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Liquidity holdings, diversification, and aggregate shocks

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Abstract

This paper shows that US banks' increased geographic diversification is an important explanation for the decline of their liquidity buffers from 1976 to the 2008 crisis. Diversified banks also hold more illiquid small business loans, less liquid mortgages, and have higher net liquidity creation. During the crisis, however, better diversified banks hoard more liquidity. These results suggest that diversification increases liquidity risk-taking capacity in normal times, and that exploiting this advantage leaves banks more exposed to aggregate shocks.

Key words: Liquidity, diversification, crises, regulation.

JEL classification: G21, G28, G32.

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US banks' liquidity buffers decreased by 30% between 1976 and 2006. The consequences of this secular decline are well documented: faced with liquidity outflows, banks hoarded liquid assets and cut lending during the 2007-2008 crisis (Millon Cornett et al., 2011). Less is known about the reasons why liquidity holdings declined so much in the first place.

This paper investigates the role of a parallel secular trend: the rise of geographic diversification. Between 1976 and the crisis, the share of US banks operating branches in multiple counties increased from 8% to 47% as states lifted geographic barriers to bank branching (Figure 1). In theory, diversification reduces idiosyncratic risks and the need for self-insurance, for instance in the form of a liquidity buffer. But exploiting this very benefit also increases banks' vulnerability to aggregate shocks. The paper's key contribution is to document empirical evidence supportive of these two untested ideas.

First, I show that the diversification gain experienced by a representative US bank from 1976 and 2006 is associated with a 1 to 6 percentage-point decline in its liquidity buffer - a substantial share of the mean decline over the same period (11 percentage points). Diversified banks also use a larger share of their balance sheets to perform their core functions - lending and liquidity creation. Second, however, the relationship between diversification and liquidity almost halves during the 2007-2008 crisis. Compared to less diversified banks and the pre-crisis period, diversified banks are more prone to *increasing* their liquidity buffers and reduce loan holdings during the crisis.

I obtain these results using annual bank-level and branch-level data for all US banks from regulatory filings (Call Reports and Summary of Deposits). Liquidity buffers are defined as the share of bank assets held in the form of securities and Federal Funds. I first measure diversification using the dispersion of a banks branches across counties (Goetz, 2012). This proxy might overestimate diversification if banks expand into similar counties. Alternatively, I thus directly measure the co-movement of economic activity in the counties a bank expands into, expanding on the idea of Duchin (2010). Figure 2 shows that the two measures grow in tandem from 1976 to the crisis.

The analysis starts with fixed-effects OLS regressions for the 1976-2006 period. The results indicate that the relationship between diversification and liquidity holdings is sizable. The diversification increase experienced by the average US bank from 1976 to 2006 is associated with a 1 to 2.5 percentage-point decrease in liquidity buffers, or 8 to 23% of the mean buffer decline over this period.

A first challenge for identification is that diversification and liquidity choices may have common determinants. However, the key result holds when controlling for known determinants of liquidity management - securitization, group affiliation, size, deposit funding, and capitalization (Loutskina, 2011; Houston et al., 1997; Kashyap and Stein, 2000; Loutskina and Strahan, 2009; Calomiris and Carlson, 2016), as well as established consequences of diversification - distance-to-default, funding costs, and competition intensity (Goetz et al., 2016; Levine et al., 2016; Jiang et al., 2016), and unobserved heterogeneities in expansion and lending opportunities across regions and time (via state-year effects) and in sophistication and propensity to expand across banks (via bank fixed effects).

A second challenge is reverse causality; for instance liquidity-rich banks could be more prone to acquiring banks in new markets (Harford, 1999), and to decreasing their liquidity holdings thereafter. Drawing on Goetz (2012) and follow-up studies, I exploit two plausibly exogenous constraints on bank expansion - intrastate branching regulation, and distance between bank headquarters and potential destination counties. Regulation varies by state and year, and mean distance varies by bank. Interacting the two factors thus provides a bank-time-specific instrument that can be used while controlling for the endogeneity of deregulation via state-year fixed effects. The IV results are similar to the less conservative OLS estimates; they suggest that the diversification increase experienced by the average bank from 1976 to 2006 is associated with a 2.4 percentage-point decrease in liquidity buffers - 22% of the mean buffer decline over this period.

The main finding is consistent with three mechanisms. First, expanding across imperfectly correlated markets reduces the risk that funding is insufficient to cover profitable investment opportunities (Kim et al., 1998; Duchin, 2010), and the risk of default (Acharya et al., 2006). In turn, facing lower risks reduces the need to hold liquidity as self-insurance. Third, diversification might reduce agency frictions within banks (Diamond, 1984), and thus the need to hold liquid assets as a credible signal of due diligence (Calomiris and Carlson, 2016).

These mechanisms all predict that the relationship between liquidity and diversification should be stronger for (i) banks with few means to self-insure or overcome agency frictions other than holding liquidity, and (ii) banks active in less correlated markets. I document four consistent findings. First, the relationship between diversification and liquidity is stronger for smaller banks. This coincides with the notion that small banks are more opaque and thus face frictions in external funding markets, increasing the value of self-insurance (Kashyap and Stein, 2000). Second and third, the diversification-liquidity relationship is stronger for standalone banks, and for banks affiliated to a less geographically diversified Bank-Holding Company (BHC). This is consistent with evidence that affiliation to a BHC gives access to group-wide internal capital markets; this reduces the need to resort to external finance in the first place, particularly when affiliates' liquidity needs are imperfectly correlated (Stein, 1997). Fourth, the diversification-liquidity relationship decreases with the co-movement in economic activity across the counties in which a bank operates: banks expanding into less synchronised counties reduce liquidity buffers by more than banks expanding into more correlated counties.

