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Does Competition Affect Bank Risk?

Although policymakers often discuss trade-offs between bank competition and stability, past research provides differing theoretical perspectives and empirical results on the impact of competition on risk. We employ a new approach for identifying exogenous changes in the competitive pressures facing individual banks and discover that an intensification of competition materially boosts bank risk. With respect to the mechanisms, we find that competition reduces banks' profits, pricing power, and charter values and increases banks' provision of nontraditional, riskier banking services and lending to riskier firms.

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> Many policymakers seem to think that some curbs on competition may be a price worth paying to improve stability. (The Economist 2009).

1. INTRODUCTION

Following the 2008 global financial crisis, policymakers reoriented their focus toward financial stability, often expressing willingness to trade off competition and ef-

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ficiency for stability. For example, the Bank of England (2015) notes that its primary responsibility is to foster financial stability, while other considerations are secondary goals, and U.S. Federal Reserve Governor Daniel Tarullo (2012) explains that the primary aim of the Dodd–Frank Act is to contain systemic risk, even if this reduces the competitiveness and efficiency of banks.

But is there a trade-off? Extensive research establishes both the economic costs of bank failures (e.g., Friedman and Schwartz 1963, Bernanke 1983, Ashcraft 2005, Schularick and Taylor 2012) and the economic efficiency benefits of competitive banking systems (e.g., King and Levine 1993, Jayaratne and Strahan 1998, Stiroh and Strahan 2003, Dick 2006, Amore, Schneider, and Zaldokas 2013, Cornaggia et al. 2015). However, research has not yet established that authorities can trade competition for stability. In this paper, we employ a new approach for identifying exogenous changes in the competitive pressures facing individual banks. We conduct a series of validation tests of our time-varying, bank-specific competition measure, including demonstrating its impact on bank profits, pricing power, and charter value and its influence on the types of services provided by banks. We then use our approach to assess the impact of competition on bank risk. In this way, we contribute both to policy deliberations and research debates.

Economic theory offers differing perspectives on whether competition increases or decreases bank risk. The *competition-fragility* view holds that an intensification of competition reduces bank profit margins and charter values, encouraging banks to increase risk (e.g., Keeley 1990, Hellmann, Murdock, and Stiglitz 2000, Demirguc-Kunt and Detragiache 2002, Corbae and D'Erasmo 2011, 2015, 2018). Related research explains that competition can curtail the ability of banks to earn information rents from relationship lending (Petersen and Rajan 1995), reducing their incentives to screen and monitor borrowers with adverse effects on bank stability and market efficiency (e.g., Berger et al. 2005, Dell'Ariccia and Marquez 2006). In contrast, the *competition-stability* view argues that competition reduces risk. Boyd and De Nicoló (2005) show that an intensification of competition tends to lower interest rates charged on loans, reducing adverse selection and moral hazard, and boosting bank stability. Research also stresses that the competition-fragility and competition-stability influences are not mutually exclusive (e.g., Martinez-Miera and Repullo 2010), and the impact of competition on managerial incentives is theoretically ambiguous (e.g., Raith 2003).

Empirical research offers conflicting findings on the impact of competition on bank risk, arguably reflecting challenges to (i) measuring competition, (ii) identifying exogenous sources of variation in competition, and (iii) measuring risk. Some research finds evidence consistent with the competition-fragility view (e.g., Keeley 1990, Bushman, Hendricks, and Williams 2016). Other work supports the competition-stability view (e.g., Petersen and Rajan 1995, Schaeck, Cihak, and Wolfe 2009, Houston et al. 2010, Anginer, Demirguc-Kunt, and Zhu 2014, Akins et al. 2016, Goetz 2018). Still, other research suggests that the results depend on the measures of risk and competition (e.g., Beck, Demirguc-Kunt, and Levine 2006, Berger, Klapper, and Turk-Ariss 2009).

Researchers use different measures of bank competition, each with challenges. Many use bank concentration indicators (e.g., Keeley 1990, Beck, Demirguc-Kunt, and Levine 2006, Berger, Klapper, and Turk-Ariss 2009, Houston et al. 2010, Akins et al. 2016). However, bank concentration indicators do not necessarily measure the contestability of banking markets and, therefore, might omit an important influence on the competitive pressures facing banks. Others employ indicators of the responsiveness of prices to costs, such as the Lerner index and H-statistics, to gauge a bank's market power (e.g., Schaeck, Cihak, and Wolfe 2009, Berger, Klapper, and Turk-Ariss 2009, Anginer, Demirguc-Kunt, and Zhu 2014). However, price-cost measures require nontrivial assumptions about bank operations and data that are unavailable to many banks. Rather than using concentration or price-cost measures, Bushman, Hendricks, and Williams (2016) extract information from banks' 10-K filings regarding competition facing each bank. This measure advances the existing literature by providing a bank-specific time-varying competition measure under the maintained hypothesis that the text-based measure is not subject to bank disclosure bias or management perception bias. However, endogeneity might remain a concern as the bankers' perception of competition pressures might be related to unobserved bank fundamentals. This paper contributes to the literature by proposing a bank-specific regulatory-based contestability measure and exploring how it affects bank risk-taking.

Another strategy for assessing the relationship between bank competition and risk, and the one to which we contribute, examines regulation-induced changes in the contestability of banking markets. An influential line of research focuses on the relaxation of regulatory restrictions on the geographic expansion of banks, arguing that this deregulation increased the contestability and efficiency of banking markets (e.g., Jayaratne and Strahan 1998, Dick 2006, Burks et al. 2018). More specifically, for most of the twentieth century, U.S. states prohibited banks from other states from establishing subsidiaries within their borders. During the 1980s and 1990s, individual states started removing these restrictions in different years, allowing other states' banks to enter and compete with local banks. While deregulation was associated with narrowing interest rates and profit margins, Jayaratne and Strahan (1998) also found that nonperforming loans fell after deregulation, suggesting a negative link between competition and bank risk. However, Bushman, Hendricks, and Williams (2016) find a positive relationship between interstate bank branch deregulation and bank risk. These studies measure regulation-induced bank competition at the state-year level, that is, they measure the degree to which each state's regulations limit competition among banks.

There are, however, concerns with using these traditional state-year deregulation measures to identify the impact of competition on bank risk: Omitted state-year factors might be correlated with interstate bank deregulation or triggered by deregulation. These omitted factors could shape bank risk, leading to spurious inferences about the relationship between competition and risk. For example, expectations of future bank stability could encourage policymakers to deregulate restrictions on interstate banking, or bank deregulation could trigger a surge in state economic growth that shapes banking system stability.

To address these concerns and identify the impact of competition on bank risk, we construct time-varying measures of the competitive pressures facing each bank holding company (BHC). In this way, we can condition out all state-year factors by including state-year fixed effects to better identify the impact of bank competition on risk. To accomplish this, we extend Jiang, Levine, and Lin (2016) and augment traditional state-year measures of regulatory-induced competition in two ways. First, past studies code a state as either prohibiting or permitting interstate banking and show that deregulation increased the entry of banks into those states (Stiroh and Strahan 2003, Dick 2006). These studies use the first year that a state deregulates with any other state as the date when the state moves from being coded as "prohibiting" to "permitting." However, not only did states begin interstate deregulation in different years, but they also followed different dynamic paths. Individual states made unilateral, bilateral, and multilateral agreements with other states from 1982 until the Riegle–Neal Act eliminated restrictions on well-managed, well-capitalized BHCs acquiring BHCs and bank subsidiaries in any state after September 1995. Thus, for each state and each year, we determine which other state's BHCs can establish subsidiaries within its borders.

Second, we differentiate among BHCs within each state and year to construct time-varying, BHC-specific competition measures. To do this, we exploit the gravity model of investment, which stresses that the costs of establishing and effectively operating a subsidiary, including screening, governance, and operational costs, are inversely related to the geographic distance between the BHC's headquarters and the new subsidiary (e.g., Helpman, Melitz, and Rubinstein 2008, and Giroud 2013). Consistent with this view, Goetz, Laeven, and Levine (2013) show that BHCs were more likely to expand into (i) geographically closer states, and (ii) within those states, they were more likely to expand into communities geographically closer to the BHC's headquarters. This expansion spurred the contestability and competitiveness of those banking markets. Therefore, the gravity model predicts that a BHC *b* headquartered in state *k* will experience a more significant intensification of competition from BHCs in state *j* if BHC *b* is geographically closer to state *j* because it is less costly for state *j*'s BHCs to establish subsidiaries closer to BHC *b*. That is, when California relaxes interstate banking restrictions with Arizona, BHCs in southern California will experience a sharper increase in competition than BHCs in northern California.

Based on the dynamic process of interstate bank deregulation and the gravity model of investment, we construct time-varying measures of the competitive pressures facing each BHC. First, for each bank subsidiary in each year, identify those states where its BHCs can enter the subsidiary's state. Second, compute the distance between each subsidiary and those states where BHCs can enter the subsidiary's state. Third, use the inverse of this distance as an indicator of the competitive pressures facing the subsidiary. Fourth, calculate the competitive pressures facing each BHC by weighting these subsidiary-level competition measures by the percentage of each subsidiary's assets in the BHC and then aggregating them to the BHC level. Using different methods to compute the distance between each subsidiary and other states, we construct and analyze several regulatory-induced competition measures.

