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Bank Competition and Financial Stability:

Evidence from the U.S. Banking Deregulation*

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Abstract

This paper examines the causal relationship between banking competition and financial stability. We find that an exogenous competition shock significantly improved the stability of banks, consistent with the 'competition-stability hypothesis'. We show that banks improved their cost efficiency and reduced credit risks in response to U.S. banking deregulation. In addition, we show the competition shock had a larger impact on banks who were initially operating in a less competitive environment. Our findings provide the first quasi-natural experimental evidence on the non-linear relationship between bank competition and financial stability.

Keywords: Bank Competition, Bank Risk, Financial Stability, Banking Deregulation

JEL Classficiation: G18 G20 G21 G28

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1 Introduction

In this paper we provide evidence on the relationship between banking competition and the stability of banks using a quasi-natural experiment. There has been a ongoing debate on the relationship between bank competition and financial stability in the literature for more than two decades. This issue became apposite after the 2008 global financial crisis, which has been attributed to the intensified competition in the financial sector due to the U.S. banking deregulation and worldwide financial liberalisation. The crisis caused economic recessions in several major economies (Reinhart and Rogoff, 2009).

How should we expect competition to impact the stability of banks? The literature in economics and finance has yet to reach consensus. On one hand, intensive competition may increase the likelihood of a global financial crisis. Many have argued that the banking deregulation and financial liberalisation that occurred in the decades prior to the 2008 crisis intensified the overall level of competition in the financial sector, which then encouraged banks and other types of financial institutions (primarily investment banks) to take excessive risks as they competed for profit. This argument is known as the 'competition-fragility' hypothesis (Keeley, 1990). In a more competitive environment banks lose their "charter value" and are more likely to shift risk towards depositors with the deposit insurance policy. While in a less competitive environment, banks tend to have higher profit margins and a larger capital buffer, and therefore are not likely to take risks which endanger the whole financial system (Hellmann et al., 2000; Beck et al., 2006; Berger et al., 2009; Beck et al., 2013). On the other hand, a higher level of competition could be desirable if competition increases economic efficiency. The 'competition-stability' hypothesis argues that there is a positive relationship between bank competition and financial stability. If lower lending rates result from higher levels of banking competition and this reduces the cost of borrowing for both firms and individuals, then this in turn would reduce the credit risk facing banks. Thus, the banking system as a whole could be more stable in a competitive environment (Schaeck et al., 2009; Boyd and Nicolo, 2005;

Anginer et al., 2014).

Given there are both potentially stabilizing and destabilizing forces associated with competition, it is possible that a non-linear U-shaped relationship between competition and stability may exist. At low levels of competition, more competition could be preferred with the stabilising forces of competition dominating. In highly competitive banking environments it is possible the destabilising forces of competition dominate, where excessive risk taking concerns outweigh the benefits of competitive efficiency. Therefore the observed relationship between competition on stability could be positive or negative, depending on current the level of competition in the sector (Martinez-Miera and Repullo, 2010; Hakenes and Schnabel, 2011; Jiménez et al., 2013).

Our analysis shows that the competition shock introduced by the intra-state branching deregulation in the United States improved the stability of banks significantly. This is consistent with the competition-stability hypothesis. Our result is robust to several econometric specifications. We examine the channels through which competition improves the stability of banks. We show that exogenously intensified competition in the banking market improved banks' cost efficiency and ensured their profitability was not eroded as interest margins were squeezed. We show that banks do not take excessive risks when the competition level increases. Instead, they exert more effort in identifying good borrowers and monitoring, so that banks suffer fewer losses due to credit risks. These channels have been largely overlooked in prior studies.

Finally, consistent with Martinez-Miera and Repullo (2010)'s theoretical findings, we show that there is a significant non-linear relationship between competition and stability. The exogenously intensified competition had a greater positive impact on banks operating in a less competitive environment prior to the shock. We contribute to the empirical literature by providing the first quasi-natural experimental evidence on the non-linearity between competition and the stability of banks.

The rest of this paper proceeds as follow. Section 2 reviews the literature in relation with this study. Section 3 explains the empirical setting and model specifications for the econometric analysis. Section 4 describes the main datasets and variables. Section 5 presents the main results from the analysis, and the robustness checks for the main results are presented in Section 6. Section 7 analyses the mechanisms through which competition may have an impact on the stability of banks, while Section 8 performs the analysis on the non-linearity between competition and stability. Section 9 concludes the paper.

2 Literature Review

This study is related to two strands of literature. Primarily, it is related to the papers which identifies the effect of bank competition on financial stability. Literature on this topic has been comprehensively reviewed by Carletti and Hartmann (2002), Beck (2008) and Vives (2011). These authors conclude that there is an ambiguous relationship between competition and stability.

Keeley (1990) develops a theoretical model suggesting that with protection of the deposit insurance, a bank's moral hazard problem would be intensified due to increased competition and decreased charter value. Keeley (1990) also provides empirical evidence by using U.S. banking deregulation in the 1980s as a test for the effect of increased competition. The results show that higher level of competition in the banking sector increases banks' default risk by increasing their asset risk and reducing their capital. Allen and Gale (2004) provides a theoretical analysis on the effect of competition on financial stability. They use several models to explore this question: general equilibrium models of financial intermediation and markets, agency models, spatial competition models, Schumpeterian competition models, and contagion models. The predictions of these models are not consistent; in some cases competition is positively related with stability while other models predict a trade-off between competition and stability.

As discussed above, higher levels of competition could reduce a bank's charter value and result in excessive risk taking, or alternatively competition could reduce borrowing costs and result in lower credit risk. However, Martinez-Miera and Repullo (2010) argues that there is another channel in operation: higher competition not only reduces banks' credit risks but also reduces their profit from performing loans, which provides provisions for loan losses. Taking this into account, Martinez-Miera and Repullo (2010)'s model predicts an U-shaped relationship between competition and stability. Competition affects bank stability through two channels: the risk-shifting effect by which higher loan rates due to a lack of competition would increase the credit risks faced by banks; and the margin effect through which a bank's revenue would be reduced since higher competition would reduce a bank's interest margin. They found that in a highly competitive banking system, the margin effect is dominant. Further increases in the level of competition would then have a negative effect on bank stability. However, in a concentrated banking system, the risk-shifting effect is expected to be dominant and more competition would then increases the stability of banks. Hakenes and Schnabel (2011) also propose a model suggesting that there is a U-shaped relationship between competition and stability. Therein, the effect of capital requirements on financial stability would be ambiguous due to the non-linear effect of banking competition on stability.

In terms of the empirical literature, there is also no consensus as to the relationship between banking competition and financial stability. Using data for 69 countries from 1980 to 1997, Beck et al. (2006) shows that a banking crisis is less likely to occur in countries where the banking system is highly concentrated, where the banking concentration is measured by the proportion of total assets held by the largest banks in the system. Opposing evidence is provided by Schaeck et al. (2009); measuring competition by Panzar and Rosse H-statistics for 45 countries they show that highly competitive banking systems are less likely to suffer from a systemic banking crisis, even after controlling for the initial level of bank concentration. This also result indicates that banking competition is more closely associated with the operational and regulatory constraints facing the banks, than the concentration ratio of the industry. Banking concentration itself could be only a weak proxy for actual banking competition.

Using bank-level data, Berger et al. (2009) calculate a variety of measurements of market power and stability of the each bank. Overall, their results are consistent with the competition-fragility hypothesis that banks with higher market power generally have less risks. Though they also found that a bank's portfolio risks increase due to higher market power, it is argued that this risk may partly be offset by higher bank capital. Beck et al. (2013) also uses bank level data to investigate the effect of a bank's market power on bank soundness, where market power is measured by the Lerner index and soundness is measured by the Z-score. The results show that there is a consistent positive relationship between a bank's market power and soundness, indicating that higher levels of competition would erode a bank's charter value and increase a bank's risk taking incentives. These results are consistent with Berger et al. (2009). In addition, their study shows that the positive relationship between market power and stability is even more significant in countries where there are stricter activity restrictions, lower systemic fragility, better developed stock markets, more generous deposit insurance and a more effective credit information sharing system.

Anginer et al. (2014) also use bank-level data to calculate market power and risk measurement. Similar with Beck et al. (2013), market power is measured by the Lerner index. However, they use Distance to Default (DD) as a measure of bank risk. [1] Overall, their results suggest that bank competition has a positive effect on bank stability, and this effect is quite robust. This result is in line with the competition-stability hypothesis.

A small number of papers have used the U.S. banking deregulation as a experiment to identify the effect of bank competition on bank performance. Stiroh and Strahan (2003) and Strahan (2003) find that banks with better performance tend to grow faster in terms of bank size after banking deregulation, indicating that banking assets are reallocated towards better banks due to the effect of increased competition. Using similar method,

[1]The Distance to Default measure was first proposed by Merton (1974). There are two advantages using this indicator rather than Z-score: first, both Lerner index and Z-score are calculated based on profitability measures, which makes them more likely to be positively correlated, thus using DD indicator avoids this potential problem; second, Z-score is calculated from bank's balance sheet (usually annual data) while DD indicator is based on market value (daily basis), which makes DD measurement updated more frequently and also more forward looking.

Subramanian and Yadav (2012) show that the instance of bank failure significantly reduced after banking deregulation, arguing that there is a increase in financial stability as a result of banking deregulation. However, bank failure itself might not be a strong indicator of stability. The reduction in the number of bank failures could be due to the deregulation policy which allows banks to acquire otherwise failing banks. Hence, while fewer failures may be observed, this does not necessarily imply an overall improvement in the stability of banks.

The paper closest to ours is Goetz (2017) who provides evidence that the degregulation in the banking sector significantly improved the stability of banks. He argues that the improvement in stability is due to higher level of profitability and less credit risks given the intensified competition in the banking sector. Our evidence his consistent with his findings. Our departure from his paper is to provide evidence on the underlying mechanisms driving the improvement in the stability of banks from deregulation. This leads us to identify evidence of a non-linear positive relationship between banking competition and financial stability, consistent with recent theoretical models of Martinez-Miera and Repullo (2010) and Hakenes and Schnabel (2011).

