composition of funding. This produces an estimate of how a change in the composition of funding effects funding costs. If changes in funding costs pass through to borrowers, this estimate also provides the expected change in loan rates for bank borrowers.

In this section, we invert this methodology and instead use our empirical estimate of the elasticity between loan rates and capital requirements and use it to back out the Modigliani-Miller offset.

[13]The dataset is downloaded from here https://www.fhfa.gov/DataTools/Downloads/pages/house-price-index-datasets.aspx.

Note that the weighted average funding cost for a firm can be written as

$$
\begin{aligned}
WACC &= R_e \frac{E}{E+D} + R_d \frac{D}{E+D}(1-\tau) \\
&= (R_e - R_d)\frac{E}{E+D} + \tau R_d \frac{E}{E+D} + R_d(1-\tau),
\end{aligned}
$$

where R_e and R_d are the costs of equity and debt, τ is the tax rate, and $\frac{E}{D+E}$ and $\frac{D}{E+D}$ is the percentage of bank funding from equity and debt, respectively. The effect of increasing capital requirements is seen in the first two terms: first it causes a shift in the composition of funding towards a more expensive funding source ($R_e - R_d > 0$), second it causes a bank to shift funding away from tax deductible debt, reducing the value of this tax shield.

Assuming that R_e is a function of $\frac{E}{E+D}$ and differentiating $WACC$ with respect to $\frac{E}{E+D}$ shows how bank funding costs respond to changes in capitalization.

$$
\begin{aligned}
\frac{\partial WACC}{\partial(\frac{E}{E+D})} &= R_e - R_d + \frac{E}{E+D}\frac{\partial R_e}{\partial(\frac{E}{E+D})} + \tau R_d \qquad (3) \\
&= (1 - MM_{offset})(R_e - R_d) + \tau R_d,
\end{aligned}
$$

where $MM_{offset} = \frac{\frac{E}{E+D}\frac{\partial R_e}{\partial(\frac{E}{E+D})}}{R_e - R_d}$ is the percentage of the increase in funding cost from switching from debt to equity (excluding the tax shield) which is offset by a reduction in required returns. Different assumptions about this term underlie much of the heterogeneity in estimates in the literature. For example, Kashyap et al. (2010) argue that this offset is around 100%, and thus that capital requirements mostly matter due to tax treatments. Other calibrations such as Slovik and Cournède (2011) and Bank of International Settlements (2010) assume that this offset is 0, and thus find that changes in capital requirements are more costly.

Following Miles et al. (2013), assume $R_e - R_d = 9.85\%$ and $R_d = 5\%$.[14] We set $\tau = .35$. Thus, if the MM_{offset} is 0, then a 1% increase in capital will raise funding costs by 9.85bp due to the switch to a more expensive funding source and an additional 1.75bp due to lost tax shield. Assuming that changes in bank funding costs pass through directly to loan rates, this would mean that the HVCRE rule, which increased equity requirements on effected loans 8% to 12%, would be expected to increase loan rates by about 46bp $(4 \times (9.85 + 1.75))$ instead of the 35bp we find.

This gap may reflect several factors: attenuation bias in our econometric specification due to not having an exact measure of HVCRE treatment, incorrect calibration of the components of funding costs, or non-binding capital constraints for some of our sample to name a few. However, if we assume the difference is due to Modigliani and Miller (1958) effects, we can get a sense of the degree of offset from reductions in R_e. Substituting our estimated elasticity between loan rates and capital requirements of 8.75bp in for $\frac{\partial WACC}{\partial(\frac{E}{E+D})}$ in (3) implies that $MM_{offset} \approx 30\%$.[15]

Tables

[14] Slovik and Cournède (2011) and Elliott (2010) estimate that $R_e - R_d \approx 12.5\%$, we take the lower estimate to reflect lower ROEs following the crisis. The 5% estimated cost of funds may seem high given deposit rates at the time, however we assume decreases in debt mostly come from longer term debt. The Moody's Baa corporate bond yield averaged around 5% over the sample period.

[15] The equation is $8.75 = (1 - MM_{offset})9.85 + 1.75$.