These BHC-time competition measures have several appealing features. They measure the contestability of markets and avoid the complications associated with inferring competition from market structure or price-cost indicators. Furthermore, by integrating the process of interstate bank deregulation with the gravity model, the resultant time-varying, BHC-specific measures differentiate among BHCs within the same state and year. This granularity allows us to control for state-year fixed effects, reducing the possibility that omitted variables that vary simultaneously with interstate bank deregulation, including intrastate deregulation, drive the results. Furthermore, as demonstrated below, the results depend on controlling for state-year fixed effects, which are omitted from past studies using state-year deregulation measures. This finding highlights the importance of our identification strategy that uses BHC-year measures of competition.

We further contribute to the bank competition-risk literature by focusing on market-based risk measures. An extensive body of research uses accounting-based risk measures, such as nonperforming loans, loan loss provisions, loan charge-offs, profit volatility, changes in the face value of debt relative to the market value of banks' assets, or risk-weighted assets (e.g., Keeley 1990, Jayaratne and Strahan 1998, Bushman and Williams 2012, 2015, Dou, Ryan, and Zou 2018), and risk measures that combine accounting and market data, such as the Z-score (e.g., Laeven and Levine 2009, Houston et al. 2010, Bushman, Hendricks, and Williams 2016, Berger et al. 2017). These measures are appropriate for many empirical strategies.

However, there are critical drawbacks associated with using accounting-based risk measures to draw precise inferences about the impact of regulatory reforms on bank risk, such as in Goetz (2018). First, regulatory reforms that intensify the contestability and competitiveness of banking markets increase banks' manipulation of their accounting statements (e.g., Jiang, Levine, and Lin 2016, Burks et al. 2018). This manipulation makes it difficult to identify the impact of competition on risk using accounting-based risk measures. That is, the competition–manipulation link makes it difficult to separate the effect of competition on manipulation from the impact of competition on risk using accounting-based risk measures. Instead, we employ market-based risk measures to evaluate the impact of competition on bank risk. Second, lower regulatory barriers to the contestability of banking markets might take several quarters to materialize as nonperforming loans, loan losses, charge-offs, or other accounting measures. Furthermore, the lag time between changes in regulatory-induced competition and accounting metrics could differ across states and time. The uncertain lags between deregulation and changes in accounting statements make it difficult to match the timing of deregulation with accounting-based risk measures. In contrast, securities prices, and therefore market-based risk measures, are more likely than bank accounting statements to immediately reflect the expected present value of the regulatory-induced change in the competitive environment facing banks. Thus, we employ market-based risk measures that are less prone to the drawbacks of accounting-based measures and control for state-year fixed effects to address these concerns and draw more confident inferences about the competition–risk relationship.

We use several market-based risk measures. We focus on two individual bank risk measures: *Total Risk* equals the natural logarithm of the standard deviation of daily stock returns, and *Tail Risk* equals a BHC's expected loss during the 5% worst return days in a year as in Ellul and Yerramilli (2013). We show that the results are robust to using (i) a risk measure of unlevered equity volatility that equals *Total Risk* divided by the BHC's market leverage as in Berg and Gider (2017), and (ii) a measure of implied asset volatility based on the Black–Scholes–Merton option pricing model.

In our primary analyses, we use panel regressions. The dependent variable is one of the bank risk measures, and the main explanatory variable is one of the time-varying, BHC-specific competition measures. The regressions control for state-year and BHC fixed effects. The state-year fixed effects control for all time-varying state characteristics, including economic output, the volatility of output, and state-level policies and bank regulatory reforms. The BHC fixed effects condition away all time-invariant bank characteristics. We also control for time-varying, BHC-specific traits, such as size, the ratios of deposits to assets, loans to assets, and capital to asset.

We discover that intensifying competition materially boosts bank risk. Each BHC competition measure enters positively and significantly across all seven bank risk measures. The results hold when including BHC and state-year fixed effects. Furthermore, the results are robust to (i) including or excluding time-varying BHC traits and (ii) altering the sample of banks. The effects are economically significant. For example, consider a BHC when its regulation-induced competition level is "low," that is, at the 25th percentile of sample distribution, and the same BHC when competition is "high," at the 75th percentile. The estimated coefficients suggest that such a regulatory change would boost *Total Risk* and *Tail Risk* by about 50%. The estimated impacts of competition on the other bank risk measures are similarly large. The empirical findings suggest that bank competition exerts a statistically and economically significant effect on bank risk-taking.

Furthermore, we conduct validation tests of our BHC-specific competition measures and examine theoretically motivated mechanisms through which regulation-induced competition increases risk. First, a cornerstone of the *competition-fragility* view is that competition reduces bank profitability, pricing power, and charter value. Thus, as a validation test, we evaluate the impact of our BHC-specific competition measures on profit margins, pricing power, and charter values. Second, as an additional validation test, we examine whether the relationship between our BHC-specific competition measures and risk varies across BHCs with different sensitivities to the competitiveness of local banking markets in a theoretically predictable way. Suppose our BHC-specific competition measures are reliable indicators of local bank competition. In that case, the relationship between these measures and risk should be more substantial among BHCs more reliant on local retail deposits than those more reliant on state or national wholesale markets. We test this implication. Third, as competition squeezes profit margins on traditional lending services, banks might seek to generate income through noninterest-generating activities that boost bank risk (e.g., Stiroh 2004). Thus, we assess the effect of the BHC-specific competition measures on the proportion of income banks raise through nontraditional services.

Fourth, another mechanism through which regulation-induced competition might increase bank risk is by inducing banks to lend to riskier borrowers, and we also assess this mechanism. Although it is beyond the scope of this paper to examine all potential channels through which competition might shape risk, we provide new evidence on these mechanisms.

We find evidence consistent with the validity of our BHC-competition measures and the proposed mechanisms linking competition and risk. Specifically, we find that the BHC competition measures are negatively associated with BHC return-on-assets, earnings-per-share, net interest margins, and charter values. These findings are consistent with the view that our BHC-competition measures are positively associated with competition as reflected in bank profitability, pricing power, and charter values. Furthermore, in an extension of this validity test, we discover that the estimated relationship between our BHC-competition measures and risk is significantly larger among banks that rely more on deposits likely to be especially sensitive to local bank competition: retail deposits. These results are consistent with the view that our BHC-competition measures capture the competitiveness of local banking markets, and intensifying competition increases bank risk. We also discover that intensifying BHC competition increased the proportion of income from noninterest-generating activities, which tend to involve higher risk than traditional banking services. Furthermore, we find that competition boosts risk more among BHCs more reliant on retail deposits. This finding is consistent with the view that deregulation increases BHC risk by intensifying the contestability of local banking markets. Finally, we show that regulation-induced competition increased risk by inducing BHCs to lend to riskier firms, such as smaller and less profitable firms. Besides providing evidence on the mechanisms linking interstate bank deregulation and bank risk, these findings improve identification. Specifically, these results on the mechanisms reduce concerns that confounding factors drive the finding that regulation-induced competition increases risk, as those factors would also have to account for the findings on the underlying mechanisms.

The rest of the paper is organized as follows. Section 2 describes data and the construction of key variables. Section 3 explains the empirical methodology, while Section 4 reports our findings. Section 5 extends the results by examining potential mechanisms linking competition and risk. Section 6 concludes.

2. DATA

This section describes the sample of banks and the measures of bank risk and time-varying competitive pressures facing each BHC. We define the other bank-level variables when presenting the analyses and results. Table 1 provides detailed definitions of all variables, and Table 2 presents summary statistics.

TABLE 1

VARIABLE DEFINITION

Variable name	Definition
Risk measures	
Total Risk	Log(standard deviation of annualized daily stock returns on a BHC's stock over the year *100).
Tail Risk	Log(the negative of the average return on a BHC's stock during its 5% worst return days over the year *100, annualized).
Asset Risk	Log(standard deviation of annualized daily stock returns on a BHC's stock over the year *100) divided by (1 – market value of equity/(market value of equity + liability)).
Implied Asset Volatility	Log(standard deviation of the asset return implicit in Merton's (1974) option pricing model*100).
Competition measures	We calculate the interstate bank competitive pressure facing each BHC *b* in year *t* by weighting its assets across all subsidiaries by the regulation-induced competition pressure facing each subsidiary *i*. To calculate the regulatory environment facing each subsidiary in each year, we first identify all states (*k*'s) whose BHCs are allowed (by state *j*'s regulators) to establish subsidiaries in *j*. We then measure the distance from each subsidiary bank to the capitol of every other state *k* by computing the road distance between two zip codes using Google maps API. For each subsidiary *i* in state *j* in year *t*, we weight the interstate deregulation between state *j* and *k* in period *t* by that subsidiary's inverse log-distance to the other state.
Competition (Distance Weighted)	
Competition (Distance and # of BHCs Weighted)	We calculate the interstate bank competitive pressure facing each BHC *b* in year *t* by weighting its assets across all subsidiaries by the regulation-induced competition pressure facing each subsidiary *i*. To calculate the regulatory environment facing each subsidiary in each year, we first identify all states (*k*'s) whose BHCs are allowed (by state *j*'s regulators) to establish subsidiaries in *j*. We then measure the distance from each subsidiary bank to the capitol of every other state *k* by computing the road distance between two zip codes using Google maps API. For each subsidiary *i* in state *j* in year *t*, we weight the interstate deregulation between state *j* and *k* in period *t* by that subsidiary's inverse log-distance to the other state. We further weight this regulatory environment index by the number of banks in the other state.
Synthetic Competition (Distance Weighted)	We calculate the interstate bank competitive pressure facing each BHC *b* in year *t* by weighting its assets across all subsidiaries by the regulation-induced competition pressure facing each subsidiary *i*. To calculate the regulatory environment facing each subsidiary in each year, we first identify all states (*k*'s) whose BHCs are allowed (by state *j*'s regulators) to establish subsidiaries in *j*. We then calculate the *synthetic* distance from each subsidiary bank to the *center* of banking activity in every other state. To identify the *center* of banking activity in each state *k* in year *t*, we follow a three-step procedure. First, calculate the distance between subsidiary *i* (located in state *j*) and each county *c* in state *k* that is allowed to enter state *j* in year *t* (based on interstate bank regulations). To calculate the distance between subsidiary *i* and county *c* of state *k*, we use the distance between the zip code of subsidiary *i* and the zip code within county *c* with the largest population (among the zip codes in county *c* of state *k*). Second, weight each of these distances by the ratio of county *c*'s bank assets to total bank assets in state *k*. That is, the more bank assets in the county, the greater the weight. Third, sum these weighted distances to create the synthetic distance between subsidiary *i* and the center of banking activities in state *k* in year *t*. We use the inverse of this distance to calculate the competitive pressures facing each subsidiary in each year. Finally, we aggregate the synthetic regulation-induced competition pressures facing each of the BHC's subsidiaries by weighting its assets across all subsidiaries to get the interstate bank competitive pressure facing each BHC *b* in year *t*.