3 Empirical Setting

3.1 The U.S. Banking Deregulation

The U.S. banking system has had a long history of regulation while deregulation is only a relatively recent episode. Branch banking across counties or states was not allowed until the 1980s. The banking system of the U.S. had a unitary structure where most entities in the system were stand-alone banks. In the late 1970s, individual states in the U.S. started to deregulate their banking system which allowed banks to branch across counties and states. One of the reasons for the deregulation was that the ability of banks to compete over a longer distance was enhanced by the technological improvement (e.g. the invention of ATM), see e.g. Kroszner and Strahan (1999). The deregulation in branch-banking intensified competition in the banking sector as it ended the barrier to market entry and thus exposed incumbent banks in a certain county or state to new competitors from other administrative regions.

Two types of deregulation took place over the years: intra-state branching and inter-state branching. Intra-state branching deregulation allowed banks to branch across counties within a state while inter-state branching deregulation allowed banks to branch across different states. Intra-state branching deregulation was implemented with immediate effect while the inter-state branching deregulation was based on state-level reciprocation and it took longer to be implemented.[2] Therefore, we expect that the competition level of the banking sector was intensified gradually after the implementation of the inter-state deregulation.

[Insert Figure 1 here]

Figure 1 provides evidence on the volume of mergers and acquisitions (MAs) following the two types of deregulation. It shows that there was a significant increase in the cross-

[2] For example, Alabama deregulated their banks for inter-state branching in 1987. However, the banking sector of Alabama would still be a closed system and would not be exposed to outside competitors until another state reach an agreement with Alabama on the issue of interstate bank branching.

county (within state) M&As activity in the banking sector during the 1980s when most of the states ended the restriction on intra-state bank M&As and branching as documented by Amel (1993). However, even though most of the state also deregulated inter-state bank M&As during the same time period, the cross-state bank M&As only became popular after 1995 when the Riegle-Neal Act removed all barriers for inter-state M&As and branching activities in the US banking sector. This fact suggests that the implementation of the intra-state deregulation policy were more substantive then that of the inter-state deregulation policy, which further implies that the intra-state deregulation may have lead to a stronger competition shock in the banking sector of the home state. As the banking deregulation was levied by each individual state in different years, this staggered feature of the policy implementation provides us an opportunity to test the impact of the exogenously intensified competition in the banking sector. We will use difference-in-differences to examine the deregulation policies on the stability of banks.

3.2 Measurement for Competition and Stability

The aim of this study is to test the causality between bank competition and the stability of banks, thus the measurement of competition and stability is the key issue throughout the analysis. Most empirical papers in the competition-stability literature use different types of synthetic competition indicators such as market concentration (Beck et al., 2006), H-statistics (Schaeck et al., 2009) or Learner index as a measurement of market power (Berger et al., 2009; Beck et al., 2013; Anginer et al., 2014).

This study looks at the exogenous competition shocks caused by the banking deregulation in the U.S. during the 1980s, as the policy changes exposed the local banking system to outside competitors. Following Stiroh and Strahan (2003); Subramanian and Yadav (2012), two dummy variables - $Intra$ and $Inter$ - are created as the equations show below in order to capture the competition shocks caused by the intra-state and inter-state deregulation.

$$Intra_{s,t} = \begin{cases} 1, & \text{if intra-state branching is deregulated;} \\ 0, & \text{otherwise.} \end{cases}$$

$$Inter_{s,t} = \begin{cases} 1, & \text{if inter-state branching is deregulated;} \\ 0, & \text{otherwise.} \end{cases}$$

where s indicates the state of the deregulation and t stands for the year of the deregulation. As the equations show, the dummy variable $Intra$ is to 1 if the intra-state branching has been deregulated in state s at time t, otherwise it is equal to 0. Similarly, the dummy variable $Inter$ is equal to 1 if the inter-state branching has been deregulated in state s at time t, otherwise 0. The dummy variables based on the timing of the two types of banking deregulation capture the exogenous competition shock to the banking system induced by the policy changes in different states at different time period.

Following Beck et al. (2013), we use the Z-score as the main indicator for bank stability. The Z-score at bank-level is calculated as the equation shows below:

$$Z\ Score_{i,s,t} = \frac{ROA_{i,s,t} + Equity_{i,s,t}/Asset_{i,s,t}}{\sigma_n(ROA_{i,s})} \tag{1}$$

where i stands for bank in state s at time t. The denominator of the fraction, $\sigma_n(ROA_{i,s})$, is the standard deviation of the return on assets for bank i in state s with a time rolling window of n. As frequently used in the literature of financial economics as a risk indicator, the standard deviation of return captures the risk of a bank in a given period around time t. The numerator of the Z-score has two components: the return on assets of bank i at time t and the bank's equity over assets. The summation of the two components can be seen as a measure of a bank's solvency at a given point in time. Thus, the Z-score as a whole captures a bank's solvency per unit of its risk. Higher Z-scores indicates greater stability.

3.3 Econometric Method

Following Strahan (2003), the specification of the DiD regression model is illustrated by equation (2) below. Both intrastate and interstate banking deregulation are of interest, thus the DiD method is implemented by introducing the dummy variables for intra- and inter-state banking deregulation in the regression.

$$Stability_{i,s,t} = \alpha_0 + \alpha_1 Intra_{s,t} + \alpha_2 Inter_{s,t} + \mathbf{X}'_{i,s,t}\rho + \mathbf{S}'_{s,t}\phi + \gamma_t + \gamma_i + \epsilon_{i,s,t} \tag{2}$$

where i stands for each bank in the sample; s stands for each state in the sample; t denotes each quarter/year over the sample period; $Stability_{i,s,t}$ is the bank-level stability measurement for bank i in state s at time t; $Intra_{s,t}$ is a dummy variable for intrastate branching deregulation which takes value 1 if the time is after the deregulation year, otherwise 0; $Inter_{s,t}$ is a dummy variable for interstate banking deregulation which takes value 1 if the time is after the deregulation year, otherwise 0; $\mathbf{X}'_{i,s,t}$ is a set of bank-level control variables for bank i in state s at time t; $\mathbf{S}'_{s,t}$ is a set of state-level control variables for state s at time t; γ_t denotes time dummy variables controlling for year effect; γ_i is a set of dummy variables controlling for bank level fixed effect; $\epsilon_{i,s,t}$ is the error term for bank i in state s at time t.

The two deregulation dummy variables, $Intra_{s,t}$ and $Inter_{s,t}$ can be seen as the DiD term in a regression. Banks in a specific state with deregulation dummy variables equal to 1 can be seen as the treatment group in a DiD setting while those with deregulation dummy variables equal to 0 the control group. For example, Alabama deregulated intra-state bank branching in 1981 but its neighbour state Mississippi implemented the same policy not until 1986. In this case, the effect of the competition shock due to the policy change (treatment effect) on the banking system can be correctly identified by comparing the banking system in the two states during the period 1981-1985, meanwhile considering their difference before 1981 and after 1986 (common trends). Thus, the key parameters to be estimated is the coefficient on the dummy variables for both intra- and inter-state banking deregulation, as measurement for competition shocks in the banking system. A positive and significant coefficient on the dummy variables would indicate that competition has a positive effect on the stability of banks. If the coefficient is not statistically significant, there may yet be an effect working through the non-linearity of the relationship between competition and stability.

A dynamic Difference-in-Differences regression is implemented as a robustness check for the results estimated based on equation (2). The specification for the dynamic DiD analysis is illustrated by equation (3) below.

$$Stability_{i,s,t} = \alpha + \sum_{n=-5}^{5} \beta_n Dereg_{n,s,t} + \mathbf{X}'_{i,s,t}\rho + \mathbf{S}'_{s,t}\phi + \gamma_t + \gamma_i + \epsilon_{i,s,t} \tag{3}$$

where $Dereg = \{Intra, Inter\}$; $Dereg_{n,s,t}$ is a dummy variable equal to 1 if the difference between time t and the deregulation year is equal to n, otherwise 0. Taking observations from Alabama as an example. Alabama deregulated the restrictions on intra-state bank branching in 1981, thus the dummy variable $Dereg_{-1}$ would be equal to 1 if time t is 1980 for banks located in Alabama. Similarly, $Dereg_1$ is equal to 1 if time t is 1982. However, $Dereg_5$ is equal to 1 for all observations from Alabama after 1985.

$Dereg_{0,s,t}$ is the omitted dummy variable in the regression. Thus, the stability of banks in the deregulation year is used as the benchmark in the dynamic DiD regression. An insignificant coefficient estimated on the pre-deregulation terms ($Dereg_{n,s,t}$, $n \in$ [-5,-1]) would indicate that there is a common trend between the treated group and the control group before the deregulations took place, while positive and significant estimates on the post-deregulation dummies ($Dereg_{n,s,t}$, $n \in [1, 5]$) would imply that deregulation had a positive impact on the stability of banks.

4 Data

The main database for this study is *Consolidated Reports on Condition and Income* (Call report). It provides detailed balance sheet and income statement data for all banking institutions regulated by the *Federal Deposit Insurance Company* (FDIC). The sample period is from 1976 to 1994.[3] The final sample in this analysis includes 250,654 observations for 18,012 banks from 49 states. Summary statistics for the key variables are presented by Table 1.

[Insert Table 1 here]

The first variable in Table 1, $log(Z_3)$, is the logarithm of Z-score calculated with a 3-year rolling window, which is the main stability indicator in our analyses. $log(Z_5)$ is logarithm of Z-score calculated with a 5-year rolling window. $log(1/\sigma_3(ROA))$ and $log(1/\sigma_5(ROA))$ are inverse standard deviation of ROA with a 3- and 5-year rolling window respectively, and they are one of the key components of the Z-scores. Other components of the Z-score, return on assets (ROA) and equity to assets ratio, are also listed in the table. *Intra* and *Inter* are dummy variables for the implementation of the intra- and inter-state deregulations respectively, capturing the competition shock induced by the two types of policy change.