I then show that diversification allows banks to operate not only with lower liquidity buffers, but also with a higher proportion of illiquid loans in their loan books. Lower liquidity buffers translate nearly one-to-one into higher holdings of loans, and diversification changes the composition of banks' loan books. When diversification increases by one standard deviation, the share of commercial and industrial loans increases by 7%, while the share of single-family mortgages decreases by 5%. Besides lending, a core function of banks is to create liquidity by offering credit lines and transaction deposits drawable on demand (Kashyap et al., 2002). Using the liquidity creation index by Berger and Bouwman (2009), I show that, for a given liquidity buffer size, a one-standard deviation increase in diversification increases liquidity creation by 9%. Together, these results indicate that diversification improves banks' ability to use their balance sheet to perform their key functions, while mobilizing a smaller part of their assets in the form of liquid, low-return assets.

Finally, I show that better diversified banks hold larger liquidity buffers and a smaller proportion of loans during the crisis, compared to less diversified banks and the pre-crisis period. One challenge is that diversification could proxy for a number of determinants of banks' ability or willingness to raise liquidity during the crisis. However, I find that controlling for the interaction of crisis dummies with bank size, capitalisation, z-score, exposure to wholesale funding, return on equity, chargeoffs, regional economic activity, or reposessed real estate does not change the conclusions.

To my knowledge, this paper is the first to establish a causal link between bank diversification and liquidity holdings in normal and crisis times.[1] The literature gives a key role to liquidity buffers for monetary policy transmission, liquidity creation, and crises (Kashyap and Stein, 2000; Kashyap et al., 2002; Millon Cornett et al., 2011). However, studies of the determinants of liquidity buffers are rare and typically do not consider diversification.[2] One important exception is Loutskina (2011). She shows that securitization eases banks' access to external finance and lowers their need to hold liquidity; my paper suggests that diversification reduces

[1] Carlson (2004) finds that multi-branch US banks lowered their reserve-to-deposit ratio ahead of the 1930s banking crisis, and that this left them more vulnerable to the crisis compared to unit banks.

[2] See for instance Bonner et al. (2015).

the need for external finance altogether.

A larger literature studies the costs and benefits of US banks' growing geographic diversification, and its role in the pre-crisis housing bubble.[3] My paper documents the unexplored consequences of diversification for liquidity management.[4] Theory shows that *inter*bank markets reduce banks' idiosyncratic risks and increase their exposure to aggregate risk, but there is little evidence for these arguments and their relevance for intra-bank networks.[5] Evidence suggests that *product-line* diversification explains a part of the secular *rise* in US non-financial corporate cash holdings.[6] My paper studies geographic diversification in banking, an important and different issue since liquidity plays a key role on both sides of banks' balance sheet.

My findings also contribute to ongoing policy discussions. Basel III standards restore the prominent role of liquidity requirements in micro-prudential regulation (Calomiris et al., 2015). Parallel policy initiatives like ring-fencing are expected to diminish banks' ability to diversify across product lines and geographies. My findings suggest that the combination of these two policies might help to shield credit supply from the risks of bank illiquidity, but at the price of lowering the benefits of diversification in normal times.

[3]Diversified banks have lower valuation, profitability, and monitoring intensity (Acharya et al., 2006; Loutskina and Strahan, 2011; Goetz et al., 2013), but also less volatile stock returns, and lower distance-to-default and funding costs (Goetz et al., 2016; Levine et al., 2016). Multi-market banks increased house price correlations across regions (Cotter et al., 2014; Landier et al., 2017).

[4]Earlier studies on the consolidation of US Bank-Holding Companies suggest that diversification increases loan holdings (Hughes et al., 1996; Demsetz and Strahan, 1997; Strahan and Weston, 1998; Morgan and Samolyk, 2003), but causation is unclear. Loutskina and Strahan (2011) show that diversified banks accept and retain fewer illiquid mortgages, but do not study balance-sheet composition.

[5]Allen and Gale (2000), Freixas and Holthausen (2005), Brusco and Castiglionesi (2007). Interbank "co-insurance" induces banks to reduce liquidity holdings and increase lending, but exposes their lending to aggregate liquidity shortages (Castiglionesi et al., 2015). In Wagner (2008), diversification reduces bank liquidity risk, decreasing incentives to hold liquid assets. Castiglionesi et al. (2014) establish empirically that banks address systematic liquidity risk (illiquidity in interbank markets) by holding more capital. Wagner (2010) and Ibragimov et al. (2011) show that diversification makes individual banks safer but collectively riskier.

[6]Opler et al. (1999), Acharya et al. (2007), Duchin (2010). These papers do not study geographic diversification, for which datasets like Compustat does not provide data. Matvos and Seru (2014) and Kuppuswamy and Villalonga (2015) show that non-financial conglomerates perform *better* during crises, as diversified internal capital markets allow to circumvent shortages of external finance. At face value, my results indirectly suggest that the crisis-time lending performance of diversified banks decreases relative to focused banks and the pre-crisis period.

1 Theories and Empirical Strategy

Three main theoretical arguments suggest a link between geographic diversification and liquidity holdings. The common starting point of these arguments is that diversification acts to decrease correlations across geographies, which changes the risks or frictions faced by banks. The difference between these arguments is that they emphasise different types of risk, and different key characteristics of the securities held in liquidity buffers.

The first argument is that diversification changes the need to hold *liquid assets* in order to reduce *underinvestment risk*. Firms face uncertain future funding and investment opportunities. If external finance is costly, funding could not suffice to cover profitable opportunities (Kim et al., 1998). For instance, banks might have to reject profitable loan applications if monetary policy reduces the supply of insured deposits (Kashyap and Stein, 2000; Campello, 2002), or if income is low (Houston et al., 1997). This makes it optimal to hold a buffer of securities that can be liquidated on demand, despite the opportunity costs of holding low-return securities (Stein, 1998). Diversification might reduce this motive insofar as it decreases the volatility and correlation of funding and investment opportunities; this allows to fund investments by moving liquidity from funding-rich to funding-poor branches via internal capital markets, instead of doing so by liquidating securities (Opler et al., 1999; Acharya et al., 2007; Duchin, 2010).[7]