(*Continued*)

TABLE 1
(CONTINUED)

Variable name	Definition
Synthetic Competition (Distance and # of BHCs Weighted)	We calculate the interstate bank competitive pressure facing each BHC *b* in year *t* by weighting its assets across all subsidiaries by the regulation-induced competition pressure facing each subsidiary *i*. To calculate the regulatory environment facing each subsidiary in each year, we first identify all states (*k*'s) whose BHCs are allowed (by state *j*'s regulators) to establish subsidiaries in *j*. We then calculate the *synthetic* distance from each subsidiary bank to the *center* of banking activity in every other state. To identify the *center* of banking activity in each state *k* in year *t*, we follow a three-step procedure. First, calculate the distance between subsidiary *i* (located in state *j*) and each county *c* in state *k* that is allowed to enter state *j* in year *t* (based on interstate bank regulations). To calculate the distance between subsidiary *i* and county *c* of state *k*, we use the distance between the zip code of subsidiary *i* and the zip code within county *c* with the largest population (among the zip codes in county *c* of state *k*). Second, weight each of these distances by the ratio of county *c*'s bank assets to total bank assets in state *k*. That is, the more bank assets in the county, the greater the weight. Third, sum these weighted distances to create the synthetic distance between subsidiary *i* and the center of banking activities in state *k* in year *t*. We use the inverse of this distance and further weight by the number of BHCs of state *k* in year *t* to calculate the competitive pressures facing each subsidiary in each year. Finally, we aggregate the synthetic regulation-induced competition pressures facing each of the BHC's subsidiaries by weighting its assets across all subsidiaries to get the interstate bank competitive pressure facing each BHC *b* in year *t*.
Other bank/borrower characteristic variables	
Log(Total Assets)	The natural logarithm of total assets in '000 $ in year *t*–1.
Deposits to Assets	Ratio of total deposits over total assets in year *t*–1.
Loans to Assets	Ratio of total loans over total assets in year *t*–1.
Capital to Asset	Ratio of book value of equity over total assets in year *t*–1.
Charter Value	The natural logarithm of market value of assets (market value of equity plus liabilities) over book value of assets.
ROA	Net income over total assets.
EPS	Net income over common share outstanding.
Net Interest Margin	Interest income over interest earnings assets minus interest expense over interest-bearing liabilities.
Noninterest Income/Total Income	Log [(income from fiduciary activities + noninterest income from trading assets and liabilities + other noninterest income + account-based service charges)/total income].
Short-Term Funding	The sum of demand, savings, and time deposits divided by the BHC's total liabilities
SBA Lending	An indicator variable that equals one if a bank lends to small businesses in year *t* and zero otherwise.
Borrower Profitability	Borrower's annual net income divided by its total assets.

2.1 Sample of Banks

The Federal Reserve Bank of Chicago started providing complete annual Condition and Income statements for all consolidated BHCs in 1987. We match these data with CRSP/Compustat using the CRSP–FRB link provided by the Federal Reserve Bank of New York to obtain stock price information on BHCs. Restricting the sample to banks

TABLE 2

SUMMARY STATISTICS

Variable	*N*	Mean	SD	P25	Median	P75
Risk measures						
Total Risk	2,634	3.54	0.46	3.23	3.54	3.86
Tail Risk	2,634	4.35	0.62	3.98	4.30	4.67
Asset Risk	2,630	3.62	0.46	3.31	3.62	3.94
Implied Asset Volatility	1,595	3.04	0.83	2.46	3.01	3.56
Competition measures						
Competition (Distance Weighted)	2,634	1.53	0.55	1.14	1.77	1.96
Competition (Distance and # of BHCs Weighted)	2,634	3.49	0.96	3.07	3.88	4.14
Synthetic Competition (Distance Weighted)	2,634	1.54	0.55	1.17	1.77	1.96
Synthetic Competition (Distance and # of BHCs Weighted)	2,634	4.56	1.03	4.06	4.97	5.30
Bank controls						
Total Assets (in billion)	2,634	6.88	20.85	0.41	1.10	3.79
Log(Total Assets)	2,634	14.20	1.57	12.92	13.92	15.16
Deposits to Assets	2,634	0.83	0.07	0.79	0.85	0.88
Loans to Assets	2,634	0.62	0.10	0.56	0.63	0.69
Capital to Asset	2,634	0.08	0.02	0.06	0.08	0.09
Other variables						
Charter Value	2,625	4.43	0.62	4.13	4.52	4.84
ROA	2,630	0.02	0.01	0.01	0.02	0.02
EPS	2,584	1.84	1.88	1.03	1.93	2.81
Net Interest Margin	2,182	0.08	0.03	0.06	0.07	0.09
Noninterest Income/Total Income (ratio)	2,573	0.09	0.06	0.06	0.08	0.11
Short-Term Funding	2,507	0.74	0.20	0.72	0.79	0.85
SBA Lending	2,634	0.19	0.39	0.00	0.00	0.00
Borrower Profitability	5,880	0.02	0.08	0.00	0.03	0.07

Note: This table provides summary statistics.

located in the 50 U.S. states with daily stock price data yields 513 BHCs. Next, we (i) only include the ultimate parent BHC that owns, but is not owned by, other financial institutions, defining ownership as holding 50% or more of outstanding shares, and (ii) eliminate BHCs that we could not match to their subsidiaries using Call Report data provided by the Federal Reserve. This procedure yields 486 BHCs. Finally, we follow the literature and drop Delaware and South Dakota because they have special laws to encourage the entry of credit card banking. After dropping missing values, the final sample includes 2,634 BHC-year observations on 447 BHCs from 1987 to 1995.

2.2 Risk-Taking Measures

We use four market-based measures of individual bank risk. We use market-based measures of risk rather than accounting-based measures, such as capital-asset ratios, loan charge-offs, loan loss provisions, and Z-scores for two reasons. First, banks sometimes manipulate accounting statements, and we do not want to confound the impact of competition on bank risk with its effect on the manipulation of accounting statements. Second, it typically takes several years for a change in a bank's environment to shape its loan charge-offs, loan loss provisions, and other accounting-based indicators of risk. These uncertain lags make it challenging to match changes in competition with bank risk appropriately. Since asset prices reflect the expected present value of changes in the competitive environment, market-based risk measures are likely to be less subject to manipulation and less prone to lags that complicate the analyses. One limitation with the market-based measures is that we need information on stock prices, which eliminated privately held banking firms.

Total Risk measures the volatility of stock returns and equals the natural logarithm of the standard deviation of a bank's daily stock returns. Throughout the analyses, we annualize all daily returns. Many banking studies use stock return volatility, including Houston and James (1995), and Goetz, Laeven, and Levine (2016), but they do not study the impact of competition on bank risk.

Tail Risk measures a BHC's expected loss during bad times. Following Ellul and Yerramilli (2013), *Tail Risk* equals the natural logarithm of the negative of the average return on a BHC's stock over the 5% worst return days for the BHC's stock in a year.

Asset Risk is the natural logarithm of the standard deviation of daily stock returns over the year divided by book leverage, where book leverage equals one minus the book value of equity divided by total assets. Berg and Gider (2017) propose this as a measure of unlevered equity volatility, and we use it to assess the robustness of our findings.

Implied Asset Volatility provides an options-based measure of BHC risk and equals the natural logarithm of the standard deviation of the asset return implicit in Merton's (1974) option pricing model. Specifically, we estimate the volatility of asset returns by solving the following Black–Scholes–Merton equation:

$$E = \mathrm{V} \cdot N(d_1) - e^{-\gamma T} \cdot D \cdot N(d_2), \tag{1}$$

where E is the market value of the bank's equity, V is the asset value of the bank, D is the face value of the bank's debt (equal to current liabilities plus one-half of long-term debt), r is the risk-free rate, and $N(\cdot)$ is the cumulative standard normal distribution function. d_1 and d_2 are given by:

$$d_1 = \frac{\ln\left(\frac{V}{F}\right) + \left(r + 0.5\sigma_v^2\right) T}{\sigma_v \cdot \sqrt{T}}, \tag{2}$$

and

$$d_2 = d_1 \ - \sigma_v \sqrt{T}, \tag{3}$$

where σ_v is the volatility of bank assets. The Merton model also assumes that the bank has issued just one discount bond maturing in T periods.