Size is the logarithm of total banking assets in a state. It controls for the effect of the size of a bank on its stability. *Size Growth* is the year-on-year growth of a bank's total assets. We expect a negative relationship between growth and stability as those who expand faster tend to take more risks on board. The variable commercial and industrial loans over total loans (*C&I loans*) controls for the riskiness of a bank's loan portfolio, as lending to commercial and industrial sectors tend to be riskier than mortgages and other types of lending. Compared with central bank reserves, investment in government

[3] As documented by Stiroh and Strahan (2003), some banks started to consolidate their subsidiary banks in other states into its primary account since 1994, leading to a jump in their total assets and other variables. To avoid the potential disturbance due to this inconsistent method of data reporting, our sample period stops at the year of 1994.

bonds and other types of investment, loans are the riskiest assets on a bank's balance sheet. Thus, *Loan to Assets* ratio controls for the overall riskiness of the total assets of a bank. *Liquidity* is defined by total liquid assets over total assets, which captures the capability of a bank to meet its short-term obligations. *Interbank Borrowing* captures a bank's dependence on unstable short-term funding. Finally, state-level *GDP Growth* rate, *Unemployment* rate, and *Housing Price Index* are used to control for the influence of macroeconomic conditions on the stability of banks.

5 Main Results

The main regression results for our analysis are presented in Table 2. Dummy variables *Intra* and *Inter* are the key variable of interest in these regressions as they capture the competition shock introduced by the specific deregulation policies. The regression analysis starts with a simple specification. As column 1 in Table 2 shows, it regresses the main stability indicator, logarithm of state-level Z-score with a 3-year rolling window ($log(Z_3)$), on the dummy variable *Intra* and a constant, with the bank fixed effect. The coefficient on the key term, *Intra*, is estimated to be -0.476 from this simple regression, and this effect is statistically significant at 1 percent level. It suggests that there is an increase in the stability at the bank-level given the competition shock induced by the implementation of intra-state bank branching policy. However, this simple regression specification does not control for factors other than the state fixed effect thus the result could be driven by the omitted factors such as time fixed effects.

[Insert Table 2 here]

In the second column in Table 2, year fixed effects are introduced into the model and there is a noticeable decrease in the size of the estimated coefficient on *Intra*. The estimated R^2 suggests that the model with time fixed effect is preferred as it increases from 35% in column 1 to 37% in column 2. The estimated coefficient 0.028 in the second column in Table 2 indicates that the individual bank stability is on average improved by 2.8% in the post intra-state deregulation period. This implies that the positive impact of the competition shock induced by the intra-state branching deregulation on stability is not just statistically but also economically significant.

Along with the bank and year fixed effects, other control variables are then introduced into the regression, and the results are presented by column 3 in Table 2. Even with this strict specification the coefficient of interest remains statistically significant, albeit at the 10 percent level. It also shows that bank size and liquidity condition are positively associated with stability, while banks with more interbank borrowing tend to be less stable. Indicators for state-level macroeconomic conditions are also added into the model as control variables. As it shows in column 3 in Table 2, GDP growth of a state is positively associated with the stability of the banks in the state, while an increase in unemployment rate and housing price can destabilise banks, as the coefficient on unemployment rate and housing price index are both estimated to be negative and significant. Compared with the previous model specification in column 2, the goodness of fit of the model is also improved with the control variables: 38% of variations in state-level stability is explained by the current model.

Column 4 in Table 2 presents the results estimated with the full specification where region-year fixed effect is introduced into the model.[4] As it shows in column 4, the stability of individual banks is on average improved by 1.9% by the intensified intra-state competition in the banking sector. Though the effect of housing price level on stability is estimated to be insignificant with this full specification, the estimates on all other control variables remain qualitatively the same. Introducing BEA region-year fixed effects into the model further improves the estimated R^2 to 39%, indicating that some variations in stability indeed can be explained by the time-varying regional factors that should not be

[4]The Bureau of Economic Analysis (BEA) divides the United States into eight regions for the purpose of economic and statistical analysis, and each region contains several states.[5] Thus, including the BEA region-year fixed effect in the model controls for all types of time-varying regional factors which would have am impact on stability.

omitted in the model.

The analysis continues with the full specification. In column 5 in Table 2, the dummy variable *Intra* is replace by *Inter* to explore the effect of inter-state competition induced by the inter-state branching deregulation on stability. As it shows, the estimated coefficient on *Inter* is also positive and significant, which suggests that the policy change have a significant and positive impact on stability. Finally, in the last column in Table 2, dummy variables *Intra* and *Inter* are both introduced into the model. The results are very consistent with the previous estimations. To summarise, the regression results presented in Table 2 show that the intensified competition induced by the policy changes significantly improved the stability of banks, and this result is robust to different model specifications. Overall, our results are consistent with the competition-stability hypothesis advanced in the literature.

6 Robustness Checks

6.1 Balanced Panel

As described in the previous sections, the main dataset in this analysis is the Call Report, which records financial statements data for all banking institutions regulated by the FDIC. It contains 250,654 observations for 18,012 banks and the sample period starts from 1976 to 1994, with an annual frequency of 19 years. However, the panel is unbalanced: some banks are entered the market and recorded by the database after 1976 while some others disappeared before 1994, due to the reason of failure, merger or acquisition. This unbalanced feature of the bank-level data might introduce sample selection bias to our estimated coefficients. For instance, banks that failed or were subjected to mergers and/or acquisitions by others might have been those more unstable banks.

[Insert Table 3 here]

This section examines whether the previous findings are driven by the unbalanced feature of the panel dataset. To construct a balanced panel, those unbalanced observations are dropped from the dataset, and only banks that could be observed over the whole sample period are kept. Table 3 shows the results estimated with the balanced panel dataset. The first column in Table 3 shows the estimated results from our previous analysis serving as the baseline results, while column 2-4 present the results estimated based on the balanced panel. As the bottom of Table 3 shows, the number of banks in the balanced panel decreased by 51.1% from 16,410 to 8,107, and the number of observations decreased by 35.4% from 213,154 to 137,779 accordingly. Though there is a significant drop in the number of observations in the balanced panel, the key regression result remain qualitatively unchanged. It shows that the estimations on the key terms, $Intra$ and $Inter$, are all positive and significant, and the scale of the estimated effect of the competition shock on stability are very close to those in the baseline results. Overall, these consistent results suggests that the previous findings in the bank-level analysis are unlikely to be biased due to the unbalanced nature of the dataset.

6.2 Mergers and Acquisitions

The U.S. banking deregulation was to allow banks to branch across counties and states mainly through bank mergers and/or acquisitions (M&As), thus many bank M&A cases occurred over our sample period as Figure 1 depicts. This may create noise in the estimated results, as the M&As lead to revaluation of balance sheet variables for those involved in the cases. To control for the potential influence of bank M&As, we drop the observations for the involved banks from the M&A year and rerun the regressions as robustness checks in addition to the test with the balanced panel in the previous section.

[Insert Table 4 here]

The results are presented in Table 4. The first column in Table 4 presents the baseline results for comparison. In column 2, observations for involved banks from the M&A year are dropped, while the estimated coefficients remain qualitatively unchanged. We further drop observations for the involved banks from the M&A year (T_0) and the year after (T_1) as an additional check in column 3, and our main results hold. Overall, these results suggests that our main results are not driven by the bank M&As encouraged by the U.S. banking deregulation.

6.3 Dynamic difference-in-differences

Following regression specifications illustrated by equation (3), a dynamic difference-in-differences is also implemented in our analysis to reinforce the results reported above. The results from the dynamic DiD regressions are presented by Table 5.

As the bottom of Table 5 shows, all these regressions follow the full specification where the bank-level and state-level controls variables, bank fixed effects, and the BEA region-year fixed effects are all included. The first column in Table 5 presents the regression results from the typical DiD regression serving as a baseline. In column 2, to further confirm the causality between competition and stability, the DiD term *Intra* is decomposed into ten dummy variables denoting the pre- and post-treatment periods. *Pre-n* (*Post-n*) is the dummy variable for the period n year(s) before (after) the deregulation year for $n \in [1, 4]$. *Pre*-5 (*Post*-5) is the dummy variables for all the periods that is 5 years or more before (after) the deregulation year. The dummy variable for the deregulation year is omitted to make sure that the the stability of banks indicated by the Z-score at the year of deregulation is used as the benchmark in this dynamic DiD setting.

[Insert Table 5 here]

The regression results presented by column 2 in Table 5 show that the coefficients on the pre-treatment dummy variables are all estimated to be statistically insignificant. There is no significant differences between banks in the treatment group and those in the control group before the competition shock comes into play. This is consistent with the the common trend assumption of the DiD. The coefficient estimated on the post-treatment dummy variables, *Pre-n*, are all positive and statistically significant. Furthermore, the size of the impact is growing over time. In the first year of the post-treatment period, stability on average improved by 2.4% given the competition shock, while this number increases to over 6% in after 4 years of the deregulation. The regression results in column 2 are graphically presented in Figure 2. Overall, these results confirm our previous findings that the intensified competition induced by the intra-state deregulation has improved the stability of banks, which is consistent with the competition-stability hypothesis.

[Insert Figure 2 here]

Similarly, the term *Inter* which captures the competition shock induced by the Inter-state deregulation, is decomposed into ten dummy variables according to the timing of the deregulation, and the regression results are presented in column 3 in Table 5. Although most of the coefficients estimated on the pre-treatment dummy variables are statistically insignificant, the one on *Pre*-2 is significant at 95% level. This suggests that the common trend assumption in this case is not fully satisfied. In terms of the post-treatment periods, only the coefficient on *Post*-1 is estimated to be positive and significant, which suggests that stability on average improved by 1.6% in the first year of the post-deregulation period. The impact turned to be insignificant 2 and 3 years after the deregulation. In later periods, it even turned to be negative and significant. These regression results are also graphically presented in Figure 3.