A second argument is that diversification reduces the need to hold a buffer of *safe assets* in order to reduce *bank fragility*. Diversification decreases the correlation of loan returns and thus idiosyncratic credit risk (Acharya et al., 2006). Lower correlations might also reduce the risk of large liquidity outflows (for instance because of deposit withdrawals or credit-line draw-

[7] In other words, liquidity buffers provide self-insurance; they allow banks to transfer liquidity to *periods* in which funding (liquidity inflows) does not cover profitable lending opportunities (outflows). In contrast, diversification provides co-insurance; it allows to transfer liquidity to *branches* where liquidity is insufficient. Carlson and Mitchener (2009) show that branch networks first emerged in 1920's California because liquidity demand was little correlated across the state given the diversity of crops and industrial production. Noting that Canadian branch banks' cash reserves were only half of US unit banks Sprague (1903) concludes that branching increases bank safety and lending.

downs), and thus the risk of early liquidation (Diamond and Dybvig, 1983). A less fragile bank might need to hold fewer liquid assets because it can operate at a higher risk-return frontier (Hughes et al., 1996).

A third argument is that diversification changes the need to hold a buffer of assets with *transparent* value in order to reduce *agency frictions*. Holding observably safe assets helps to convince outside creditors that bank risk is under control when managers are subject to moral hazard (Calomiris and Carlson, 2016). If diversification decreases frictions between bank creditors and managers (Diamond, 1984), this motive becomes less important. But diversification could also *increase* agency problems, for instance if a more diverse set of projects makes it more difficult to monitor managers and borrowers (Winton, 1999). Banks could thus hold more liquidity in order to reduce moral hazard, or less liquidity if this limits managers' flexibility to grant unprofitable loans (Jensen, 1986).

1.1 Empirical Strategy

I investigate the link between diversification and liquidity holding using the following model:

$$Liquidity_{i,t} = \beta_1 \cdot Diversification_{i,t} + \beta_2 \cdot Controls_{i,t} + Bank_i + StateYear_{i,t} + \epsilon_{i,t} \quad (1)$$

(The variables are defined in section 2 below.) I start by estimating 1 with OLS, clustering standard errors by bank. The main parameter of interest is β_1; this captures the way liquidity holdings vary with diversification. I use banks as the unit of observation instead of Bank-Holding Companies (BHC). I do so because regulation requires banks to hold adequate liquidity on a standalone basis, and constrains liquidity flows within BHCs. But since parents can provide some liquidity supports to subsidiaries, I investigate how β_1 changes for BHC subsidiaries, and explore BHC-level regressions in robustness checks.

There are three main identification challenges. First, β_1 could capture confounding correlates of diversification and liquidity. This is addressed through the vector of bank-time controls $Controls$, whose content is described in section 2.3. Second, β_1 could pick up unobserved factors associated with liquidity and diversification choices. The model 1 addresses this issue with two sets of fixed effects. Bank fixed effects ($Bank_i$) control for unobservable, time-invariant heterogeneities across banks. State-year fixed effects ($StateYear_{i,t}$) capture common trends, such as ike changes in regulation, technology (e.g. securitization), or aggregate and state-level macroeconomic conditions ($State$ is defined as the state in which a given bank is headquartered). Including state-year fixed effects implies that identification rests on differences in diversification across banks within the same state and year. This alleviates the concern that regulation changes could be correlated with unobserved changes in the broader regional environment. A final challenge is that β_1 could be biased by reverse causality. This is addressed separately through the instrumental variable strategy described in Section 4.

2 Data, Sample, and Variable Definitions

Sources Data is obtained from three main sources. Bank balance-sheet and income-statement data are drawn from quarterly FDIC filings (”Call Reports”). Branch location data is obtained from the FDIC’s Summary of Deposits. Additional data includes county income from the Bureau of Economic Analysis (BEA), intrastate branching deregulation dates from Goetz (2012), and county-to-county distances from the CTA Transportation Network.[8]

Sample The baseline (”normal times”) sample covers the 1976 to 2006 period. The sample starts in 1976 because Summary of Deposits and Call Reports first become available at this

[8]Call Reports are available from the Federal Reserve Bank of Chicago’s website. Summary of Deposits data for the 1994-2010 period is accessible from the FDIC’s website. I thank the Federal Reserve Board and Martin Goetz for providing the data for the 1976-1994 period. County-to-county distance data can be downloaded from http://cta.ornl.gov/transnet/SkimTree.htm.

point. Call Reports are quarterly, but Summary of Deposits data is yearly. I thus conduct the main analysis at yearly frequency. Summary of Deposits report data as of June of a given year. I thus match Summary of Deposits for a given year with the Call Report of the second quarter of the year, using regulatory identifiers provided in the two datasets. For the crisis-time analysis, I follow Millon Cornett et al. (2011) and construct a similar sample at quarterly frequency for the 2006q1 to 2009q3 period in order to capture the dynamics of the crisis more precisely.

The raw matched dataset contains 21,349 banks active between 1976 and 2006. Following Loutskina (2011), I drop banks involved in a merger in a given year, as well as banks with yearly asset growth over 150%, loan growth over 200%, less than 10% of loans over total assets, negative size or deposits, or liquidity buffers smaller than 1%. This leaves 21,214 banks.

2.1 Liquidity Holdings

Following the bulk of the literature, the main dependent variable *Liquidity* is defined as securities and federal funds as percentage of total assets. I do not include cash holdings in *Liquidity* since they largely reflect non-drawable regulatory reserves (Kashyap and Stein, 2000; Loutskina, 2011). Figure 1 plots the average *Liquidity* over time. From 1984 onward, Call Reports give more granular information on the composition of securities. This allows me to separate mortgage-backed or asset-backed securities (MBS and ABS) from other securities like Treasuries or agency debt. I drop MBS and ABS from *Liquidity* in the crisis-period test because they become illiquid in that period, while other types of securities remain liquid.[9]

[9] In unreported tests, I find that the results are robust to leaving MBS and ABS in *Liquidity*.