2.3 BHC-Specific Competition Measures: Overview

To create measures of the time-varying competitive pressures facing each BHC, we integrate two sources of variation in competition: the time-varying, state-specific process of interstate bank deregulation and the geographic distance between a BHC and its potential competitors. We begin with an overview and then provide a detailed explanation of the construction of the competition measures.

First, we exploit the staggered removal of regulatory restrictions on interstate banking. For most of the twentieth century, states prohibited interstate banking, that is, each state prohibited banks from other states from establishing bank subsidiaries (or branches) within its geographic borders. Individual states began removing these restrictions in 1982. More specifically, Maine passed legislation permitting out-of-state banks to buy Maine banks if that state allowed Maine's banks to buy its banks in 1978. Since no states reciprocated until 1982, this deregulation process was in fact stalled until 1982, when Alaska and New York passed laws like Maine's. States both started interstate bank deregulation in different years and followed different paths of deregulation over time. Specifically, some states unilaterally opened their borders to out-of-state banks, while others signed a series of bilateral and multilateral reciprocal agreements with other states over time. For example, Figure 1 illustrates the evolution of interstate bank deregulation in California. It displays the year when California permitted BHCs located in every other state to enter California. As shown, California started interstate banking in 1987 by allowing banks in Alaska, Arizona, Oregon, Texas, Utah, and Washington to enter. California then allowed entry of banks from Idaho in 1988, Nevada and New Mexico in 1989, and so forth. Similarly, Figure 2 illustrates the evolution of interstate bank deregulation for the state of New York. New York started interstate banking in 1982 by allowing Alaska, Maine, and Missouri to enter, followed by Arizona and Kentucky in 1986, and Oklahoma, Texas, Utah, Washington, and Wyoming in 1987, and so on. These two figures illustrate the more general point: different states started the process of interstate bank deregulation in different years and followed different patterns over the years. Ultimately, the Riegle–Neal Act effectively eliminated restrictions on well-managed, well-capitalized BHCs acquiring BHCs and bank subsidiaries in any state after September 1995.

Thus, we use the information on the evolution of each state's exposure to competition from banks headquartered in other states. When state j's regulators permit the entry of BHCs headquartered in other states, this intensifies the contestability of state j's banking sector. Since state j deregulates with different states over time, we measure the competitive pressures facing state j each year. It is worth noting that our

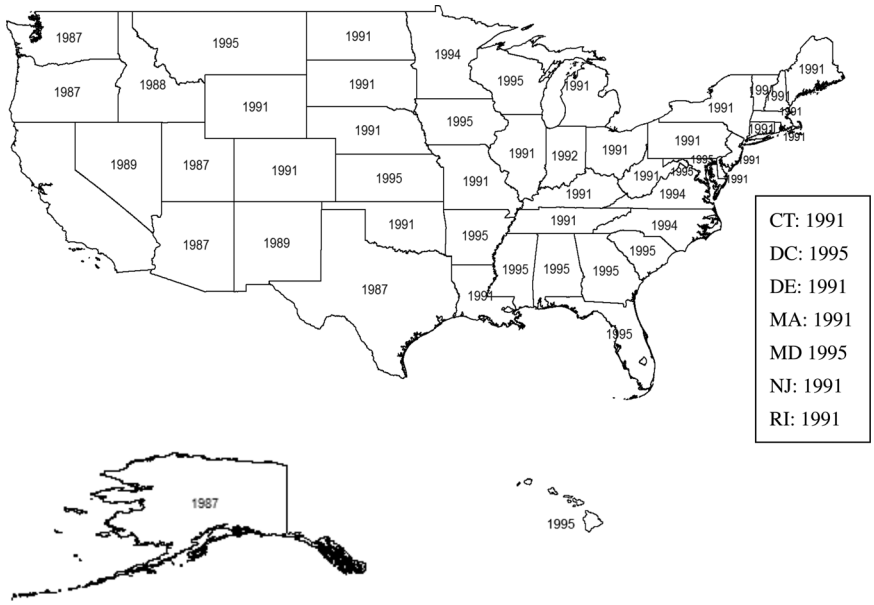

Fig 1. Pattern of Interstate Banking Deregulation for California. This map illustrates the evolution of interstate banking deregulation for the state of California. For each state, the figure displays the year when BHCs from that state were allowed to enter California.

measure of regulation-induced competition is different from the traditional measures of interstate bank deregulation. Researchers typically use the first year that a state allowed banks from any other state to enter its borders and establish subsidiaries (either through an acquisition or *de novo*) as the "treatment." This traditional, discrete indicator of interstate bank deregulation equals zero in the years before the state first allowed out-of-state banks to enter and one afterward. However, we examine the year-by-year, state-specific process of removing regulatory restrictions on interstate banking. Although this is an improvement over traditional measures, this dynamic interstate bank deregulation measure does not differentiate among BHCs within a state and year.

Second, we exploit the geographic distance between each BHC and potential competitors in other states to construct a time-varying, BHC-specific measure of competition. The gravity model of investment predicts that the costs to a BHC of establishing a subsidiary are inversely related to the distance between the BHC's headquarters and the subsidiary. The gravity model allows us to differentiate among BHCs within a state, as each BHC in a state has a different distance to other states and hence faces different competition from BHCs in those states. We construct time-varying measures of the "regulatory-induced competitive pressures" facing each BHC by integrating the state-time process of interstate bank deregulation with the gravity model's differentiation of banks in the same state.

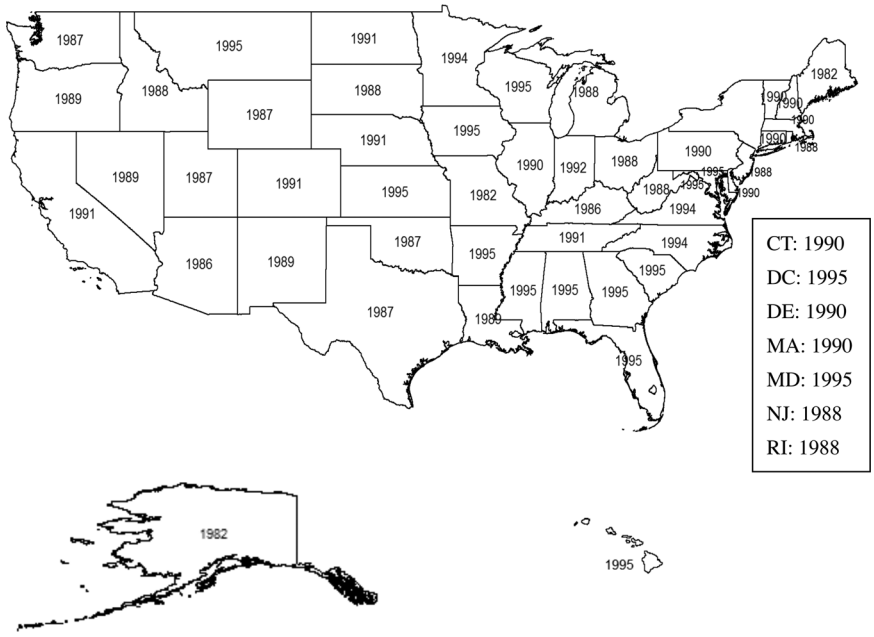

Fig 2. Pattern of Interstate Banking Deregulation for the State of New York. This map presents the evolution of interstate banking deregulation for New York. For each state, the figure displays the year when BHCs from that state were allowed to enter New York.

2.4 BHC-Specific Competition Measures

We construct four time-varying measures of the competitive pressures facing each BHC. The first two use the distances between the subsidiaries of BHCs and the capitols of other states, and we construct them using the following procedure. First, for each year t, identify all states (k's) whose BHCs are allowed to establish subsidiaries in state j and set I_{jkt} equal to one if banks from state k can enter state j in period t and zero otherwise. Second, set DIS_{ik} equal to the natural logarithm of the distance between bank subsidiary I within state j and state k's capitol. We measure the distance from bank I to the capitol of every other state k by computing the road distance in miles between two zip codes using Google maps API encoded in Stata. Third, for each subsidiary I in state j in each year t, calculate its exposure to regulation-induced competition from state k as follows:

$$Subsidiary\ Competition\ (Distance\ Weighted)_{ijt} = \sum_{k} \frac{I_{jkt}}{DIS_{ik}}\ . \tag{4}$$

Fourth, calculate the regulation-induced competition facing each BHC b in state s and year t ($Competition\ (Distance\ Weighted)_{bst}$). We do this by aggregating the regulation-induced competition pressures facing each subsidiary of the BHC. In per-

forming this aggregation, we weight each subsidiary I within BHC b in year t by P_{ibt}, which is the proportion of BHC b's assets in year t held by subsidiary i.

Thus, the first BHC-specific competition measure is:

$$Competition(Distance\ Weighted)_{bst} = Ln \sum_{i \in b} \left[Subsidiary\ Competition\ (Distance\ Weighted)_{it} * P_{ibt} \right]. \quad (5)$$

We take the natural logarithm of the sum of the weighted distance measure to improve the interpretability of the coefficient estimates. Note that the state in which subsidiary I is physically located might differ from the state in which its parent BHC b is located.