[Insert Figure 3 here]

Overall the results in column 3 in Table 5 confirm that intra-state banking deregulation had a causal effect of stability, but we cannot establish causality when using the inter-state deregulation. There are two possible reasons that explain this results. First, the inter-state deregulation were implemented based on state-level reciprocation, thus the policy would not be effective if no other state reached a mutual agreement with the home state to allow outside banks to enter their market. However, the intra-state deregulation was implemented with immediate effect and this is confirmed by figure 1. Thus, the variable *Intra* may capture a clearer and stronger exogenous competition shock. Second, as the inter-state deregulation was to allow banks to branch across states, those banks that expanded across state borders may have potentially benefited from geographical diversification. Facing less idiosyncratic local risks, banks' overall stability may be improved (Goetz et al., 2016). Therefore, the dummy variables for the timing of the announcement of the inter-state deregulation might not be capturing fully the competition shock. For this reason, the analysis in the next section focuses on the impact of the intra-state deregulation. This should allow us to better isolate the potential impact of bank geographical diversification activities after the inter-state deregulation.

6.4 Placebo Test

Placebo tests are conducted to check whether our main findings are not spurious artifacts of the DiD research design. As the dynamic DiD results suggests that the timing for the implementation of the inter-state banking deregulation does not capture the competition shock successfully, the placebo tests in this section only focus on the competition shock induced by the intra-state deregulation.

To conduct the placebo test, we rerun the regression based on equation (2) with a placebo term for $Intra$, where the implementation year of the policy is randomly assigned to each state in the sample. This should result in a coefficient not statistically different from zero on the placebo term.

[Insert Figure 4 here]

We repeat the process of the placebo test over 1,000 trials and calculate the t-statistics for the point estimates on the placebo terms from each regression. Figure 4 presents the distribution and the estimated kernal density of the t-statistics, along with the normal distribution curve. As the figure shows, the t-statistics estimated from the placebo tests are well distributed around zero following the shape of the normal distribution. In other words, it shows that the placebo term is a normally distributed random variable with a zero mean. This reinforces our interpretation of our DiD result as robust.

7 Mechanism Analysis

The analysis above shows that the intensified competition induced by the intra-state deregulation improved the stability of banks. However, the empirical literature provides little evidence on *how* banking competition could have an impact on stability. Goetz (2017) argues that the positive impact of the competition shock on stability is driven by the improvement in both profitability of banks and the quality of their assets. However, the author does not provide further explanation on the counter-intuitive results that intensified competition improves profitability. This section aims to fill the gap in the literature to provide empirical evidence on the mechanism through which the intensified competition improves the stability of banks.

7.1 Z-score Components

Following the banking literature, the main indicator for the stability of banks in our analysis is Z-score calculated with a 3-year rolling window (Z_3). We re-estimate equation (2) using a Z-score with a 5-year rolling window. Results are presented in column 2 in Table 6, along with the previous results in column 1 for ease of comparison. As it shows, the coefficient estimated on $Intra$ in column 2 is qualitatively the same with the one in column 1, which indicates that our previous findings are not driven purely by the time-window for the Z-score calculation.

[Insert Table 6 here]

Having ruled out any possible impact coming from the rolling window, we proceed to identify the impact of the competition shock on each components of the Z-score. This should give us some better understanding of the drivers of our key finding. Column 3 in Table 6 shows that banks' equity to assets ratio on average decreased by 19 basis points due to the intensified competition in the banking industry. Though the effect is statistically significant, it is only marginally economically significant given the small scale. The results in column 3 suggests that the improved stability is not driven by the equity to assets ratio. Column 4 in Table 6 then examines the impact of the competition shock on bank profitability. Different from (Goetz, 2017), our finding suggests that bank profitability is not significantly affected by the intensified competition in the banking industry, as the coefficient is estimated to be insignificant. It also confirms that the improved stability is not driven by an increase in profitability.

We then examine the impact on the competition shock on the last component of the Z score - the inverse standard deviation of profitability, which captures the stability of a bank's earnings. Column 5 in Table 6 shows that banks' earnings stability is on average improved by 4.4% given the intensified competition. This exercise is repeated with a inverse standard deviation of profitability calculated with a 5-year rolling window, and the results are presented in the last column in Table 6. The coefficient estimated on *Intra* is almost the same, even though the number of observations decreased significantly due to the widened time window. This confirms that the positive impact of the competition shock on banks' earning stability is not driven by the rolling window for calculating the standard deviation. The results in column 5 and 6 confirm that the improvement in stability given the intensified competition is mainly driven by the stabilised earnings in the banking industry.

7.2 Profitability and Efficiency

In the previous section we looked at the various components of the banks' Z-score and we found that bank profitability is not significantly affected by the increase in competition. To shed further light on this relationship, this section looks at the impact of the competition shock on bank profitability and cost efficiency. The hypothesis here is that if a bank's profitability has not been affected then a bank's cost efficiency should increase. To test this hypothesis, we start by considering a different set of variables to measure bank profitability. Firstly, we use *Loan Rate* which is the total interest income from loans divided by total loans; second, we utilise the *Deposit Rate* calculated as the total interest expenses on deposits divided by total deposits; third, we employ the *Funding Cost* as the total interest expenses on deposits and inter-bank borrowings divided by total deposits plus total inter-bank borrowings; fourth we look at the *Interest Margin* as the total interest income minus total interest expenses then divided by total assets; finally we use the *Earning Spread* which is the *Loan Rate* minus *Deposit Rate*.

[Insert Table 7 here]

The results for the profitability analysis are presented in Table 7. The estimated coefficient on *Intra* in Column 1 suggests that banks do not tend to charge for a lower interest rate on their borrowers facing the intensified competition. However, the coefficient in column 2 indicates that banks tend to offer a higher interest rate for their depositors in order to compete for deposits. The deposit rate on average increased by 5 basis points due to the intensified competition. This leads to a higher overall funding cost for banks, as suggested by the estimate in column 3. Not surprisingly, given the unchanged loan rate and increased funding cost, the increased level of competition squeezed banks' net interest margin - it on average decreased by 5 basis points due to the competition shock as indicated by the estimate in column 4. The estimate in column 5 suggests that banks' earning spread on average decreased by 4.6 basis points.

Overall the previous results in Table 6 suggests that the competition shock did not have a significant impact on banks' profitability. We now turn our attention to the banks' cost efficiency to identify how banks maintained their profitability given the squeeze in the net interest margin after the competition shock. We look at the *Cost to Income* ratio as the indicator for bank cost efficiency, which is banks' total non-interest expenses divided by total revenue. This ratio measures how much a bank needs to spend on non-interest items to generate one unit of revenue.

[Insert Table 8 here]

The regression results for cost efficiency are presented in Table 8. The estimate in column 1 shows that the cost-to-income ratio significantly decreased given the intensified competition in the banking sector. This result indicates that banks became more efficient in making use of non-interest expenses. We further investigate this issue by decomposing the cost-to-income ratio based on the two major categories of a bank's non-interest expenses: labour cost (i.e. salaries) and expenses on fixed assets (e.g. premises and office equipment). As Table 8 shows, the estimates in column 2 and 3 are both negative and significant, which suggests that the competition shock made banks make more efficient use of both labour and fixed assets. This analysis indicates that the increased bank cost efficiency compensated for the the squeezed net interest margin, leaving banks' overall profitability unchanged.

7.3 Loan Quality and Credit Risks

The competition-fragility hypothesis (Keeley, 1990) argues that banks tend to take excessive risks when the competition level increases. The quality of their banking assets may deteriorate which could lead to instability. This section examines whether the competition shock had an impact on the quality of bank loans and the credit risks faced by banks.

We use several variables to measure loan quality and credit risks: $Non\text{-}performin$ is the most commonly used indicator for loan quality which is calculated as total non-performing loans divided by total loans; *Loss Reserves* is a ratio between total reserves for loan losses and total loans, which captures a bank's perceived level of riskiness for its loan portfolio. $Charge\text{-}offs$ is the total impaired loans that have been written-off from the book divided by total loans, which measures the actual losses due to credit risks; and *Loss Provision* is calculated as total loss provisions divided by net income, which measures how much risks a bank would take to generate one unit of profit.

[Insert Table 9 here]

The regression results for the analysis on loan quality and credit risks are presented in Table 9. The first column shows that the intensified competition did not have a significant impact on banks' non-performing loan ratio. It suggests that banks' assets quality did not deteriorate given the intensified competition. The coefficient in column 2 is also estimated to be insignificant, which suggests that banks did not perceive a higher level of riskiness on their loan portfolio given the intensified competition. These results are inconsistent with the competition-fragility hypothesis.

As column 3 in Table 9 shows, banks' loan charge-offs significantly decreased as a proportion of total loans, which indicates that banks suffer fewer losses on their lending activities. In turn, this suggests that the credit risks faced by banks actually decreased given the intensified competition. More interestingly, column 4 shows that banks' loan loss provisions significantly decreased by on average 3 percentage points as a proportion of net income. This result suggests that banks became more able to generate profit with less credit risks on board given the intensified competition. The results in column 3 and 4 together may suggest that the higher level of competition forced banks to improve their efficiency on identifying high quality borrowers. This may further explain why bank earnings were stabilised given the intensified competition as suggested by the results in column 5 and 6, Table 6.

To summarise, our mechanism analysis reveals several channels through which a higher level of competition in the banking sector may improve stability. First, the intensified competition shock squeezes banks net interest margin so that they are forced to improve their cost efficiency to maintain their overall profitability. Second, the intensified competition shock does not force banks to take excessive risks to try to achieve a higher level of profitability. Instead, it forces banks to make more effort to identify high-quality borrowers and monitor borrowers' activities, so that banks expose themselves to fewer credit risks and achieve more stable profits. We argue that these two channels, which have been overlooked in the literature to date, are important underlying factors in how banks respond to competition.

8 Non-linearity Analysis

In this section we explore the possibility that there exists a non-linear relationship between banking competition and stability as suggested by Martinez-Miera and Repullo (2010). Using the intra-state branching deregulation in the U.S. as a quasi-natural experiment, our analysis proceeds to test the non-linear impact of competition on the stability of banks.

Before the implementation of the intra-state branching deregulation, all banks were only allowed to operate within its own county, so each county is an independent banking market. We calculate the county-level Herfindahl-Hirschman index (HHI) one year before the implementation of the intra-state deregulation for each county in each state, to measure the pre-deregulation level of competition in each banking market. The distribution of this pre-deregulation county-level HHI is depicted in Figure 5.