2.2 Diversification

Following Goetz et al. (2013), my main proxy of diversification measures the dispersion of a bank's branches across counties using the following (inverted) Herfindahl Index:

$$Diversification_{i,t} = 1 - \sum_c \left[\frac{Branches_{i,c,t}}{Branches_{i,t}} \right]^2, \tag{2}$$

where $Branches_{i,c,t}$ is the number of bank i's branches in county c and year t, and $Branches_{i,t}$ is the total number of i's branches at t. I subtract the index from 1 so that *Diversification* increases with diversification. *Diversification* varies between 0 (a single-county bank) and 1 (a bank with equal presence in a large number of counties). Figure 2 shows that the average $Diversification$ increases from 2.6% in 1976 to 19.6% in 2006. I focus on counties since the bulk of the literature uses counties to delineate local banking markets - see for instance Gilje et al. (2016). Below, I show that my results are robust to focusing on zip codes or metropolitan statistical areas instead. I use the location of branches because data is available for the entire sample (1976 onwards), whereas borrower location data would only be available from 1990 onwards through HMDA data.

Alternate Proxy $Diversification$ captures how much a bank expands across counties, but not necessarily how much its effective diversification improves when doing so. For instance, a bank expanding into a large number of counties with very similar demographic and industrial characteristics would appear highly diversified according to *Diversification*. But this bank might be poorly diversified in practice since these counties should co-move to a high degree. This caveat is significant because theory typically starts from the premise that diversification reduces correlations across geographies (Section 1).

In robustness checks, I thus alternatively use the diversification indicator by Duchin (2010).

This proxy measures the reduction in the volatility (risk) of cash flows and investment opportunities enjoyed by a firm when it expands across product lines. Adapting its logic to the case of geographic diversification in banking, the indicator is defined as:

$$Diversification\ Gain_{i,t} = (Volatility_{i,t} - \bar{Volatility}_{i,t}) \times (-1). \quad (3)$$

The first term in (3) is the volatility a bank effectively faces in the counties where it operates:

$$Volatility_{i,t} = \sqrt{\sum_{c=1}^{C}\sum_{d=1}^{D} Share_{i,c,t} \cdot Share_{i,d,t} \cdot Correlation_{c,d} \cdot Volatility_{c,t} \cdot Volatility_{d,t}}, \quad (4)$$

where $Share_{i,c,t}$ is the percentage of a bank's branches in a given county and year; $Volatility_{c,t}$ is the variance in this county-year; $Correlation_{c,d}$ is the correlation between all the county pairs in which the bank operates. The second term in (3) is the hypothetical risk the bank would face if these counties were perfectly correlated (that is, if $Correlation_{c,d} = 1$):

$$\bar{Volatility}_{i,t} = \sqrt{\sum_{c=1}^{C}\sum_{d=1}^{D} Share_{i,c,t} \cdot Share_{i,d,t} \cdot Volatility_{c,t} \cdot Volatility_{d,t}}. \quad (5)$$

I multiply the difference between these two terms by -1 so that *Diversification Gain* increases with diversification benefits. Specifically, *Diversification Gain* varies between zero and infinity. In the former case, the diversification benefits are inexistent: counties are perfectly correlated, so effective risk ($Volatility_{i,t}$) is as high as if counties were perfectly correlated ($\bar{Volatility}_{i,t}$). In the latter case, the diversification benefits are high: effective risk is much smaller than hypothetical risk under perfect correlation.

I measure volatilities and correlations using a 10-year rolling window of annual county income growth. I mainly do so because income data is available through the sample, and is less endogenous than possible alternatives like county deposit growth.[10] I measure $Correlation_{c,d}$ between pairs of counties within the same state only, because considering every possible pair of 3,144 counties would be computationally difficult. Furthermore, a handful of banks only have expanded into multiple states, so within-state correlations provide a reasonable approximation for the large majority of US commercial banks (more details in Section 4).

2.3 Control Variables

Table 1 provides detailed definitions of the controls included in the baseline model. I first follow Loutskina (2011) and include the following known determinants of liquidity management: bank size (log of total assets), group affiliation (Bank-Holding Company affiliate dummy), deposit funding (% total liabilities), deposit funding costs (interest expenses/deposit volume), capitalization (% total assets), net income (% total assets), and letters of credit (% total assets).[11] To control for the role of securitization in liquidity management, I measure the share of a bank's loans that could be potentially securitized using the index of Loutskina (2011).[12]

Holding liquidity is less costly when expected investment opportunities are high, and funding opportunities are low (Duchin, 2010). I control for lending opportunities using the mean annual income growth in the counties in which a bank is active, weighted by the share of a given county in the bank's branch network (Carlson and Mitchener, 2009). I proxy for

[10] County income data starts in 1969. So variance from 1976 to 1979 is computed using less than 10 years of data. Duchin (2010) separately considers the volatility and correlation of (i) cash flows and (ii) investment opportunities. For simplicity, I only consider the volatility and correlation of one representative county outcome, income growth.

[11] Size can impact liquidity management via access to external finance (Stein, 1998), bail-out probablity (Gropp et al., 2011), economies of scale, or sophistication. Affiliated banks can access liquidity through group-level internal capital markets (Ashcraft and Campello, 2007). Deposits reduce liquidity risk by shielding banks from variations in the cost of wholesale funding (Loutskina and Strahan, 2009). Equity reduces liquidity risk because it is not drawable on demand and dividend payments are non-contingent (Castiglionesi et al., 2014). Income relaxes funding constraints (Houston et al., 1997; Campello, 2002). Because the benchmark model includes bank fixed effects, the BHC dummy effectively captures the fact of being acquired by a BHC during the sample period.

[12] The index varies between 0 (a portfolio with only illiquid loans) and 1 (a portfolio with only liquid loans) as a function of (i) the depth of the secondary market for a given loan type and year, and (ii) the share of this loan type in a given bank's portfolio and year. For instance, 60% of single-family mortgage loans were securitized in 2006, against only 3% for commercial and industrial loans. For a bank whose 2006 loan portfolio entirely consists of single-familiy mortgages, the index would be equal to 0.6.

funding opportunities using the mean yearly deposit growth in a given county (measured using Summary of Deposits data), weighted similarily.