Table I
Summary Statistics for Loan Variables in the Different Samples

	Baseline sample of non-1-4 family ADC loans							
	Mean	Std	p1	p10	p50	p90	p99	N
Interest rate (percentage points)	3.35	1.12	1.50	2.18	3.10	5.00	6.76	8643
Percent maturing after January 1, 2015	0.56	0.35	0.00	0.00	0.66	0.96	1.00	8643
HVCRE designation (1 if HVCRE)	0.16	0.36	0.00	0.00	0.00	1.00	1.00	8643
s.d. of Δhouse prices of loan zip code	7.56	3.01	2.70	3.91	7.21	11.47	16.02	7458
Loan probability of default (percentage points)	1.96	6.30	0.00	0.28	1.09	2.53	21.72	6263
Committed exposure at origination ($ millions)	11.16	14.54	0.33	1.20	5.03	30.00	74.05	8643
Time to maturity at origination (yrs.)	4.73	5.57	0.35	1.00	3.00	10.69	25.96	8643
Floating rate (0) or fixed (1)	0.15	0.36	0.00	0.00	0.00	1.00	1.00	8643
Loan to value ratio	0.63	0.36	0.02	0.21	0.62	0.86	2.34	8643
	Sample of 1-4 family construction loans							
	Mean	Std	p1	p10	p50	p90	p99	N
Interest rate (percentage points)	3.96	0.96	1.87	2.79	3.92	5.25	6.25	2352
Percent maturing after January 1, 2015	0.44	0.36	0.00	0.00	0.47	0.92	0.99	2352
HVCRE designation (1 if HVCRE)	0.10	0.30	0.00	0.00	0.00	1.00	1.00	2352
s.d. of Δhouse prices of loan zip code	8.00	2.81	2.90	4.38	7.96	11.45	14.52	1999
Loan probability of default (percentage points)	3.11	10.28	0.03	0.26	1.00	4.63	40.00	1507
Committed exposure at origination ($ millions)	5.32	9.55	0.33	1.00	1.95	12.62	55.00	2352
Time to maturity at origination (yrs.)	2.91	4.41	0.22	1.00	1.50	5.00	25.00	2352
Floating rate (0) or fixed (1)	0.20	0.40	0.00	0.00	0.00	1.00	1.00	2352
Loan to value ratio	0.63	0.40	0.02	0.14	0.67	0.80	2.34	2352
	Sample of loans originated before announcement							
	Mean	Std	p1	p10	p50	p90	p99	N
Interest rate (percentage points)	4.10	1.28	1.49	2.50	4.00	5.75	7.61	9395
Percent maturing after June 7, 2012	0.40	0.37	0.00	0.00	0.37	0.92	0.99	9395
HVCRE designation (1 if HVCRE)	0.21	0.41	0.00	0.00	0.00	1.00	1.00	9395
s.d. of Δhouse prices of loan zip code	7.19	2.96	2.61	3.70	6.81	11.10	15.57	7770
Loan probability of default (percentage points)	7.08	20.82	0.03	0.42	1.30	9.00	100.00	3442
Committed exposure at origination ($ millions)	8.33	10.85	0.33	1.19	3.89	21.57	52.14	9395
Time to maturity at origination (yrs.)	3.23	4.19	0.08	0.46	2.00	6.52	24.99	9395
Floating rate (0) or fixed (1)	0.12	0.32	0.00	0.00	0.00	1.00	1.00	9395
Loan to value ratio	0.65	0.36	0.02	0.22	0.65	0.94	2.34	9395

This table reports the distribution of the loan-level variables used in our baseline sample of non-1-4 family ADC loans (top panel), control group of 1-4 family ADC loans (middle panel), and placebo sample of loans originated before the announcement of the HVCRE rule (bottom panel). N is the number of nonmissing observations for that variable. The variable "s.d. of Δhouse prices of loan zip code" is the standard deviation of the annual change in house prices of the zip code of loan. Further information on variable construction is in Appendix A.