[Insert Figure 5 here]

We follow the U.S. Department of Justice guidance and consider the banking market is highly competitive if the HHI is below 1500; moderately competitive if the HHI is higher than 1500 but lower than 2500; and highly concentrated if the HHI is above 2500.[6] Two dummy variables are generated to indicate the pre-deregulation level of competition:

$$Moderate_{c,s,t} = \begin{cases} 1, & \text{if } 1500 < \text{pre-deregulation HHI} < 2500; \\ 0, & \text{otherwise.} \end{cases}$$

$$Low_{c,s,t} = \begin{cases} 1, & \text{if pre-deregulation HHI} > 2500; \\ 0, & \text{otherwise.} \end{cases}$$

where c stands for each county, s stands for each state and t stands for the period one year before the year of deregulation. To identify the non-linear impact of the competition shock on stability, we interact the DiD term $Intra$ with the two dummy variables, and the

[6] https://www.justice.gov/atr/herfindahl-hirschman-index

regression results are presented in Table 10, along with the baseline results presented in column 1 for comparison reason. Column 2 shows that the estimated coefficient on $Intra$ is estimated to be negative, though it is not statistically significant. The interaction between $Intra$ and $Moderate$ is also estimated to be insignificant, while the coefficient on the interaction between $Intra$ and Low is estimated to be positive and significant. Overall, it shows that our previous findings are mainly driven by banks operating in a less competitive environment. The competition shock has no significant impact on banks operating in a relatively more competitive environment prior to the shock. This supports the notion that there exists a non-linear relationship between competition and stability.

[Insert Table 10 here]

We also interact the DiD term $Intra$ directly with the pre-deregulation county-level competition measurement HHI to estimate the marginal effect of the competition shock at different level of pre-deregulation competition. Column 3 in Table 10 presents the results. As it shows, the coefficient on $Intra$ is estimated to be negative and significant, which indicates that the competition shock tend to deteriorate banking stability if the local banking market was highly competitive prior to the shock. The estimate on the interaction between $Intra$ and HHI is positive and significant, which is consistent with the results in column 2. However, the effect is estimated to be very small, as HHI ranges from 0 to 10,000.

[Insert Figure 6 here]

To further present the non-linearity effect, a linear prediction of the marginal effects of the competition shock at different level of pre-deregulation competition is estimated and depicted in Figure 6. It illustrates that the positive impact of intensified competition becomes larger and more significant as the pre-deregulation level of competition decreases. Overall, our results suggests that there is a non-linear relationship between competition and stability.

9 Conclusion

In this paper, we employ a robust empirical strategy to measure the effect of banking competition on the stability of banks. Taking advantage of the staggered introduction the U.S. branch banking deregulation in the 1980s, we conduct a difference-in-differences analysis to isolate the causal impact of competition on stability. Our analysis shows that the intensified competition shock caused by the intra-state branching deregulation improved the stability of banks significantly.

Consistent with Martinez-Miera and Repullo (2010)'s theoretical findings, we show that there is a significant non-linear relationship between competition and stability. We show the exogenously intensified competition tended to have a greater positive impact on banks operating in a less competitive environment prior to the shock. Our results constitute the first quasi-natural experimental evidence on the non-linearity between competition and stability of banks.

The relationship between banking competition and financial stability is of central importance to the proper functioning of modern economies. It is imperative that banking regulators have a clear view of how banking competition interacts with financial stability if global disasters such as the 2008 crisis are to be avoided in the future. Concerns voiced by policymakers that banking competition results in excessive risk-taking and an unstable financial system may be misplaced, given that the dominant impact of competition in our study is observed to increase the stability of the banking system. Likewise, policymakers should be careful that tighter banking regulations do not create an absence of competition within the sector. There may be unanticipated consequences of enacting competition-reducing policies resulting in the reduced stability of the banking system.

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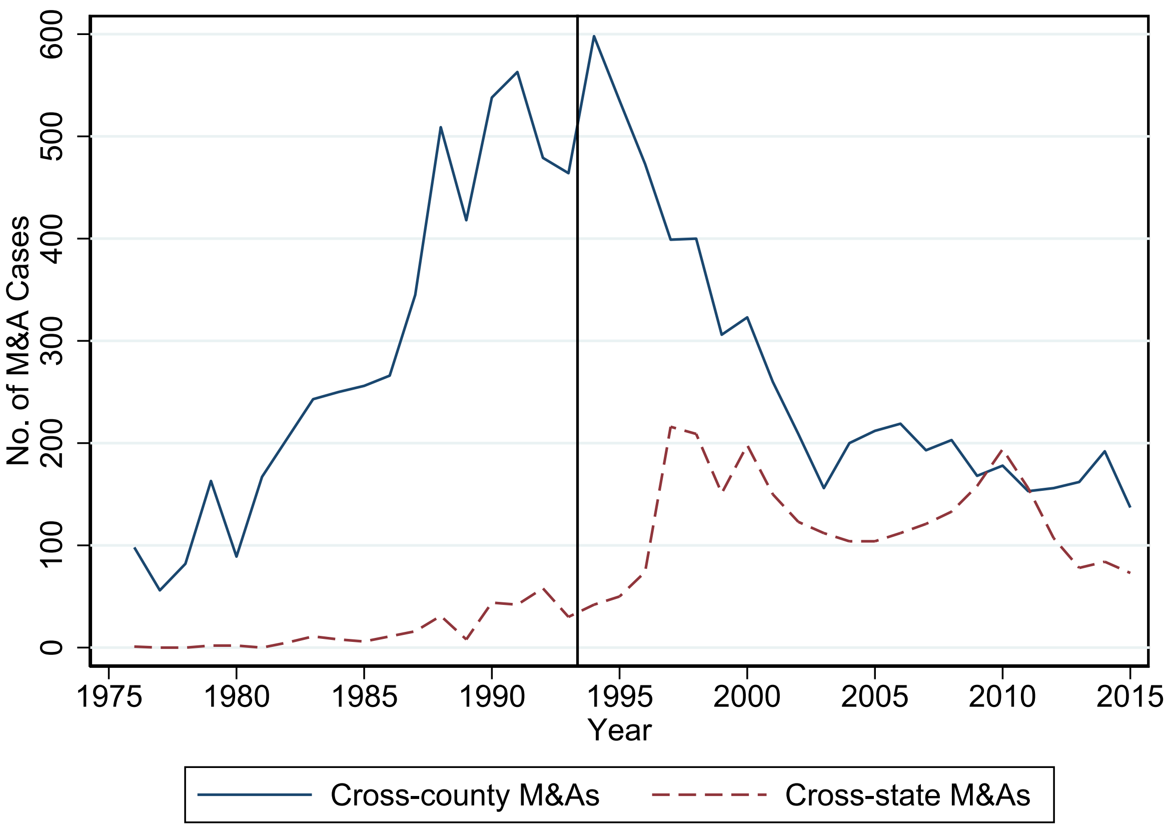
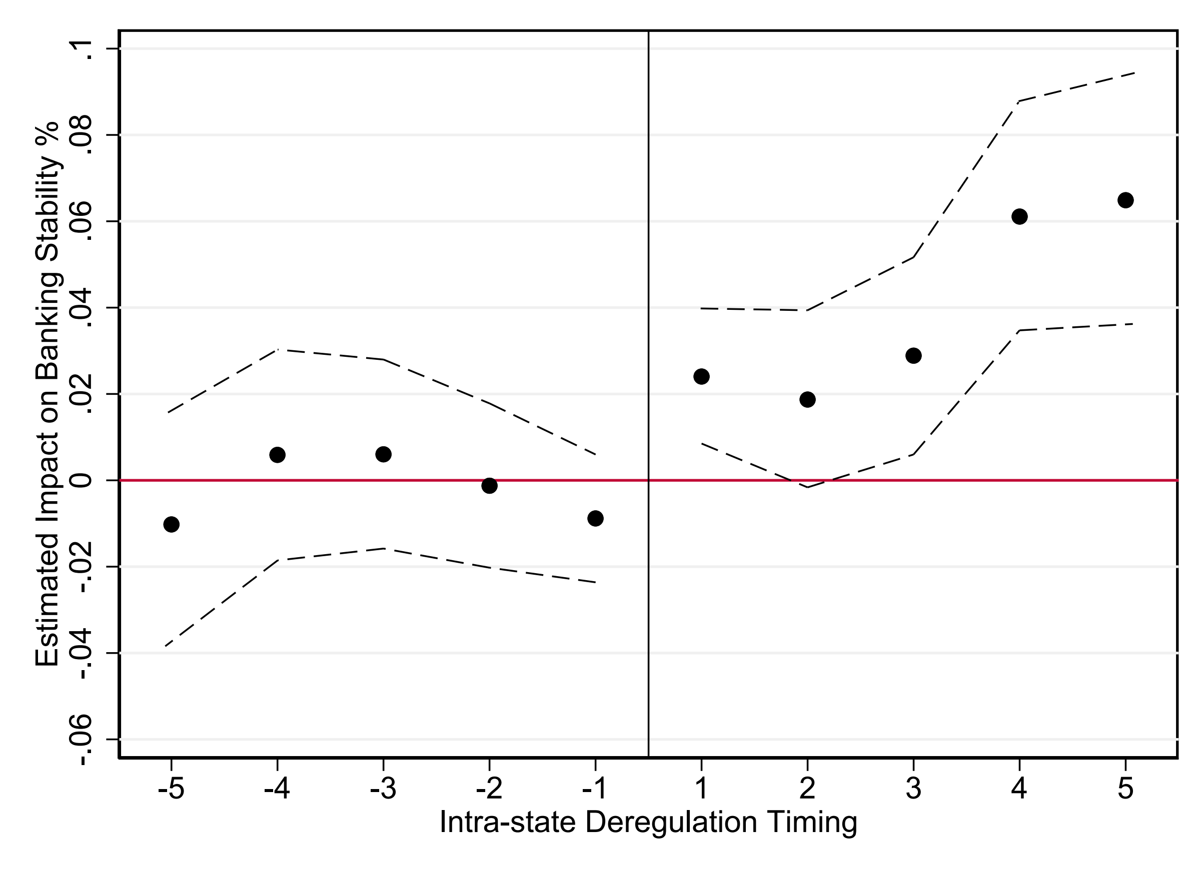
Figure 1: Number of Bank M&A Cases