Finally, I add factors found to be affected by diversification by recent studies (Jiang et al., 2016; Goetz, 2012; Goetz et al., 2016). These include: competition intensity (weighted mean Herdindahl Index of bank market shares in all the counties in which a bank is active), competitors' diversification (weighted mean *Diversification* of the bank's competitors in a given county, summed across all the counties in which the bank is active), and bank z-score.

3 Liquidity and Diversification

Before turning to formal regressions, I start by discussing high-level indications of the relationship between liquidity and diversification. Table 2 reports summary statistics for non-diversified (single-county) and diversified (multi-county) banks. Consistent with the main hypothesis, non-diversified banks hold more liquid assets (34.2%) than diversified ones (27.4%). Figure 3 plots the average liquidity holdings for the two groups over time. Liquidity buffers are stable or moderately declining until the 1990s, except during recessions when they increase before reverting.[13] From then on, liquidity buffers decrease almost constantly. Figure 3 also shows that the difference in liquidity buffer size between diversified and non-diversified banks seems stable over time. In other words, the relationship between liquidity and diversification seems constant, but the share of diversified banks in the cross-section of US banks increases steadily.

Table 2 indicates that non-diversified and diversified banks differ in dimensions other than diversification. The average single-county bank is smaller, less likely to be affiliated to a BHC and better capitalised, and its loan book has higher securitization potential. I now discuss

[13] Banks typically shed riskier assets during recessions to improve their capitalization (Calomiris and Wilson, 2004). The larger increase in the late 1980s might be due to the introduction of risk-weighted capital requirements under the Basel I regime (Keeton, 1994).

multivariate OLS results that control for both confounding factors and unobserved trends.

3.1 Multivariate OLS Results

Table 3 reports the result of OLS regressions of the baseline empirical model 1. To gauge the role of controls, column 1 shows the outcome of a univariate regression of liquidity on diversification without fixed effects. β_1 is negative, and economically and statistically significant. The estimate indicates that a one-standard deviation increase in $Diversification$ (+0.2) is associated with a 3-percentage point decrease in $Liquidity$; this represents 8.3% and 12% of the mean liquidity buffer in 1976 and 2006, respectively. Put otherwise, the diversification increase experienced by the mean bank from 1976 to 2006 (+0.17) can explain around 23% of the mean decrease in liquidity over the same period (-0.11).

Column 2 adds the baseline fixed effects and controls described in Section 2.3. β_1 remains negative and significant. This suggests that the relationship between liquidity and diversification holds over and above the effect of size, securitization or affiliation to a BHC on liquidity holdings. Since they can be jointly determined with diversification, these controls are bound to reduce the size of the effect attributed to diversification. In addition, state-year fixed effects mechanically absorb changes in *average* diversification across states and over time. While the univariate results likely overestimate the true effect of diversification, the multivariate estimates thus likely underestimate this effect. Consistent with this prior, β_1 is three times smaller than in the univariate regression: specifically, $Liquidity$ declines by 1 percentage point (8% of the mean decrease in liquidity buffers over the same period) when $Diversification$ grows by 0.17 percentage points (the 1976-2006 mean increase). Section 4 shows that IV regressions suggest economic magnitudes closer to those of the univariate OLS regression.

Robustness The appendix section A shows that these results are robust to: changing the diversification proxy in three different ways; running the regression at the BHC-level; dropping single-county or the 1%-largest banks; and clustering standard errors by state. Furthermore, estimating the model year-by-year shows that the main result is not specific to a particular period.

3.2 Cross-Sectional Variation

I now investigate how the relationship between diversification and liquidity varies across banks. I first test whether this relationship is weaker for banks facing less severe external finance frictions, or a lower need for external finance. The intuition follows from the theories outlined in Section 1. Diversification affects liquidity holdings because it (i) improves internal capital markets and thus reduces underinvestment risk, (ii) reduces bank fragility, and (iii) has an ambiguous effect on agency frictions. These three motives should be less important when access to external capital markets is unconstrained. The ability to raise external finance should reduce the need to run efficient internal capital markets, increase the ability to address fragility (for instance by raising equity), and be indicative of less severe agency issues.

I proxy for external frictions in two ways. First, larger banks tend to be less opaque, and to find it easier to raise wholesale funding or equity (Kashyap and Stein, 2000). Column 3 of Table 3 confirms that the relationship between diversification and liquidity decreases with size. The parameter estimate for $Diversification \times Size$ is positive; it suggests that the effect of diversification on liquidity is -0.08 for a bank at the 25th percentile of the distribution of size, against only -0.05 for a bank at the 75th percentile of size. The effect would be zero for a bank with a log size of 13.5, which is above the 95th percentile of bank size. In other words, the relationship between liquidity and diversification remains negative for all but the largest banks.

Second, parents can raise funding and transfer it to subsidiaries trough group-wide internal capital markets (Houston et al., 1997; Campello, 2002; Cremers et al., 2010). This can act to reduce subsidiaries' funding frictions. Column 4 of Table 3 confirms that the relationship between diversification and liquidity is stronger for standalone banks. The effect of diversification on liquidity is -0.04 (=0.018-0.06) for affiliated banks, against -0.06 for standalone banks.

Extending the logic of Section 1 suggests that the potential for intragroup liquidity transfer should also depend on the BHC's diversification. Column 5 thus keeps affiliated banks only, and additionally controls for BHC diversification and its interaction with the bank's diversification.[14] The results show that *BHC diversification* is associated with lower bank liquidity buffers, but this effect is around three times lower than the effect of the bank's own diversification (-0.02 vs. -0.08). As expected, *BHC diversification* also decreases the relationship between bank diversification and liquidity. Specifically, the effect of diversification on liquidity holdings is -0.08 for a bank whose parent is at the 25th percentile of BHC diversification (0), against -0.03 for a bank with a parent at the 75th percentile (0.64).