To construct the second BHC-specific competition measure, we further weight *Subsidiary Competition* (*Distance Weighted*) (equation 7) by the number of BHCs in state k in year t (Num_{kt}), so that

$$Subsidiary\ Competition\ (Distance\ and\ \#\ of\ BHCs\ Weighted)_{ijt} = \sum_{k} \frac{Num_{kt} * I_{jkt}}{DIS_{ik}}. \quad (6)$$

Thus, the second BHC-specific competition measure is:

$$Competition(Distance\ and\ \#\ of\ BHCs\ Weighted)_{bst} = Ln \sum_{i \in b} \left[Subsidiary\ Competition\ (Distance\ and\ \#\ of\ BHC\ Weighted)_{it} * P_{ibt} \right] \quad (7)$$

The next two BHC-specific competition measures are based on the synthetic distance between each BHC subsidiary and the *center* of banking activity in every other state. We follow a three-step procedure to identify the *center* of banking activity in each state k in year t. First, calculate the distance between subsidiary I (located in state j) and each county c in state k allowed to enter state j in year t (based on interstate bank regulations). To calculate the distance between subsidiary I and county c of state k, we use the distance between the zip code of subsidiary I and the zip code within county c with the largest population (among the zip codes in county c of state k). Second, weight each of these distances by the ratio of county c's bank assets to total bank assets in state k. The more bank assets in the county, the greater the weight. Third, sum these weighted distances to create the synthetic distance between subsidiary I and the center of banking activities in state k in year t.

Formally, we compute the synthetic distance and the regulation-induced competitive pressures facing each subsidiary based on the synthetic distance as follows. We define synthetic distance as:

$$Synthetic\ Distance_{ikt} = \sum_{c \in k} (Bank\ assets\ ratio_{ct} * Distance_{ic}). \quad (8)$$

We then use the inverse of this distance to calculate a measure of the competitive pressures facing each subsidiary in each year. That is, for each subsidiary I, in state j, in each year t, the exposure to regulation-induced competition from state k is:

$$Subsidiary\ Synthetic\ Competition\ (Distance\ Weighted)_{ijt} = \sum_k \frac{I_{jkt}}{Synthetic\ Distance_{ikt}}\ . \tag{9}$$

Using this subsidiary-level measure, we calculate the third BHC-specific competition measure. Specifically, we calculate the synthetic regulation-induced competition facing each BHC b in state s and year t ($Synthetic\ Competition\ (Distance\ Weighted)_{bst}$) by aggregating the synthetic regulation-induced competition pressures facing each of its subsidiaries as defined by equation (9). In performing this aggregation, we weight each subsidiary I within BHC b in year t by the proportion of i's assets in the BHC (P_{ibt}) in year t, so that:

$$Synthetic\ Competition(Distance\ Weighted)_{bst} = Ln \sum_{i \in b} \left[Subsidiary\ Synthetic\ Competition\ (Distance\ Weighted)_{it} * P_{ibt} \right]. \tag{10}$$

To create the fourth time-varying measure of the competitive pressures facing each BHC, we augment the third measure by weighting it by the number of BHCs in state k in the year. Thus, at the subsidiary level, we set

$$Subsidiary\ Synthetic\ Competition\ (Distance\ and\ \#\ of\ BHCs\ Weighted)_{ijt} = \sum_k \frac{Num_{kt} * I_{jkt}}{Synthetic\ Distance_{ikt}}\ . \tag{11}$$

Using this number-of-banks weighted subsidiary competition measure, the BHC synthetic competition measure weighted by the distance and the number of banks is

$$Synthetic\ Competition(Distance\ and\ \#\ of\ BHCs\ Weighted)_{bst} = Ln \sum_{i \in b} \left[Subsidiary\ Synthetic\ Competition\ (Distance\ and\ \#\ of\ BHCs\ Weighted)_{it} * P_{ibt} \right] \tag{12}$$

3. EMPIRICAL METHODOLOGY

To examine the impact of competition on bank risk, we primarily use panel regressions. The unit of analysis is a BHC-year observation, and we control for both state-year (θ_{st}) and BHC (θ_b) fixed effects. The state-year fixed effects control for all time-varying state influences, and the BHC fixed effects condition out all time-

invariant BHC characteristics. Specifically, we estimate the following ordinary least squares equation:

$$Log(Bank\ Risk_{bst}) = \beta \cdot Competition_{bst} + \gamma' \cdot X_{bst} + \theta_b + \theta_{st} + \varepsilon_{bst}. \quad (13)$$

where *Bank Risk*$_{bst}$ is one of the four measures of risk for BHC b, headquartered in state s in year t (i.e., *Total Risk, Tail Risk, Asset Risk*, or *Implied Asset Volatility*). *Competition*$_{bst}$ is one of the four measures of the competitive pressures facing each BHC b in state s in year t (i.e., *Competition (Distance Weighted)*, *Competition (Distance and # of BHCs Weighted)*, *Synthetic Competition (Distance Weighted)* and *Synthetic Competition (Distance and # of BHCs Weighted)*). X_{bst} represents a vector of time-varying BHC traits: *Log(Total Assets)* is the natural logarithm of the BHC's total assets, *Deposits to Assets* is the ratio of bank deposits to total assets, *Loans to Assets* is the ratio of bank loans to total assets, and *Capital to Asset* is the BHC's capital-asset ratio. The average BHC in our sample has $6.9 billion of assets (*Total Assets*), while the median BHC has $1.1 billion. Due to the skewed distribution of assets, we use the natural logarithm of total assets in the regression analyses. Furthermore, we use lagged values of these bank-specific measures, but all results hold when measuring them contemporaneously. In addition, when not using the natural logarithm of variables, we winsorize by 0.025 on both tails to reduce the influence of outliers.

To assess the impact of an intensification of competition on bank risk, we focus on estimating β. We report heteroskedasticity-consistent standard errors clustered at the state level. As shown in columns (1–4) of Online Appendix Table 4, our results hold using standard errors clustered at the state and year levels. The results are also robust to clustering at the BHC level or the BHC and year levels.

Our econometric strategy mitigates the concern that bank risk influences the timing of when states remove restrictions on interstate banking. For example, if heightened bank risk within a state induces state officials to lower barriers to the entry of out-of-state banks to improve lending quality, this could confound the ability to identify the impact of competition on bank risk. However, we use a time-varying, BHC-specific measure of competition that differentiates among banks within the same state and year, so that we can control for state-year fixed effects. This reduces the possibility that time-varying, statewide factors impede our ability to assess the differential effects of competition on individual bank risk within a state.

We also conduct a robustness test and find that bank risk does not predict interstate bank regulatory reforms. For each state, we aggregate the *Total Risk* of individual BHCs headquartered in that state and calculate the n-year average of *Total Risk* at the state level, where n represents 1 or 2 years before the interstate deregulation. We aggregate across banks by (i) computing the simple average and (ii) calculating the value-weighted mean. The results are very similar, and we report the findings with a simple average. We examine two dependent variables. *Deregulation* equals one in period t for state s if state s started interstate deregulation by year t and zero otherwise. *Num_of_States* equals the natural logarithm of one plus the number of states

with which state *s* in year *t* had liberalized interstate banking restrictions. We also control for the series of state characteristics used by Kroszner and Strahan (1999) in their assessment of the timing of interstate bank deregulation. These controls include per capita gross state product, state unemployment rate, an indicator for unit banking law, small firm share in the state, small bank share in the state, the capital ratio of small banks relative to large banks, the relative size of insurance in states where banks can sell insurance, the relative size of insurance firms in states where banks cannot sell insurance, an indicator for one-party control in the state, and the share of the state government controlled by Democrats. Online Appendix Table 1 shows that bank risk does not predict the timing of regulatory reforms. As evinced by the insignificant coefficients on all the lagged risk measures, there is no indication that bank risk predicts the timing of interstate bank deregulation.

3. EMPIRICAL RESULTS

3.1 Core Results

In our core analyses of the competition–risk nexus, we discover that the regulation-induced intensification of competition increased bank risk. Table 3 reports estimates of equation (13), where the dependent variable is *Total Risk* in columns (1–4) and *Tail Risk* in columns (5–8). For each of these two bank risk measures, we report regression results for the four BHC-specific competition measures. In all cases, each of these BHC-specific competition measures enters positively and significantly at the 1% significance level. Intensifying competition is associated with a sharp increase in bank risk. Concerning the BHC-level control variables, banks with higher *Capital to Asset* ratios tend to have a lower risk. This result accords with the capital buffer theory that bank capital absorbs adverse shocks, reducing risk. Finally, it is worth emphasizing that these results hold when excluding the time-varying BHC traits from the analyses. Although including endogenous BHC-level controls could contaminate the analyses, Online Appendix Table 2 shows that the estimated coefficients on the competition measures, and their statistical significance, do not change much when excluding these regressors. Furthermore, Online Appendix Table 4 (columns 5–8) shows that the results hold when using MSA-year fixed effects to condition out all local time-varying factors.