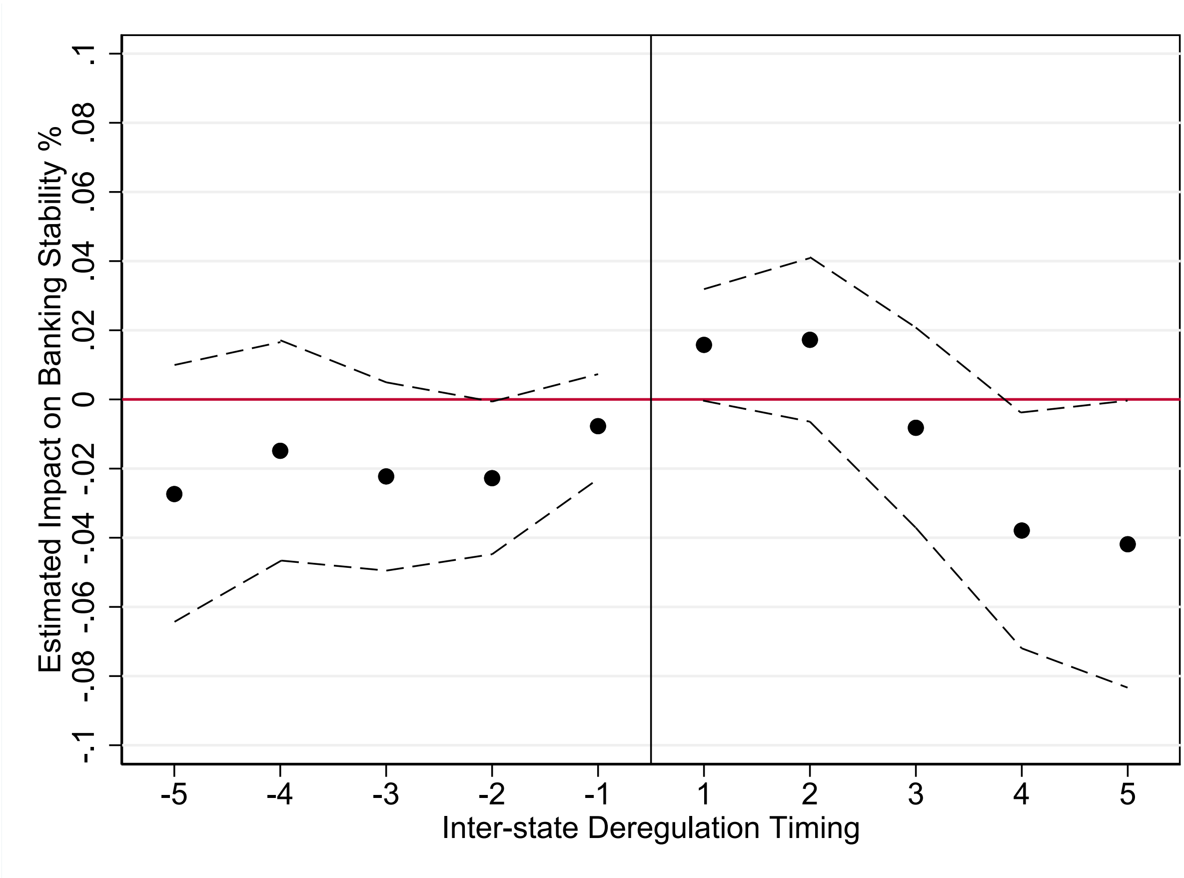
Notes: This figure provides evidence on the effectiveness of the two types of deregulation. It shows that there was a significant increase in the cross-county (within state) M&As activities in the banking sector during the 1980s when most of the states deregulated the restriction on intra-state bank M&As and branching. However, even though most of the states also deregulated inter-state bank M&As during the same time period, the cross-state bank M&As only became popular after 1995 when the Riegle-Neal Act removed all barriers for inter-state M&As and branching activities in the US banking sector.

Figure 2: Dynamics in Estimated DiD Effects (Intra)



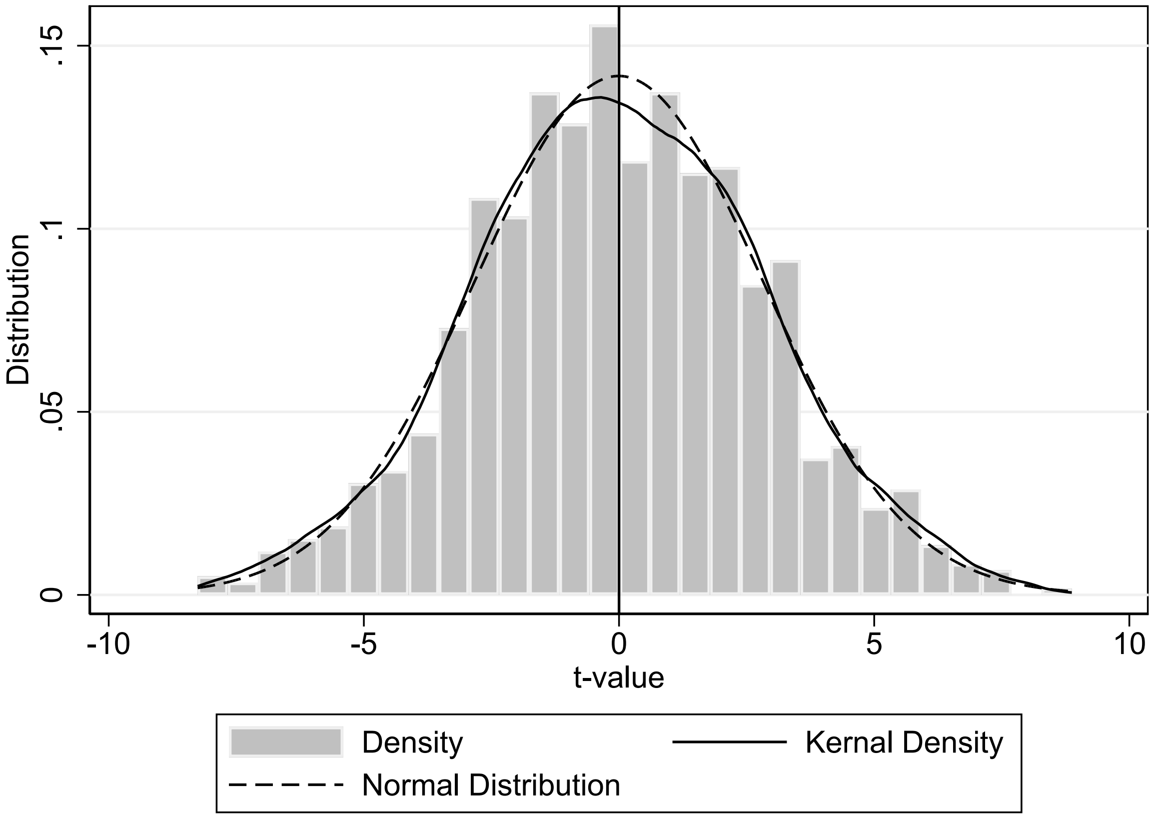
Notes: This figure graphically presents the estimated coefficients from the dynamic DiD regression in column 2, Table 5. As it shows, there is no significant difference between the control group and the treatment prior to the inter-state deregulation shock, which confirms the common trend assumption of the DiD setting. It also confirms our main finding that the competition shock induced by the intra-state deregulation significantly improved banking stability in the post deregulation period.

Figure 3: Dynamics in Estimated DiD Effects (Inter)



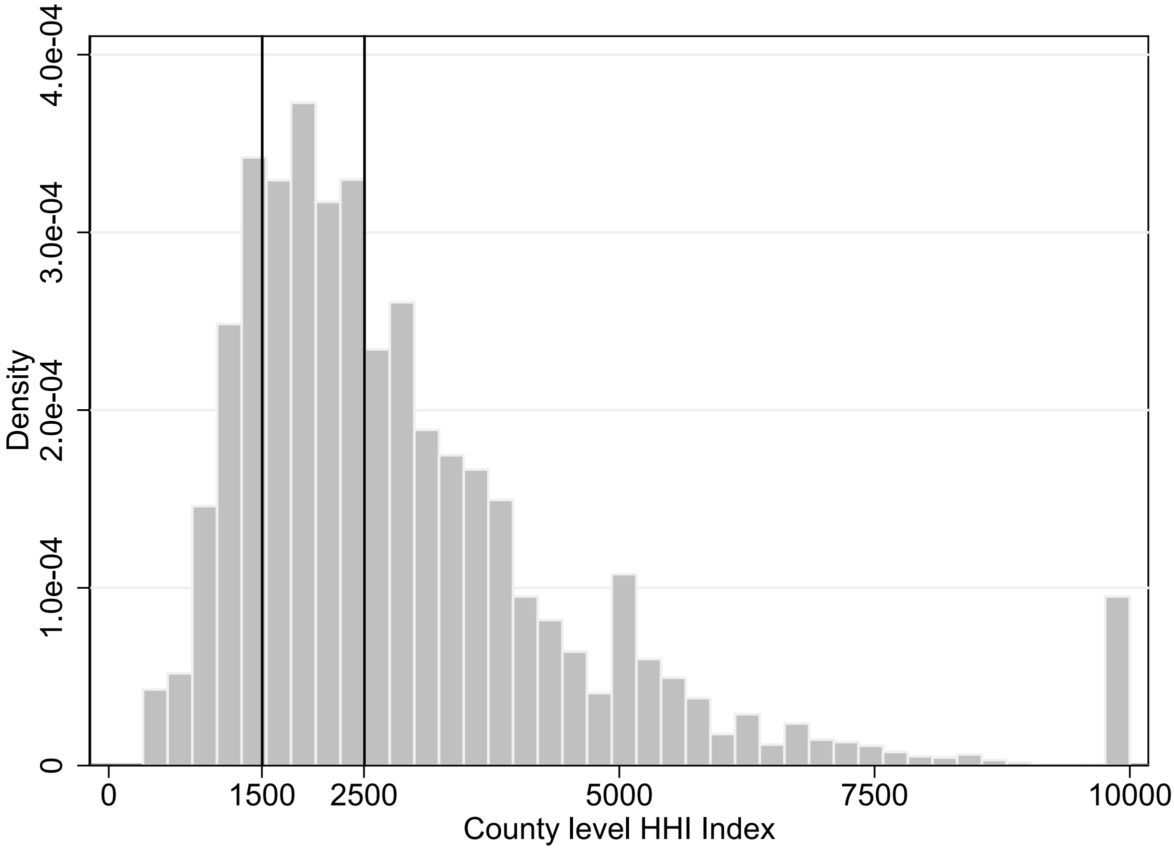
Notes: This figure graphically presents the estimated coefficients from the dynamic DiD regression in column 3, Table 5. It shows that most of the coefficients estimated for the pre-treatment period are statistically insignificant, suggesting that there exists a common trend between the control group and the treatment group prior to the policy shock. However, we do not observe consistently significant differences between the control and treatment group in the post period.