A fourth prediction stemming from the theories above is that geographic expansion should be more beneficial when it effectively reduces correlations across markets. For instance, a bank expanding into less synchronised counties should enjoy less correlated investment opportunities, funding opportunities, and loan returns; this should reduce underinvestment risk and fragility, and thus the need to hold liquidity as self-insurance. Column 6 tests this idea by interacting *Diversification* with *Diversification Gains*. As explained in Section 2.2, *Diversification Gains* increases when cross-county correlations in income growth decrease. Consistent with my prior, the parameter estimate for the interaction term is positive and statistically significant: banks expanding into less correlated counties reduce their liquidity buffers by more than banks expanding into more synchronised counties.

[14] *BHC Diversification* is defined analogously to the corresponding bank-level measure.

4 Instrumental Variable Strategy and Results

The previous section has established that geographic diversification gains are associated with a sizable reduction in liquidity buffers. The set of controls and fixed effects seeks to address the possibility that this result reflects omitted variables. But the results could still be biased by reverse causality. For instance, liquidity-rich banks could be more prone to acquiring branches in new markets (Harford, 1999), and to reducing their buffer thereafter.

Following Goetz (2012) and follow-up papers (Goetz et al., 2013, 2016; Levine et al., 2016), I address this challenge using two plausibly exogenous constraints on banks' ability to diversify. First, physical distance between lenders and borrowers exacerbates information asymmetries; this makes it harder for a bank to expand away from its headquarters (Petersen and Rajan, 2002). Second, state regulation has long prevented banks from opening or acquiring branches outside their home county and state. States have repealed these regulations at different points in time. Since distance from new potential markets is bank-specific, and deregulation is state-year-specific, interacting both factors provides a bank-year instrument for diversification.[15]

Most studies using gravity-deregulation instruments focus on the repeal of barriers to *interstate* banking - see for instance Goetz et al. (2013). Instead, I concentrate on the deregulation of *intrastate* banking. Intrastate barriers were typically removed before interstate barriers. But Figure 4 shows that a large number of states deregulated intrastate branching during the sample period. In 1976, only 15 of 51 states permitted intrastate branching. The bulk of these regulations were relaxed during the 1980s; by 1994, all states but Iowa had repealed them. Jayaratne and Strahan (1996) show that intrastate branching deregulation increased state GDP.

The key reason for focusing on intrastate banking deregulation is illustrated in Figure 5. The gray line shows that only 1.6% of banks had taken the opportunity to expand to other

[15] Jiang et al. (2016) and Goetz (2017) use a similar method to instrument for local competition intensity. Competition is controlled for in my IV (and OLS) regressions to avoid violating the exclusion restriction.

states by 2006. The reason is that most banks expanding across state lines did so by forming (or expanding) multi-state BHCs. In contrast, the black line shows that more than 16% of banks had expanded out of their home counties by 2006. This shows that the diversification of the average US bank - the focus of my study - is best captured by focusing on intrastate expansion across counties. In contrast, the diversification of the larger (publically traded) BHCs - the focus of studies like that of Goetz et al. (2013) - is better captured by focusing on expansion across states.[16]

4.1 Instrument Construction

The instrument for the diversification proxy is constructed in three steps.

Gravity Equation First, I measure the share of a bank's branches in all counties in its home state in a given year ($Share_{i,c,t}$), other than its home county. I then estimate the following gravity model:

$$Share_{i,c,t} = \alpha \quad + \quad \lambda_1 \cdot Distance_{i,c} + \epsilon_{i,c,t}, \tag{6}$$

where $Distance_{i,c}$ is the (log) distance between i's home county and county c. Because the model is misspecified for banks that cannot expand out of their home county, I estimate the gravity equation 6 using only banks whose home state allows intrastrate branching at time t. Following Goetz et al. (2016), I use a fractional logit model to do so since the dependent variable is bounded between zero and one. Panel A in Table 4 reports results consistent with the premise of the gravity model. Specifically, $Share_{i,c,t}$ diminishes significantly with distance from the bank's headquarters.

[16] My paper explores the entire universe of banks active between 1976 and 2009; there are around 21,000 banks in total - about 11,345 in the average year. By contrast, Goetz et al. (2013) focus on the 964 public BHCs only; their sample starts in 1986 because of the availability of BHC data.

Predicted Diversification Second, I use the λ_1 estimates of the gravity regression to compute a predicted *Share* for a given bank, county, and year. For all bank-county-year pairs not included in the gravity regression (i.e. all those in states that have not yet allowed intrastate branching), I set the predicted share to zero. To construct the instrument for *Diversification*, I then sum the squared predicted shares by bank and year. This provides a predicted Herfindahl Index, which I call $Diversi\hat{f}ication_{i,t}$. I winsorize the top and bottom 1% of $Diversi\hat{f}ication_{i,t}$ to attenuate the influence of outliers.[17]

Exclusion Restriction For the instrument to be valid, predicted diversification must affect liquidity only through its effect on diversification, or through factors controlled for in the IV regressions. This exclusion restriction could be violated, for instance, if branching deregulation is correlated with unobserved, time-varying local economic or political factors, and these factors affect liquidity holdings. To address this challenge, the IV regressions use the same set of fixed effects, namely state-year and bank fixed effects. This implies that any unobserved determinant of deregulation is controlled for and thus cannot violate the exclusion restriction.

Second, papers using gravity-deregulation instruments show that diversification causes a number of changes to bank behavior and to market structure. Since these factors could affect liquidity holdings, I include in IV regressions the same set of controls included in OLS regressions. Importantly, this includes all variables found to be affected by diversification and those that have been instrumented using gravity-deregulation strategies. This includes: distance-to-default (Goetz et al., 2016), funding costs (Levine et al., 2016), competitor's diversification (Goetz, 2012), and local competition intensity (Jiang et al., 2016; Goetz, 2017). One caveat is that I cannot control for the impact of diversification on stock market valuation (Goetz et al., 2013), since the vast majority of the banks in my sample are not traded publicly. However, the

[17] To instrument for *Correlation* in robustness checks, I re-calculate cross-county volatilities following equations 4 and 5, but replacing actual *Shares* by predicted shares. I also winsorize the top and bottom 1% of $Corr\hat{e}lation_{i,t}$ to attenuate the influence of outliers.

regressions control for related factors like capitalization and profitability.