The estimated coefficients in Table 3 suggest that the economic impact of competition on bank risk is large. For example, consider the estimates reported in column (1), where the dependent variable is *Total Risk*, the competition measure is *Competition (Distance Weighted)*, and the estimated coefficient on competition is 0.63. Furthermore, consider a BHC when its regulation-induced competition level (*Competition (Distance Weighted)*) is low, that is, at the 25th percentile of distribution for the entire sample, and the same BHC when the competition level is high, that is, at the 75th percentile. The difference between the 25th and 75th percentiles implies an intensification of regulation-induced competition of 0.82. The column (1) estimates suggest that the BHCs' *Total Risk* would be 52% greater in the high competition en-

TABLE 3

COMPETITION AND BANK RISK-TAKING: TOTAL RISK AND TAIL RISK

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	Total Risk				Tail Risk			
Competition (Distance Weighted)	0.6298***				1.2513**			
	(0.2114)				(0.5945)			
Competition (Distance and # of BHCs Weighted)		0.3149***				0.6622**		
		(0.1040)				(0.2721)		
Synthetic Competition (Distance Weighted)			0.7867***				1.4627**	
			(0.1990)				(0.6255)	
Synthetic Competition (Distance and # of BHCs Weighted)				0.3189***				0.6454**
				(0.0974)				(0.2611)
Log(Total Assets)	–0.1605**	–0.1623**	–0.1587**	–0.1630**	–0.1379	–0.1417	–0.1345	–0.1430
	(0.0746)	(0.0765)	(0.0754)	(0.0770)	(0.1076)	(0.1122)	(0.1086)	(0.1134)
Deposits to Assets	0.1718	0.2011	0.1786	0.2005	–0.4320	–0.3658	–0.4244	–0.3724
	(0.3368)	(0.3279)	(0.3291)	(0.3294)	(0.4622)	(0.4284)	(0.4489)	(0.4334)
Loans to Assets	–0.1811	–0.1873	–0.1799	–0.1892	0.1082	0.0926	0.1129	0.0909
	(0.2154)	(0.2109)	(0.2145)	(0.2134)	(0.2376)	(0.2308)	(0.2387)	(0.2366)
Capital to Asset	–4.2361***	–4.2035***	–4.2101***	–4.2064***	–5.6418***	–5.5662***	–5.6013***	–5.5794***
	(1.0099)	(0.9858)	(1.0064)	(0.9849)	(1.9538)	(1.8890)	(1.9396)	(1.8968)
BHC fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,634	2,634	2,634	2,634	2,634	2,634	2,634	2,634
R^2	0.7566	0.7566	0.7573	0.7567	0.7372	0.7376	0.7379	0.7374

Note: This table presents regression results of bank total risk and tail risk on bank competition. The sample consists of BHC-year observations from 1987 through 1995. The dependent variables in columns (1–4) and (5–8) are *Total Risk* and *Tail Risk*, respectively. The table reports regression results on the four BHC competition indicators. BHC-level control variables include *Log(Total Asset)*, *Deposit to Asset*, *Loan to Asset*, and *Capital to Asset*. All the control variables are lagged 1 year. Table 1 provides variable definitions. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. *, **, and *** indicate significant at 10%, 5%, and 1%, respectively.

vironment. The estimated impact is similar when considering the estimates on *Tail Risk* from column (4).

We highlight the importance of our identification strategy in Online Appendix Table 3. As emphasized above, our four BHC-specific proxies of competition differ across BHCs within the same state and year. These time-varying, BHC-specific competition measures allow us to control for state-year fixed effects and eliminate concerns that an omitted state-year variable drives the results. Thus, we identify the impact of competition on bank risk by comparing BHCs within the same state and year. To assess the importance of this strategy, we examine two traditional proxies of competition that vary at the state-year level: *Deregulation* is a dummy variable that equals one if the state allows BHCs from at least one other state to enter and establish subsidiaries within its borders and zero otherwise, and *Bank Concentration* equals the summation of the squared share of each BHC's assets headquartered in state *s* in year *t*. Neither *Deregulation* nor *Bank Concentration* differs across BHCs within a state and year, so we cannot include state-year fixed effects to reduce concerns about reverse causality or omitted state-year variables. For example, a change in the overall riskiness of a state's economy could shape the riskiness of its banking system, the timing of interstate bank deregulation, and bank consolidation, confounding the ability to identify the impact of competition on bank risk. Thus, if the results on these state-specific proxies for competition differ from those on our BHC-specific proxies, this would advertise the value of our strategy of using more granular proxies.

Consistent with our econometric strategy, neither of the state-specific competition proxies enters significantly in the *Total Risk* regressions, as shown in Online Appendix Table 3. In these regressions, we include BHC fixed effects and year fixed effects, but we cannot include state-year fixed effects since *Deregulation* and *Bank Concentration* do not differ across states within a year. The differences between the results on the BHC-specific and state-specific competition proxies advertise the importance of conditioning out all time-varying state influences to identify the impact of changes in the competitive pressures facing individual BHCs on their risk-taking.

3.2 Extensions and Additional Robustness Tests

We extend the analyses by examining the leverage weighted standard deviation of stock returns (*Asset Risk*) and *Implied Asset Volatility*. We examine *Asset Risk* because banks can increase risk by increasing the riskiness of their assets or by increasing leverage. *Asset Risk* adjusts for leverage. We examine *Implied Asset Volatility* because it captures market expectations of future price volatility. For each risk measure, we provide results for the four BHC-specific competition proxies.

Table 4 confirms that regulation-induced competition boosts bank risk when using either of these two additional bank risk measures. The estimated impacts are large and similar to those reported above on *Total Risk* and *Tail Risk*. To illustrate the estimated effect of increasing competition, again consider a change in *Competition (Distance Weighted)* from the 25th percentile to the 75th percentile of the sample distribution. Table 4 results indicate that *Asset Risk* would increase by 52% in response to such an

TABLE 4

Competition and Bank Risk-Taking: Asset Risk and Implied Asset Volatility

	(1)	(2)
Dep Var	Asset Risk	Implied Asset Volatility
Competition (Distance Weighted)	0.6286***	1.2792*
	(0.2080)	(0.7041)
R^2	0.7564	0.7858
Competition (Distance and # of BHCs Weighted)	0.3128***	0.6656**
	(0.1014)	(0.2611)
R^2	0.7564	0.7865
Synthetic Competition (Distance Weighted)	0.7866***	1.4115**
	(0.1949)	(0.6767)
R^2	0.7571	0.7861
Synthetic Competition (Distance and # of BHCs Weighted)	0.3321***	0.6478***
	(0.0980)	(0.2107)
R^2	0.7566	0.7863
BHC controls	Yes	Yes
BHC fixed effects	Yes	Yes
State-year fixed effects	Yes	Yes
N	2,630	1,595

Note: This table presents regression results of bank asset risk and implied asset volatility on bank competition. The dependent variables are Asset Risk (column 1) and Implied Asset Volatility (column 2), respectively. Asset Risk is defined as Log(standard deviation of annualized daily stock returns on a BHC's stock over the year *100) divided by (1 – market value of equity/(market value of equity + liability)). Implied Asset Volatility equals the Log(annualized standard deviation of the asset return implicit in Merton's option pricing model*100). Control variables include Log(Total Assets), Deposits to Assets, Loans to Assets, and Capital to Asset. The table reports regression results on the four BHC competition indicators. BHC-level control variables include Log(Total Asset), Deposit to Asset, Loan to Asset, and Capital to Asset. All the control variables are lagged 1 year. Table 1 provides variable definitions. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. *, **, and *** indicate significant at 10%, 5%, and 1%, respectively.

increase in the regulation-induced competitive pressures facing a bank. The results hold when eliminating California, Florida, and Texas, which were severely affected by the S&L crisis. These robustness tests further indicate that the estimated impact of deregulation-induced competition on bank risk-taking is not only statistically significant but economically important.

Next, we conduct a placebo test by randomly changing the start year of each state's interstate bank deregulation process. Specifically, for each bank, we randomly choose 1,000 start dates between 3 years before and 3 years after the actual start date. We then compute the estimated coefficients on the BHC-specific competition measures. We plot the distribution of these estimates for each of the four BHC-specific competition measures in Figure 3's corresponding four panels. The vertical axis denotes the density of the distribution of the placebo estimates. The horizontal axis denotes the value of the estimated effect of each of the four competition measures. As a reference, we also include the estimate using the actual interstate bank deregulation start date,

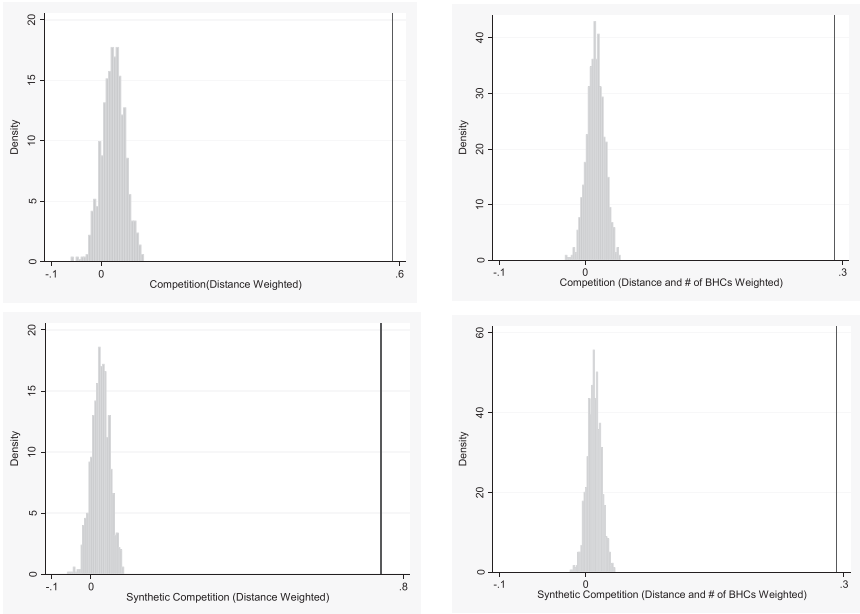

Fig 3. Distribution of Estimates from Placebo Tests. This figure plots the distribution of OLS estimates of regulation-induced competition on bank total risk from placebo tests. We randomly change the start year of the deregulation between [−3, +3] years for 1,000 times for each bank as the placebo test. The horizontal axis denotes the value of the estimated effect of each of the four competition measures, that is, *Competition (Distance Weighted), Competition (Distance and # of BHCs Weighted), Synthetic Competition (Distance Weighted), and Synthetic Competition (Distance and # of BHCs Weighted)*, based on the placebo test. The vertical axis denotes the density of the distribution of the placebo estimates. The vertical line represents the original estimated effect from our baseline analysis.

which we depict with a vertical red line. As shown by the histograms, the estimated effects from placebo treatments bunch close to zero and far from the estimate using the actual start date. This placebo test ameliorates concerns that unobserved trends drive the findings.