Table II
Effect of HVCRE Rule on Loan Rates

	Effect on Interest Rates (percentage points)						
	Sample of Non-1-4 Family ADC Loans			Sample of ADC Loans		Sample of CRE Loans	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High LTV x Pct. HVCRE	0.55**	0.58**	0.35**	-0.04	0.00	-0.34**	-0.22^{+}
	(0.12)	(0.11)	(0.10)	(0.23)	(0.23)	(0.11)	(0.12)
x Non-1-4 family ADC				0.59*	0.33	0.97**	0.69**
				(0.27)	(0.26)	(0.17)	(0.15)
Pct. HVCRE	-0.28**	-0.21**	-0.33	-0.12	-0.44	-0.34**	-0.69
	(0.07)	(0.07)	(0.65)	(0.12)	(0.63)	(0.07)	(0.47)
High LTV	-0.19*	-0.19**	2.04**	0.09	1.69**	0.37**	0.94*
	(0.08)	(0.06)	(0.58)	(0.15)	(0.52)	(0.08)	(0.41)
Non-1-4 family ADC				-0.92*	-0.94*	0.48	0.28
				(0.42)	(0.39)	(0.34)	(0.32)
x Pct. HVCRE				-0.10	-0.00	0.03	0.19**
				(0.11)	(0.12)	(0.07)	(0.07)
x High LTV				-0.25	-0.10	-0.59**	-0.48**
				(0.17)	(0.17)	(0.10)	(0.10)
Loan controls	X	X	X	X	X	X	X
Time FE	X						
Bank-Time FE		X	X	X	X	X	X
Controls×{HVCRE,High LTV}			X		X		X
Controls×{Non-1-4 Fam ADC}				X	X	X	X
R_a^2	0.360	0.441	0.457	0.449	0.461	0.447	0.465
No. banks	30	30	30	30	30	32	32
No. loans	7458	7458	7458	9457	9457	30519	30519

This table reports coefficients from the following regression:

$$r_{i,b,t} = \beta(\text{High LTV}_{i,b,t} \times \text{HVCRE}_{i,b,t} \times \text{Non-1-4 family ADC}_{i,b,t}) + \gamma \text{X}_{i,b,t} + \tau_{b,t} + \varepsilon_{i,b,t},$$

where $r_{i,b,t}$ is the interest rate on loan i from bank b at time t. The variable High $\text{LTV}_{i,b,t}$ is an indicator function taking the value of one if the loan to value ratio on the construction loan is above the HVCRE limit, the variable Pct. $\text{HVCRE}_{i,b,t}$ is the percentage of the life of the loan occurring after the implementation date, and the variable Non-1-4 family $\text{ADC}_{i,b,t}$ is an indicator for whether the loan is an acquisition, construction, or development loan for a non-1-4 family property. The variable $\text{X}_{i,b,t}$ is a vector of the loan-level controls listed in the text, the lower order interaction of the treatment variables, and in some specification the interaction of these variables with the loan controls. The variable $\tau_{b,t}$ is a bank-quarter fixed effect. Columns (1)-(3) present coefficients from the difference-in-difference specification for the sample of non-1-4 family ADC loans originated between the announcement and implementation of the HVCRE rule. Columns (4) and (5) present the triple-difference results for the sample of ADC loans, while columns (6) and (7) present the findings for the full sample of CRE loans. Standard errors, in parentheses, are clustered at the bank-quarter level. +,*,** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table III
Effect of HVCRE Rule on Loan Rates: Placebo Sample

	Effect on Interest Rates (percentage points)						
	Sample of Non-1-4 Family ADC Loans			Sample of ADC Loans		Sample of CRE Loans	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High LTV x Pct. HVCRE	0.16	0.13	0.06	0.37^{+}	0.36	0.08	0.04
	(0.10)	(0.11)	(0.10)	(0.21)	(0.22)	(0.09)	(0.09)
x Non-1-4 family ADC				-0.23	-0.26	0.10	0.04
				(0.24)	(0.23)	(0.12)	(0.11)
Pct. HVCRE	-0.58**	-0.56**	-1.34^{+}	-0.30^{+}	-1.04	-0.39**	-0.72
	(0.10)	(0.11)	(0.74)	(0.16)	(0.66)	(0.12)	(0.54)
High LTV	-0.01	0.02	0.66	0.07	0.68	0.09	0.14
	(0.05)	(0.05)	(0.58)	(0.09)	(0.52)	(0.06)	(0.36)
Non-1-4 family ADC				2.85**	3.01**	1.06**	1.07**
				(0.68)	(0.69)	(0.31)	(0.31)
x Pct. HVCRE				-0.25	-0.21	0.04	0.02
				(0.16)	(0.15)	(0.07)	(0.07)
x High LTV				-0.06	-0.03	-0.14^{+}	-0.11
				(0.11)	(0.11)	(0.07)	(0.07)
Loan controls	X	X	X	X	X	X	X
Time FE	X						
Bank-Time FE		X	X	X	X	X	X
Controls$\times${HVCRE,High LTV}			X		X		X
Controls$\times${Non-1-4 Fam ADC}				X	X	X	X
R_a^2	0.240	0.285	0.290	0.285	0.289	0.373	0.380
No. banks	28	28	28	30	30	36	36
No. loans	7770	7770	7770	9410	9410	39334	39334