IV Sample The instrument can be measured for a subset of the observations included in the baseline sample only. First, Figure 4 shows that intrastate branching regulation varies across states between 1976 and 1994 only. I thus focus on the 1976-1993 period for IV regressions; this leaves 19,060 different banks, against 21,214 for the 1976-2006 sample. Second, intrastate diversification is mismeasured for banks operating in mutliple states. I thus exclude the 90 multi-state banks. Third, I drop the 295 banks headquartered outside the mainland US, or in two states with idiosyncratic branching regulations, Delaware and South Dakota (Levine et al., 2016). Finally, I drop the 1,014 banks whose headquarters location changes over time and for which the gravity equation is thus also misspecified (Goetz et al., 2013). There are 17,716 banks left in the IV sample after this screening.

4.2 IV Regression Results

The results of the IV estimation are reported in Panel B of Table 4. To ease comparison, the first column additionally shows new OLS results obtained using the IV (1976-1993) sub-sample. This regression yields results similar to the baseline 1976-2006 OLS regression: an increase in diversification is associated with a significantly lower liquidity buffer. Column 2 shows the results of a reduced-form regression where diversification is replaced by its instrument. The result confirms that liquidity buffers decrease when the exogenous component of diversification increases.

Column 3 reports the results of the first stage of the IV regression. The relationship between $Diversification$ and its instrument is positive and significant. Finally, column 4 shows the results of the second stage of the IV estimation. The Kleibergen-Paap statistic reported at the bottom of the table confirms that the instrument is strong (a statistic below 10 is generally suggestive of a weak instrument). The effect of $Diversification$ is positive and statistically significant at the 1% confidence level. The estimated economic magnitude is close to the one found in the univariate OLS regression in Table 3. An increase in diversification from its 1976 mean to its 1993 mean (+6.4 percentage points) is associated with a 2.2% percentage-point reduction in liquidity buffer, or 24% of the mean 1976-2006 buffer decline. The appendix section A shows that this result is robust to the majority of robustness checks used for the OLS results.

Summing up, the IV results confirm that diversification gains have a causal, negative impact on liquidity holdings. The economic magnitude is more important when reverse causality is addressed by instrumenting diversification. The increase in coefficient size between the OLS and IV regressions is roughly similar to the one in Goetz et al. (2013) or Goetz et al. (2016). This increase might reflect the fact that IV regressions do not capture the effect of diversification for the average bank, but rather for banks actually taking the opportunity to expand when intrastrate branching is deregulated during the IV sample period (1976-1993). These banks may be those for which branching restrictions were the most binding, like liquidity-rich banks. Since deregulation might be particularly beneficial for these banks, the IV estimate might provide an upper bound of the effect of diversification for the average bank.

5 Implications for Credit Supply and Liquidity Production

5.1 Diversification, Liquidity Production, and Credit Supply

The finding that banks reduce their liquidity buffers when they diversify geographically begs two questions. First, does this induce banks to offer more or different types of loans? Second, does this boost liquidity creation more broadly? These questions are important because credit supply and liquidity production belong to banks' core functions (Calomiris and Kahn, 1991; Kashyap et al., 2002) and have important implications for welfare. I explore these two questions with the same OLS and IV models used above, but replacing the dependent variable with proxies for loan holdings and liquidity production.

I start by exploring the relationship between diversification and the volume of loans as a percentage of total assets. Table 5 reports the results of OLS regressions using the full sample (column 1) or the IV sub-sample (column 2), and of IV regressions (column 3). The elasticity of lending to diversification is the quasi-exact inverse of the elasticity of liquidity to diversification: a one-standard deviation increase in diversification is associated with a 0.5% (1976-2006 OLS results) to 8.6% (IV results) percentage point increase in loans holdings; this represents 4% to 57% of the standard deviation of loan holdings (0.15). In other words, lower liquidity buffers translate one-to-one into more loan holdings. This result is not entirely mechanical, since assets held in forms other than liquidity buffers and loans represent 10% of total assets on average.

The next columns explore the composition of banks' loan books. Specifically, I investigate the relationship between diversification and (i) commercial and industrial loans (columns 4-6), (ii) single-family mortgages (columns 7-9), and (iii) other mortgages (columns 10-12), all defined as share of total loans. Separating these loan types is interesting because commercial and industrial loans and other mortgages are less liquid (that is, they cannot be sold as easily into secondary markets), while single-family mortgages are the most liquid loans overall. The OLS results suggest that higher diversification goes along with less commercial and industrial lending and more single-family mortgages. However, the IV results show that these two results reverse when the endogeneity of diversification is accounted for. Specifically, the IV results show that the average diversification increase transaltes into a 7.4% increase in commercial and industrial loans, and a 5.2% decrease in single-family mortgages. In contrast, diversification does not change the share of non-single family mortgages. Overall, these results suggest that diversification induces banks to shift their loan books towards less liquid loans.

I then investigate the link between diversification and liquidity creation. Liquidity creation refers to the fact of offering deposits and credit lines that can be drawn on demand, backed by illiquid assets such as loans. The finding that diversification is associated with smaller liquidity buffers and more lending suggests that diversification boosts liquidity creation. But to understand net liquidity creation, one must measure the liquidity of all items on and off the bank's balance sheet. This is what the liquidity creation index of Berger and Bouwman (2009) does. The index classifies a bank's assets, liabilities and off-balance sheet items as liquid, semi-liquid, and illiquid. The measure increases when banks issue more liquid claims (for instance credit lines and transaction deposits) backed by illiquid assets (for instance commercial and industrial loans), and decreases when they issue more illiquid liabilites (for instance equity) backed by liquid assets (for instance liquid securities).[18]

Why could diversification change liquidity creation? Kashyap et al. (2002) show that creating liquidity is possible as long as drawdowns on demandable deposits and credit lines are imperfectly correlated. Concretely, depositors must not withdraw their transaction deposits at the same time as firms draw down on their lines of credit. One way to reduce the risk of simultaneous drawdowns is to hold a buffer of liquid assets. But this creates opportunity costs and reduces liquidity creation. If diversification makes simultaneous drawdowns less likely, banks might create more liquidity for a given liquidity buffer size, or create the same amount of liquidity using a smaller liquidity buffer.