4. MECHANISMS AND EXTENSIONS

In this section, we conduct validation tests of our BHC-competition measures and evaluate potential mechanisms linking bank competition and risk. As described in the Introduction, theory not only provides differing predictions about the effect of competition on risk but also provides differing perspectives on how competition affects bank risk. Although it is beyond the scope of this paper to examine all possible channels through which competition might shape bank risk, we explore several proposed mechanisms.

First, a cornerstone of the competition-fragility view is that competition squeezes profit margins, weakens pricing power, and reduces charter values (e.g., Keeley 1990, Hellmann, Murdock, and Stiglitz 2000, and Martinez-Miera and Repullo 2010). Therefore, as a validation exercise of our measures, we investigate the impact of our four BHC-specific competition measures on bank profits, pricing power, and charter values. To measure bank profits, we use the ratio of net income to total assets (*ROA*) and the ratio of bank earnings to the value of shares outstanding (*EPS*). To measure bank pricing power, we use *Net Interest Margin*, as measured by interest income over interest earnings assets minus interest expense over interest-bearing liabilities. To measure BHC charter values, we use the natural logarithm of the market-to-book value of assets. We use the natural logarithm because the market-to-book ratio is highly skewed in the sample. We then employ equation (13) regression framework to assess the impact of bank competition on these bank performance indicators.

As shown in Panels A and B of Table 5, ;5a, we find that each of the four BHC-specific competition measures is negatively and significantly associated with bank profitability, pricing power, and charter values. Specifically, *Competition (Distance Weighted)*, *Competition (Distance and # of BHCs Weighted)*, *Synthetic Competition (Distance Weighted)*, and *Synthetic Competition (Distance and # of BHCs Weighted)* enter negatively and significantly in the *ROA*, *EPS*, *Net Interest Margin*, and *Charter Value* regressions. The estimated coefficients indicate that bank competition has an economically large effect on bank profits, pricing power, and charter value. For example, consider a BHC that experiences a change in *Competition (Distance Weighted)* from the 25th percentile to the 75th percentile of the sample distribution, implying an increase in regulation-induced competition of 0.82. Then, the coefficient estimates from column (1) in Panel B of Table 5 indicate that *Charter Value* would fall by 45%. These results hold when controlling for the array of time-varying BHC traits discussed above, as well as when controlling for BHC fixed effects and state-year effects. These results are consistent with the view that our BHC-competition measures are positively associated with intensifying competition, as captured by smaller profit margins, less pricing power, and diminished charter values.

Second, we extend this validation exercise by examining whether the relationship between our BHC-specific competition measures and risk varies across BHCs with different sensitivities to local competition in theoretically predictable ways. Suppose the BHC-specific competition measures reliably gauge local bank competition. In that case, the relationship between our BHC-specific competition measures and risk should be more pronounced among BHCs that depend more on local retail deposits than those that rely more on state or national markets for funding. To test this conjecture, we split the sample based on banks' dependence on retail deposits and regress bank risk on each of our four bank competition measures. We define "Banks that rely more on retail deposits" as banks that have an average retail deposit share that exceeds the sample median. The retail deposit share equals retail deposits (including demand, savings, and time deposits of less than $100,000) as a share of total deposits. As reported in Table 6, we discover that the estimated relationship between the interstate bank competition measures and bank risk is significantly larger among

TABLE 5

PANEL A. COMPETITION, BANK PROFITABILITY, AND BANK PRICING POWER

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dep Var	ROA				EPS				Net Interest Margin			
Competition (Distance Weighted)	–0.0062**				–3.1906**				–0.0217***			
	(0.0023)				(1.1934)				(0.0060)			
Competition (Distance and # of BHCs Weighted)		–0.0037***				–1.1965*				–0.0071***		
		(0.0013)				(0.5977)				(0.0023)		
Synthetic Competition (Distance Weighted)			–0.0064***				–3.6843***				–0.0225***	
			(0.0024)				(1.3340)				(0.0071)	
Synthetic Competition (Distance and # of BHCs Weighted)				–0.0033**				–1.1224*				–0.0074***
				(0.0013)				(0.5719)				(0.0024)
BHC controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BHC fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,630	2,630	2,630	2,630	2,584	2,584	2,584	2,584	2,182	2,182	2,182	2,182
R^2	0.7449	0.7454	0.7448	0.7450	0.6546	0.6532	0.6551	0.6530	0.9160	0.9157	0.9159	0.9157

Note: This table presents regression results of bank profitability and pricing power on bank competition. The sample consists of BHC-year observations from 1987 through 1995. The dependent variables are *ROA* (columns 1–4), net income divided by total assets, *EPS* (columns 5–8), net income per common share outstanding, and *Net Interest Margin* (columns 9–12), interest income over interest earnings assets minus interest expense over interest-bearing liabilities. The table reports regression results on the four BHC competition indicators. BHC-level control variables include *Log(Total Asset)*, *Deposit to Asset*, *Loan to Asset*, and *Capital to Asset*. All the control variables are lagged 1 year. Table 1 provides variable definitions. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. *, **, and *** indicate significant at 10%, 5%, and 1%, respectively.

TABLE 5A

PANEL B. COMPETITION AND BANK CHARTER VALUE

	(1)	(2)	(3)	(4)
Dep Var		Charter Value		
Competition (Distance Weighted)	–0.5508**			
	(0.2423)			
Competition (Distance and # of BHCs Weighted)		–0.3054***		
		(0.1101)		
Synthetic Competition (Distance Weighted)			–0.5497**	
			(0.2540)	
Synthetic Competition (Distance and # of BHCs Weighted)				–0.2706**
				(0.1094)
BHC controls	Yes	Yes	Yes	Yes
BHC fixed effects	Yes	Yes	Yes	Yes
State-year fixed effects	Yes	Yes	Yes	Yes
N	2,625	2,625	2,625	2,625
R^2	0.8311	0.8313	0.8309	0.8310

Note: This table presents regression results of bank charter values on bank competition. The sample consists of BHC-year observations from 1987 through 1995. The dependent variable Charter Value is defined as the natural logarithm of market value of assets over book value of assets. The table reports regression results on the four BHC competition indicators. BHC-level control variables include Log(Total Asset), Deposit to Asset, Loan to Asset, and Capital to Asset. All the control variables are lagged 1 year. Table 1 provides variable definitions. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. *, **, and *** indicate significant at 10%, 5%, and 1%, respectively.

banks that rely more on retail deposits. These results are consistent with the views that the BHC-competition measures are positively associated with local competition, and intensifying competition increases bank risk.

Third, we shed additional empirical light on the channel running from interstate bank deregulation to competition and bank risk by examining the nonlending and nondepositing services banks provide. Past research suggests that as competition squeezes profit margins on traditional lending services, banks seek to generate income through higher risk noninterest-generating activities, such as trading and derivatives, fiduciary, and underwriting services (e.g., Stiroh 2004). Thus, we examine whether regulation-induced competition increases the proportion of income that BHCs receive from noninterest-generating sources. We use *Noninterest Income/Total Income*, which equals the ratio of noninterest income to total income. Noninterest income equals the aggregate income from noninterest income from trading assets and liabilities, fiduciary activities, account-based service charges, and other noninterest income. We then employ our standard regression specification to assess whether the regulation-induced competitive pressures facing individual BHCs increase the proportion of income that BHCs receive from noninterest-generating sources.