This table reports coefficients from the following regression

$$r_{i,b,t} = \beta(\text{High LTV}_{i,b,t} \times \text{HVCRE}_{i,b,t} \times \text{Non-1-4 family ADC}_{i,b,t}) + \gamma \text{X}_{i,b,t} + \tau_{b,t} + \varepsilon_{i,b,t}$$

for the sample of loans originated between the 2010 and the announcement of the HVCRE rule. The variable Pct. $\text{HVCRE}_{i,b,t}$ is the percentage of the life of the loan occurring after the announcement date. All other variables are as in Table 2: $r_{i,b,t}$ is the interest rate on loan i from bank b at time t, High $\text{LTV}_{i,b,t}$ is an indicator function taking the value of one if the loan to value ratio on the construction loan is above the HVCRE limit, and Non-1-4 family $\text{ADC}_{i,b,t}$ is an indicator for whether the loan is an ADC loan for a non-1-4 family property. The variable $\text{X}_{i,b,t}$ is a vector of the loan-level controls listed in the text, the lower order interaction of the treatment variables, and in some specification the interaction of these variables with the loan controls. The variable $\tau_{b,t}$ is a bank-quarter fixed effect. Columns (1)-(3) present coefficients from the difference-in-difference specification for the sample of non-1-4 family ADC loans. Columns (4) and (5) present the triple-difference results for the sample of ADC loans, while columns (6) and (7) present the findings for the full sample of CRE loans. Standard errors, in parentheses, are clustered at the bank-quarter level. $+$,*,** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table IV
Heterogeneous Effects By Distance to Capital Constraints

	Effect on Interest Rates (percentage points)					
	Non-1-4 Family ADC Loans		Sample of ADC Loans		Sample of CRE Loans	
	(1)	(2)	(3)	(4)	(5)	(6)
Capital Constrained						
x High LTV x Pct. HVCRE	0.69**	0.42*	-0.91+	-1.26**	-0.42+	-0.39
	(0.21)	(0.19)	(0.50)	(0.46)	(0.24)	(0.24)
x High LTV x Pct. HVCRE x Non-1-4 ADC			1.74**	1.75**	1.25**	0.98**
			(0.56)	(0.50)	(0.33)	(0.32)
x Pct. HVCRE	0.09	0.01	0.26	0.45+	-0.08	-0.27*
	(0.14)	(0.12)	(0.31)	(0.25)	(0.13)	(0.13)
x High LTV	-0.27*	-0.21	0.09	0.43	0.19	0.20
	(0.13)	(0.13)	(0.34)	(0.33)	(0.18)	(0.18)
x Pct. HVCRE x Non-1-4 ADC			-0.24	-0.44+	0.26*	0.28*
			(0.29)	(0.23)	(0.12)	(0.12)
x High LTV x Non-1-4 ADC			-0.40	-0.68+	-0.54*	-0.48*
			(0.37)	(0.35)	(0.22)	(0.22)
x Non-1-4 ADC			0.11	0.52**	-0.07	-0.03
			(0.16)	(0.14)	(0.09)	(0.08)
High LTV x Pct. HVCRE	0.16	0.06	0.21	0.54+	-0.13	0.00
	(0.14)	(0.14)	(0.35)	(0.31)	(0.17)	(0.16)
High LTV x Non-1-4 ADC x Pct. HVCRE			-0.07	-0.55	0.25	0.09
			(0.37)	(0.35)	(0.21)	(0.21)
Pct. HVCRE	-0.26**	-0.26	-0.30	-0.30	-0.33**	-0.68
	(0.10)	(0.69)	(0.22)	(0.69)	(0.10)	(0.48)
High LTV	-0.04	2.28**	0.26	1.71**	0.30*	0.84+
	(0.09)	(0.60)	(0.25)	(0.54)	(0.13)	(0.46)
Pct. HVCRE x Non-1-4 ADC			0.13	0.23	-0.08	0.11
			(0.22)	(0.18)	(0.09)	(0.08)
High LTV x Non-1-4 ADC			-0.24	0.26	-0.33*	-0.21
			(0.27)	(0.24)	(0.15)	(0.15)
Non-1-4 ADC			-0.37**	-0.89*	0.04	0.08
			(0.13)	(0.39)	(0.06)	(0.32)
Loan controls	X	X	X	X	X	X
Bank-Time FE	X	X	X	X	X	X
Controls×{HVCRE,High LTV, Capital Constrained}		X		X		X
Controls×{Non-1-4 Fam ADC}				X		X
R_a^2	0.437	0.456	0.411	0.464	0.448	0.471
No. banks	30	30	30	30	32	32
No. loans	6848	6848	8662	8662	27930	27930