Figure 4: Distribution of the t-statistics Estimated from the Placebo Tests



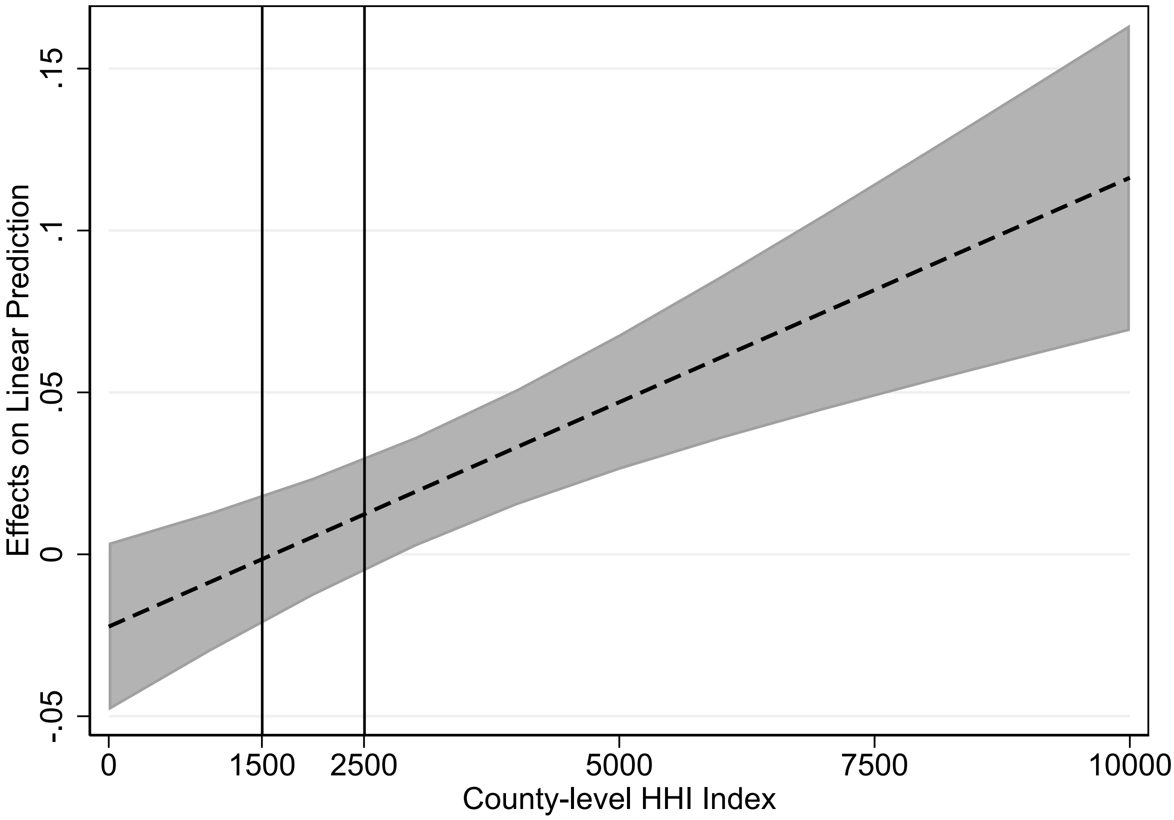
Notes: This figure presents the distribution and the estimated kernal density of the t-statistics estimated from the placebo tests, along with the normal distribution curve. As it shows, the t-statistics estimated from the placebo tests is well distributed around zero following the shape of the normal distribution. In other words, it shows that the t-statistics is a normally distributed random variable with a zero mean, which suggests that our previous key findings are not driven by the DiD research design.

Figure 5: Banking Concentration at the Year of Deregulation



Notes: This figure depicts the distribution of the county-level Herfindahl-Hirschman index (HHI) one year before the implementation of the intra-state deregulation for each county in each state, as a measurement on the pre-deregulation level of competition in each banking market. We follow the U.S. Department of Justice and consider the banking market is highly competitive if the HHI is below 1500; moderately competitive if the HHI is higher than 1500 but lower than 2500; and highly concentrated if the HHI is above 2500.

Figure 6: Non-linear Effect of Competition on Banking Stability



Notes: This figure presents the linear prediction of the marginal effects of the competition shock at different level of pre-deregulation competition estimated from the regression in column 3, Table 10. We follow the U.S. Department of Justice and consider the banking market is highly competitive if the HHI is below 1500; moderately competitive if the HHI is higher than 1500 but lower than 2500; and highly concentrated if the HHI is above 2500. It shows that the positive impact of intensified competition becomes larger and more significant as the pre-deregulation level of competition decreases. Overall, it suggests that there exists a non-linear relationship between competition and stability.

Table 1: Summary Statistics

	Mean	St.D.	Min	Max	Obs.
$log(Z_3)$	4.23	0.71	0.81	10.54	213,323
$log(Z_5)$	3.60	0.79	-1.27	8.06	180,458
$log(1/\sigma_3(ROA))$	1.77	0.82	0.00	8.01	213,326
$log(1/\sigma_5(ROA))$	1.51	0.65	0.01	6.34	180,464
ROA	0.82	0.96	-4.32	2.52	246,310
Equity/Assets	8.81	3.26	3.24	26.69	246,351
Intra	0.39	0.49	0	1	246,363
Inter	0.38	0.49	0	1	246,363
Size	10.54	1.27	5.46	19.16	246,201
Size Growth	0.91	1.69	-43.12	84.22	229,760
C&I Loan/Total Loan	20.96	13.93	0.00	100.00	245,871
Loan/Total Asset	53.69	14.04	0.00	100.00	246,071
Liquidity	34.51	14.77	0.00	99.94	246,200
Interbank Borrowing	1.30	3.70	0.00	92.52	246,200
GDP Growth	3.01	3.75	-28.08	30.61	246,213
Unemployment	6.68	2.06	2.30	17.80	246,213
Housing Price Index	4.74	0.28	3.95	5.76	246,213

Notes: $log(Z_3)$ is the logarithm of Z score calculated with a 3-year rolling window, which is the main stability indicator in our analysis. $log(Z_5)$ is logarithm of Z score with a 5-year rolling window $log(1/\sigma_3(ROA))$ and $log(1/\sigma_5(ROA))$ are inverse standard deviation of ROA with a 3- and 5-year rolling window respectively. *Size* is the logarithm of total banking assets in a state. *Size Growth* is the year-on-year growth of the total banking assets in a state. The variable *C&I loans* is commercial and industrial loans over total loans, which controls for the riskiness of a bank's loan portfolio. *Loan to Assets* ratio controls for the overall riskiness of the total assets of a bank. *Liquidity* is defined by total liquid assets over total assets, which captures a bank's capability to meet its short-term obligations. *Interbank Borrowing* captures a bank's dependence on unstable short-term funding. Finally, state-level *GDP Growth* rate, *Unemployment* rate, and *Housing Price Index* are used to control for the influence of macroeconomic conditions on banking stability.

Table 2: Main Results

	(1)	(2)	(3)	(4)	(5)	(6)
Intra	0.053***	0.028***	0.014*	0.019**		0.021**
	(0.006)	(0.008)	(0.008)	(0.009)		(0.009)
Inter					0.023**	0.025**
					(0.010)	(0.010)
Bank-level Controls						
Size			0.076***	0.096***	0.096***	0.096***
			(0.009)	(0.009)	(0.009)	(0.009)
Size Growth			-0.001	-0.004***	-0.004***	-0.004***
			(0.001)	(0.001)	(0.001)	(0.001)
Interbank borrowing			-0.002***	-0.003***	-0.003***	-0.003***
			(0.001)	(0.001)	(0.001)	(0.001)
Liquidity			0.002***	0.003***	0.003***	0.003***
			(0.000)	(0.000)	(0.000)	(0.000)
C&I Loans			0.000*	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
Loan to Assets			-0.000	-0.000	-0.000	-0.000
			(0.000)	(0.000)	(0.000)	(0.000)
State-level Controls						
GDP Growth			0.006***	0.006***	0.006***	0.006***
			(0.001)	(0.001)	(0.001)	(0.001)
Unemployment			-0.053***	-0.038***	-0.037***	-0.038***
			(0.002)	(0.003)	(0.003)	(0.003)
Housing Price Index			-0.189***	-0.007	-0.025	-0.016
			(0.027)	(0.045)	(0.045)	(0.045)
Constant	4.208***	4.411***	4.704***	3.522***	3.601***	3.540***
	(0.002)	(0.006)	(0.142)	(0.243)	(0.242)	(0.243)
Observations	213,487	213,487	213,154	213,154	213,154	213,154
R-squared	0.353	0.373	0.381	0.393	0.393	0.393
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes	-	-	-
BEA Region*Year FE				Yes	Yes	Yes

Notes: This table presents the main regression results. The dependent variable is the logarithm of Z-score calculated with a 3-year rolling window. Dummy variable *Intra* and *Inter* are the key terms in these regressions as they capture the competition shock introduced by the specific deregulation policies. The regression analysis starts with a simple specification. As column 1 shows, the coefficient on the key term, *Intra*, is estimated to be 0.053, which is statistically significant at 1 percent level. It suggests that there is a increase in banking stability at bank-level given the competition shock. In the second column, the time fixed effect is introduced into the model and there is a noticeable decrease in the scale of estimated coefficient on the key term. Other control variables are then introduced into the model as it shows in column 3 and 4. The estimated coefficient on the dummy variable *Intra* decreases from 0.028 to 0.014 in column 3, but it is still significant at 10 percent level. Column 4 presents the results estimated with the full specification where region-year fixed effect is included to control for all types of time-varying regional factors which would have am impact on banking stability. The analysis continues with the full specification. In column 5, the estimated coefficient on $Inter$ is also positive and significant. In the last column, dummy variables $Intra$ and $Inter$ are both introduced into the model, and the estimates are both positive and significant. Overall, it shows that the competition induced by the policy changes have positive and significant impact on banking stability, and this result is robust to different model specifications.