TABLE 6

BANK COMPETITION AND TOTAL RISK – DIFFERENTIATE WITH RETAIL DEPOSIT DEPENDENCE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var					Total Risk			
Retail Deposit Dependent	Yes	No	Yes	No	Yes	No	Yes	No
Competition (Distance Weighted)	1.0979***	0.4008***						
	(0.3032)	(0.1250)						
Competition (Distance and # of BHCs Weighted)			0.4668***	0.1672**				
			(0.0522)	(0.0776)				
Synthetic Competition (Distance Weighted)					1.1617***	0.4582***		
					(0.2532)	(0.1640)		
Synthetic Competition (Distance and # of BHCs Weighted)							0.4417***	0.1666**
							(0.0598)	(0.0792)
Chow Test	$p = 0.0390$		$p = 0.0107$			$p = 0.0276$		$p = 0.0289$
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,319	1,315	1,319	1,315	1,319	1,315	1,319	1,315
R^2	0.8144	0.8176	0.8150	0.8173	0.8149	0.8176	0.8149	0.8173

Note: This table presents regression results of BHC risk on bank competition while differentiating by the degree to which the BHC depends on retail deposits. We define a BHC as "Retail Deposit Dependent" if its retail deposit ratio over sample period is greater than the sample median. The retail deposit ratio equals retail deposits (including demand, savings, and time deposits of less than $100,000) as a proportion of total deposits. The sample consists of BHC-year observations from 1987 through 1995. The dependent variable is Total Risk. The table reports regression results on the four BHC competition indicators. BHC-level control variables include Log(Total Asset), Deposit to Asset, Loan to Asset, and Capital to Asset. All the control variables are lagged 1 year. Table 1 provides variable definitions. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. *, **, and *** indicate significant at 10%, 5%, and 1%, respectively.

Consistent with the deregulation-competition-risk channel, we find that an increase in regulation-induced competition increases the proportion of BHC's income generated by noninterest income. As reported in columns (1–4) of Table 7, the dependent variable is *Noninterest Income/Total Income*, and the columns provide results for the four competition measures. The estimated coefficient on each competition measure is positive and statistically significant, suggesting that a larger proportion of income is generated from noninterest sources when competition intensifies. These results and those reported in Table 3 are consistent with the competition-fragility view: Regulation-induced competition squeezes profit margins, reduces charter values, induces banks to increase their reliance on noninterest income, and boosts bank risk.

Fourth, we examine whether competition shapes bank risk by altering its liabilities. Thus far, we have focused on assessing the relationship between deregulation-induced competition and overall BHC risk and the riskiness of BHC assets. We augment these evaluations by investigating whether competition boosts BHC reliance on short-term funding, which tends to increase BHC fragility by increasing its exposure to liquidity shocks and price volatility. We measure short-term funding as the sum of demand, savings, and time deposits divided by the total liabilities of the BHC. We then regress short-term funding on the four competition measures. As shown in columns (5–8) of Table 7, competition significantly increases short-term funding, suggesting that competition is also related to bank risk through the liabilities channel.

Fifth, we provide additional evidence on the deregulation-competition-risk channel by examining whether competition induces banks to lend to riskier firms. We begin by investigating lending to smaller firms. Cetorelli and Strahan (2006) show that more intense competition between banks spurs lending to smaller businesses. To the extent that smaller firms are riskier than larger ones, perhaps because they are newer, less diversified, and have less collateral, increased lending to smaller businesses is one channel through which intensifying bank competition boosts BHC risk. We merge our data on banks with the Small Business Administration (SBA) database on loans to small businesses to evaluate this channel. We then assess the impact of regulatory-induced competition on banks' likelihood to make loans to small businesses. In particular, the SBA tracks SBA 7(a) loans, also known as "general small business loans," which are used for short-term working capital needs, equipment purchases, the refinancing of existing business debt, and so on. Researchers extensively use this data set to examine small business lending (e.g., Brown and Earle 2017). About 20% of banks have lent to small businesses in our sample. We use a dummy variable, *SBA Lending*, to indicate whether a bank lends to small businesses in year t and regress it on our bank competition measures. As shown in columns (1–4) of Table 8, we find that increased competition is associated with an increase in the likelihood of BHCs making small business loans. These findings are consistent with the view that regulatory-induced competition boosts bank risk by spurring lending to smaller firms.

We also examine whether competition boosts BHC risk by altering borrowers' risk characteristics. To measure borrower traits, we hand-match our BHCs with the lead lenders of syndicated loans recorded in Dealscan. Out of the 447 BHCs in our sample, we identify 154 that served as lead lenders during our sample period. Specifically, we

TABLE 7

COMPETITION EFFECT ON NONINTEREST INCOME AND SHORT-TERM FUNDING

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	Noninterest Income/Total Income				Short-Term Funding			
Competition (Distance Weighted)	0.1652**				0.0662**			
	(0.0794)				(0.0248)			
Competition (Distance and # of BHCs Weighted)		0.0694**				0.0342*		
		(0.0329)				(0.0189)		
Synthetic Competition (Distance Weighted)			0.2019**				0.0808**	
			(0.0910)				(0.0307)	
Synthetic Competition (Distance and # of BHCs Weighted)				0.0901***				0.0415*
				(0.0295)				(0.0230)
BHC controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BHC fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,573	2,573	2,573	2,573	2,507	2,507	2,507	2,507
R^2	0.8712	0.8712	0.8712	0.8712	0.9007	0.9007	0.9008	0.9008

Note: This table presents regression results of noninterest income and short-term funding on bank competition. The sample consists of BHC-year observations from 1987 through 1995. The dependent variables are *Noninterest Income/Total Income* (columns 1–4), defined as the natural logarithm of [(income from fiduciary activities + noninterest income from trading assets and liabilities + other noninterest income + account-based service charges)/total income], and *Short-Term Funding* (columns 5–8), which equals the sum of demand, savings, and time deposits divided by the BHC's total liabilities, respectively. The table reports regression results on the four BHC competition indicators. BHC-level control variables include *Log(Total Asset)*, *Deposit to Asset*, *Loan to Asset*, and *Capital to Asset*. All the control variables are lagged 1 year. Table 1 provides variable definitions. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. *, **, and *** indicate significant at 10%, 5%, and 1%, respectively.

TABLE 8

COMPETITION EFFECT ON SBA LOANS AND BORROWER TRAITS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	SBA Lending				Borrower Profitability			
Competition (Distance Weighted)	0.4285***				–0.0352***			
	(0.1588)				(0.0092)			
Competition (Distance and # of BHCs Weighted)		0.2600***				–0.0148***		
		(0.0447)				(0.0038)		
Synthetic Competition (Distance Weighted)			0.4188**				–0.0365***	
			(0.1911)				(0.0054)	
Synthetic Competition (Distance and # of BHCs Weighted)				0.2672***				–0.0151***
				(0.0454)				(0.0033)
BHC controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BHC fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,634	2,634	2,634	2,634	5,880	5,880	5,880	5,880
R^2	0.8064	0.8070	0.8062	0.8072	0.1120	0.1121	0.1120	0.1122

Note: This table presents regression results of SBA lending and borrowers' profitability on bank competition. The sample consists of loan-year observations from 1987 through 1995. The dependent variable *SBA Lending* (columns 1–4) is defined as an indicator variable that equals to one if a bank lends to small businesses in year *t* and zero otherwise. The dependent variable *Borrower Profitability* (columns 5–8) is measured as net income over total assets. The table reports regression results on the four BHC competition indicators. BHC-level control variables include *Log(Total Asset)*, *Deposit to Asset*, *Loan to Asset*, and *Capital to Asset*. All the control variables are lagged 1 year. Table 1 provides variable definitions. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. *, **, and *** indicate significant at 10%, 5%, and 1%, respectively.

examine *Borrower Profitability* which equals the ratio of the firm's net income to total assets. Table 1 provides more details on these variables. We match each loan with CRSP/Compustat borrower information using the Dealscan–Compustat link provided by Chava and Roberts (2008). This matching process yields 5,880 loan observations during the 1987–95 period. Columns (5–8) present the regression results where the key explanatory variable is one of four regulation-induced competition measures. The dependent variable is *Borrower Profitability*. Each BHC-specific competition measure enters negatively and significantly, suggesting that exposing a BHC to greater competition increases the likelihood that it lends to less profitable borrowers. Data limitations suggest caution in interpreting these results in that they do not cover the universe of firms to which banks make loans. They only cover the lead lenders of syndicated loans recorded by Dealscan. Nevertheless, the results are consistent with the prediction that intensifying competition encourages banks to lend to riskier firms.

5. CONCLUSIONS

Past research provides differing theoretical perspectives and conflicting empirical results on whether intensification of competition makes banks less stable. The differing findings might reflect the challenges of measuring competition, identifying exogenous sources of variation in the competitive pressures facing banks, and measuring bank risk.

In this paper, we construct time-varying, bank-specific measures of the competitive pressures facing individual banks in the United States over the 1980s and 1990s. We do this by (i) exploiting the quasi-random, state-specific process of interstate bank deregulation and (ii) integrating these state-year measures of regulatory-induced competition with the gravity model of investment to obtain bank-year measures of competition. Furthermore, we use market-based measures of bank risk that avoid several shortcomings associated with accounting-based risk measures.

We find strong evidence of a trade-off between competition and stability. We discover that an intensification of competition among banks increases bank risk. This finding holds across different measures of risk and different measures of the competitive pressures affecting individual banks. Our results also highlight several channels connecting competition and bank risk. We find that competition reduces bank profits, pricing power, and charter values and increases BHC provision of riskier nontraditional banking services and lending to less profitable firms. Our results also relate to recent development in the financial sector. As nonbanking financial institutions increasingly compete with banks, our results suggest that this competition could increase bank risk.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix Table 1. Validation Test: Banking Deregulations and Lagged Bank Risks
Appendix Table 2. Competition and Bank Risk-Taking: Total Risk and Tail Risk (Without BHC Controls)
Appendix Table 3. State-Level Competition and Bank Risk-Taking
Appendix Table 4. Competition and Bank Risk-Taking: Two Way Cluster or Controlling for MSA Fixed Effects
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