This table reports coefficients from the following regression:

$$r_{i,b,t} = \beta(\text{High LTV}_{i,b,t} \times \text{HVCRE}_{i,b,t} \times \text{Non-1-4 family ADC}_{i,b,t} \times \text{Capital Constrained}_{i,b,t}) + \gamma \text{X}_{i,b,t} + \tau_{b,t} + \varepsilon_{i,b,t},$$

where Capital Constrained$_{i,b,t}$ is an indicator for whether bank b is closer than the median to a regulatory minimum risk weighted capital ratio in quarter t. The variable $\text{X}_{i,b,t}$ includes loan level controls, lower order interactions of the four primary explanatory variables, and the interaction of these variables with the loan controls. All other variables are as in Table 2: $r_{i,b,t}$ is the interest rate on loan i from bank b at time t, High LTV$_{i,b,t}$ is an indicator function taking the value of one if the loan to value ratio on the construction loan is above the HVCRE limit, Pct. HVCRE$_{i,b,t}$ is the percentage of the life of the loan occurring after the implementation date, and Non-1-4 family ADC$_{i,b,t}$ is an indicator for whether the loan is an ADC loan for a non-1-4 family property. The variable $\tau_{b,t}$ is a bank-quarter fixed effect. Columns (1)-(2) present coefficients for the sample of non-1-4 family ADC loans originated between the announcement and implementation of the HVCRE rule. Columns (3) and (4) present the results for the sample of ADC loans, while columns (5) and (6) present the findings for the full sample of CRE loans. Standard errors, in parentheses, are clustered at the bank-quarter level. +,*,** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table V

Estimated Effect on Risk Characteristics

	Effect on Riskiness of Loans					
	Probability of Default		House Price Volatility		BBB+ rating Indicator	
	(1)	(2)	(3)	(4)	(5)	(6)
High LTV x Pct. HVCRE	-1.87	-1.85	0.42	0.36	-0.10*	-0.07
	(1.30)	(1.43)	(0.37)	(0.34)	(0.04)	(0.05)
High LTV	1.95^{+}	-5.07	-0.17	1.61	0.04	0.31
	(1.13)	(6.35)	(0.26)	(1.77)	(0.03)	(0.23)
Pct. HVCRE	-0.51	-2.62	-0.56**	1.28	0.05^{+}	0.14
	(0.40)	(3.92)	(0.20)	(1.69)	(0.03)	(0.27)
Loan controls	X	X	X	X	X	X
Bank-Time FE	X	X	X	X	X	X
Controls$\times${HVCRE, High LTV}		X		X		X
R_a^2	0.046	0.048	0.084	0.091	0.161	0.163
No. banks	26	26	30	30	30	30
No. loans	5332	5332	7458	7458	7458	7458

This table reports the estimated coefficient from estimating

$$\text{Riskiness}_{i,b,t} = \beta(\text{High LTV}_{i,b,t} \times \text{Pct. HVCRE}_{i,b,t}) + \gamma \text{X}_{i,b,t} + \tau_{b,t} + \varepsilon_{i,b,t}, \quad (4)$$

where $\text{Riskiness}_{i,b,t}$ is a measure of the riskiness of loan i from bank b at time t, $\text{High LTV}_{i,b,t}$ is an indicator function taking the value of one if the loan to value ratio on the construction loan is above the HVCRE limit, and $\text{Pct. HVCRE}_{i,b,t}$ is the percentage of the life of the loan occurring after the implementation date. The variable $\text{X}_{i,b,t}$ is a vector of the loan-level controls listed in the text, the lower order interaction of the treatment variables, and in some specification the interaction of these variables with the loan controls. The variable $\tau_{b,t}$ is a bank-quarter fixed effect. In columns (1) and (2), the dependent variable is the expected year-ahead probability of default of the loan. In columns (3) and (4), the dependent variable is the house price volatility in the zipcode of the property. In columns (5) and (6), the dependent variable is an indicator for whether the loan is rated BBB or better. Standard errors, in parentheses, are clustered at the bank-quarter level. +,*,** indicate significance at the 10%, 5%, and 1% levels, respectively.