Table 3: Robustness Check - Balanced Panel

	(1)	(2)	(3)	(4)
	Baseline	Balanced	Balanced	Balanced
Intra	0.021**	0.019*		0.022**
	(0.009)	(0.010)		(0.010)
Inter	0.025**		0.028**	0.031***
	(0.010)		(0.012)	(0.012)
No. of Banks	16,410	8,107	8,107	8,107
Observations	213,154	137,779	137,779	137,779
R-squared	0.393	0.329	0.329	0.329
Bank Controls	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes	Yes

Notes: This table shows the results estimated with the balanced panel dataset. The dependent variable is the logarithm of Z-score calculated with a 3-year rolling window. Refer to column 6 in Table 2 for the full model specification. The first column presents the baseline results for comparison purpose. As the bottom shows, the number of banks in the balanced panel decreased by 51.1% from 16,410 to 8,107, and the number of observations decreased by 35.4% from 213,154 to 137,779 accordingly. Though there is a significant drop in the number of observations in the balanced panel, the key regression result remain qualitatively unchanged. These consistent results suggests that the previous findings in the bank-level analysis are not biased due to the unbalanced feature of the dataset.

Table 4: Robustness Check - M&As

	(1)	(2)	(3)
	Baseline	without M&As	without M&As
Intra	0.021**	0.022**	0.023***
	(0.009)	(0.009)	(0.009)
Inter	0.025**	0.027***	0.027***
	(0.010)	(0.010)	(0.010)
Observations	213,154	208,263	204,428
R-squared	0.393	0.396	0.399
Bank Controls	Yes	Yes	Yes
State Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes

Notes: This table shows the results from the regressions without observations involved with bank M&As. The dependent variable is the logarithm of Z-score calculated with a 3-year rolling window. Refer to column 6 in Table 2 for the full model specification. The first column presents the baseline results for comparison purpose. In column 2, observations for involved banks from the M&A year are dropped, while the estimated coefficients remain qualitatively unchanged. We further drop observations for the involved banks from the M&A year (T_0) and the year after (T_1) as an additional check in column 3, and our main results hold. These consistent results suggests that our main findings are not driven by the bank M&As encouraged by the U.S. banking deregulation.

Table 5: Robustness Check - Dynamic DiD

	(1)	(2)	(3)
	Baseline	Intra Timing	Inter Timing
Intra	0.021**		0.023***
	(0.009)		(0.009)
Inter	0.025**	0.023**	
	(0.010)	(0.010)	
Pre-5		-0.01	-0.027
		(0.014)	(0.019)
Pre-4		0.006	-0.015
		(0.012)	(0.016)
Pre-3		0.006	-0.022
		(0.011)	(0.014)
Pre-2		-0.001	-0.023**
		(0.010)	(0.011)
Pre-1		-0.009	-0.008
		(0.008)	(0.008)
Post-1		0.024***	0.016*
		(0.008)	(0.008)
Post-2		0.019*	0.017
		(0.010)	(0.012)
Post-3		0.029**	-0.008
		(0.012)	(0.015)
Post-4		0.061***	-0.038**
		(0.014)	(0.017)
Post-5		0.065***	-0.042**
		(0.015)	(0.021)
Observations	213,154	213,154	213,154
R-squared	0.393	0.393	0.393
Bank Controls	Yes	Yes	Yes
State Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes

Notes: This table presents the results from the dynamic DiD regressions. The dependent variable is the logarithm of Z-score calculated with a 3-year rolling window. Refer to column 6 in Table 2 for the full model specification. The first column presents the baseline results for comparison purpose. The DiD term $Intra$ and $Inter$ are decomposed into ten dummy variables denoting the pre- and post-treatment periods in column 2 and 3 respectively. Pre-n ($Post$-n) is the dummy variable for the period n year(s) before (after) the deregulation year for $n \in [1, 4]$. Pre-5 ($Post$-5) is the dummy variables for all the periods that is 5 years or more before (after) the deregulation year. The dummy variable for the deregulation year is omitted deliberately to make sure that the banking stability at the year of deregulation is treated as the benchmark in this dynamic DiD setting.

Table 6: Mechanism Analysis - Z-score Components

	(1)	(2)	(3)	(4)	(5)	(6)
	$log(Z_3)$	$log(Z_5)$	Equity/Assets	ROA	$log(1/\sigma_3(ROA))$	$log(1/\sigma_5(ROA))$
Intra	0.021**	0.033***	-0.190***	-0.005	0.044***	0.044***
	(0.009)	(0.011)	(0.030)	(0.009)	(0.010)	(0.009)
Observations	213,154	180,401	229,540	229,533	213,154	180,403
R-squared	0.393	0.574	0.685	0.431	0.404	0.560
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results for identifying which components of the Z-score contribute more to the overall improvement of the banking stability. Refer to column 6 in Table 2 for the full model specification. First column presents the baseline results for comparison reason. Column 2 shows that the previous findings are not sensitive to the change of the time-window for calculating the Z-score. The results in column 3 and 4 suggests that the improved banking stability is not driven by the changes in equity to assets ratios and profitability. However, the results in column 5 and 6 shows that the improvement in banking stability given the intensified competition is mainly driven by the stabilised earnings in the banking industry.

Table 7: Mechanism Analysis - Profitability

	(1)	(2)	(3)	(4)	(5)
	Loan Rate	Deposit Rate	Funding Cost	Interest Margin	Earning Spread
Intra	0.007	0.052***	0.044***	-0.050***	-0.046***
	(0.014)	(0.008)	(0.009)	(0.009)	(0.014)
Observations	229,532	229,506	229,507	229,532	229,505
R-squared	0.777	0.899	0.899	0.877	0.582
Bank Controls	Yes	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the results for the bank profitability analysis. Refer to column 6 in Table 2 for the full model specification. *Loan Rate* is the total interest income from loans divided by total loans; *Deposit Rate* is the total interest expenses on deposits divided by total deposits; *Funding Cost* is the total interest expenses on deposits and inter-bank borrowings divided by total deposits plus total inter-bank borrowings; *Interest Margin* follows the simple calculation which is the total interest income minus total interest expenses then divided by total assets; and *Earning Spread* is simply *Loan Rate* minus *Deposit Rate*.

Table 8: Mechanism Analysis - Cost Efficiency

	(1)	(2)	(3)
	Cost/Income	Labour	Fixed Assets
Intra	-0.322***	-0.193***	-0.124***
	(0.067)	(0.052)	(0.026)
Observations	229,521	229,521	229,521
R-squared	0.712	0.705	0.654
Bank Controls	Yes	Yes	Yes
State Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes

Notes: This table presents the results for the analysis on bank cost efficiency. Refer to column 6 in Table 2 for the full model specification. *Cost to Income* is total non-interest expenses divided by total revenue, which measures how much a bank need to spend on non-interest items to generate one unite of revenue. In column 2 and 3, the cost-to-income ratio is decomposed based on the two major categories of a bank's non-interest expenses: labour cost (eg. salaries) and expenses on fixed assets (eg. premises and office equipment). These results suggest that the competition shock makes banks more efficient in making use of both labour and fixed assets, thus the overall cost efficiency is improved.

Table 9: Mechanism Analysis - Loan Quality and Credit Risks

	(1)	(2)	(3)	(4)
	Non-performing	Loss Reserves	Charge-offs	Loss Provisions
Intra	0.042	0.007	-0.022**	-3.028**
	(0.037)	(0.014)	(0.011)	(1.458)
Observations	146,780	229,539	229,533	204,877
R-squared	0.509	0.483	0.372	0.234
Bank Controls	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes	Yes

Notes: This table presents the results for the analysis on loan quality and credit risks. Refer to column 6 in Table 2 for the full model specification. *Non-performing Loans* is the most commonly used indicator for loan quality which is calculated as total non-performing loans divided by total loans; *Loss Reserves* is a ratio between total reserves for loan losses and total loans, which captures the perceived level of riskiness for a bank's loan portfolio. *Charge-offs* is the total impaired loans that have been written-off from the book divided by total loans, which measures the actual losses due to credit risks; and *Loss Provision* is calculated as total loss provisions divided by net income, which measures how much risks a bank would take to generate one unit of profit.

Table 10: Non-linearity Analysis

	(1)	(2)	(3)
Intra	0.021**	-0.007	-0.022*
	(0.009)	(0.016)	(0.013)
Moderate		0.151*	
		(0.080)	
Low		0.113	
		(0.086)	
Intra * Moderate		0.015	
		(0.017)	
Intra * Low		0.042***	
		(0.016)	
HHI			0.000
			(0.000)
Intra * HHI			0.000***
			(0.000)
Observations	213,154	213,154	213,154
R-squared	0.393	0.393	0.393
Bank Controls	Yes	Yes	Yes
State Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes

Notes: This table presents the regression results for identifying the non-linearity between bank competition and stability. Refer to column 6 in Table 2 for the full model specification. First column presents the baseline results for comparison purpose. Interaction terms between the DiD term $Intra$ and the two dummy variables $Moderate$ and Low are introduced in column 2. It shows that our previous findings are mainly driven by banks operating in a less competitive environment, which indicates that there exists a non-linear relationship between competition and stability as the competition shock has no significant impact on banks operating in a relatively more competitive environment prior to the shock. Column 3 presents the regression results where the DiD term $Intra$ is directly interacted with the county-level HHI. To further present the non-linearity effect, a linear prediction of the marginal effects of the competition shock at different level of pre-deregulation competition is estimated and depicted in Figure 6.