Columns 4 to 6 in Table 5 test this idea using the Berger and Bouwman (2009) index. I include *Liquidity* as control to keep the effect of diversification on liquidity buffers constant. I focus on the 1986-2006 (OLS regressions) and 1986-1993 (IV regressions) periods since liquidity creation data is available from 1986 only. The results suggest that larger diversification is associated with higher liquidity creation. A one-standard deviation increase in diversification

[18] Berger and Bouwman (2009) propose several variants of their index, which differ by the way they classify items. In this paper, I only consider their preferred measure ("Catfat") for brevity.

increases liquidity creation by 1.3 (OLS regressions) to 8% (IV regressions).

5.2 Liquidity and Diversification during the Crisis

Banks exposed to the 2007-2008 crisis increased liquidity buffers and cut lending as market liquidity started drying up (Millon Cornett et al., 2011). This section explores whether these two effects are stronger for diversified banks.

The theories outlined in Section 1 suggest two main arguments for this hypothesis. First, a systemic crisis is akin to a rise in aggregate risk; this mechanically reduces the possibility of diversifying idiosyncratic underinvestment and default risks away. This shock might be larger for banks previously able to do so. Second, more diverse banks might be perceived as more opaque in a crisis context, relative to more focused banks. These two arguments suggest that diversified banks might increase their liquidity holdings during the crisis relative to less diversified banks and the pre-crisis period. Alternatively, banks enjoying diversified internal capital markets and a lower opacity in normal times might be better able to circumvent freezes in external funding markets (Matvos and Seru, 2014). This suggests that liquidity holdings might decrease by less for better diversified banks.

Following Millon Cornett et al. (2011), I explore the 2006q1 to 2009q2 period at quarterly frequency to test these hypotheses. I add two crisis dummies. *Crisis 1* is 1 between 2007q3 and 2008q2, and 0 otherwise. This corresponds to the ”crisis of banks as liquidity providers”, as banks failed to attract enough funding to cover deposit outflows (Acharya and Mora, 2015). *Crisis 2* is 1 between 2008q2 and 2009q2, and 0 otherwise. This period sees the failure of Lehman Brothers, and capital markets dry up further. My main interest is in the interaction between diversification and the crisis dummies. The set of controls is similar to the baseline tests, but I add state-quarter fixed effects to account for the higher regression frequency. I also remove mortgage-backed and asset-backed securities from the definition of *Liquidity*, since these two types of securities became illiquid during the crisis.

Table 6 reports the results. Column 1 shows the results when the crisis dummies are omitted. Similar to the baseline regressions, the results indicate that higher diversification is associated with smaller liquidity buffers (Panel A), and higher loan holdings (Panel B). The results in column 2 show that the estimate for $Diversification \times Crisis$ are positive and significant. Diversified banks thus hold fewer liquid assets before the crisis, and more liquid assets during the crisis. The effect is economically sizable. Column 2 in Panel A suggests that the liquidity-diversification relationship decreases by 28.5% during the first phase of the crisis, and by another 40.7% during the second phase. In other words, the crisis more than halves the effect of diversification on liquidity. Panel B yields qualitatively similar, opposite results for loan holdings, but the crisis effect is economically weaker.[19]

One challenge is that $Diversification$ might proxy for other determinants of the willingness or ability to raise liquidity holdings during the crisis. However, the results in column 3 show that controlling for the interaction between the crisis dummies and all baseline bank controls does not change the results. In other words, the crisis-time effect of diversification on liquidity holds over and above the possible role of size, capitalization, funding cost, or distance-to-default. To account for crisis-specific factors, column 4 additionally controls for repossessed real estates (% loans), core deposits (% total assets), return on equity, chargeoffs (% total assets), and their interaction with the crisis dummies. The results also remain similar; these factors do not explain the results.

[19] These findings beg the question of why diversified banks do not seem to anticipate systematic shocks like the crisis. There are three main possible explanations. First, the prospect of nationwide, correlated shocks like a nationwide decline in house prices appeared highly unlikely based on available data (Cotter et al., 2014). Second, banks might anticipate that emergency liquidity assistance would be widely available if such a shock were to materialize (Farhi and Tirole, 2012). (Banks can obtain liquidity from both the Federal Reserve and Federal Home Loan Bank systems (Ashcraft et al., 2010).) Finally, banks might not have an incentive to internalize the negative externalities of their liquidity risk for aggregate financial stability (Wagner, 2008).

6 Conclusion

This paper shows that US commercial banks' diversification gains between 1976 and 2006 explain a sizable part of the parallel secular decline in their liquidity buffers; diversified banks also hold more illiquid loans and create more liquidity. During the crisis, however, diversification is associated with relatively larger liquidity buffers and smaller loan holdings. Together, these results indicate that, in normal times, diversification gains allow banks to operate with lower liquidity holdings; this allows them to make larger use of their balance sheet in order to fulfill their core roles of supplying credit and creating liquidity. However, this also makes diversified banks relatively more vulernable to major, unexpected aggregate shocks like the 2007-2008 crisis.

US banks' liquidity buffers have stabilized since the crisis. But their average geographic diversification has further increased, not least because a large number of small community banks have failed. This paper's findings suggest that newly phased-in liquidity regulations might prevent banks from taking advantage of these diversification gains to decrease liquidity holdings and increase lending. This might reduce the severity and transmission of future liquidity shocks through branch networks, but at the price of lower credit supply and liquidity creation in normal times. Quantifying the net impact of these two countervailing effects on welfare is a promising avenue for research.

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7 Figures and Tables

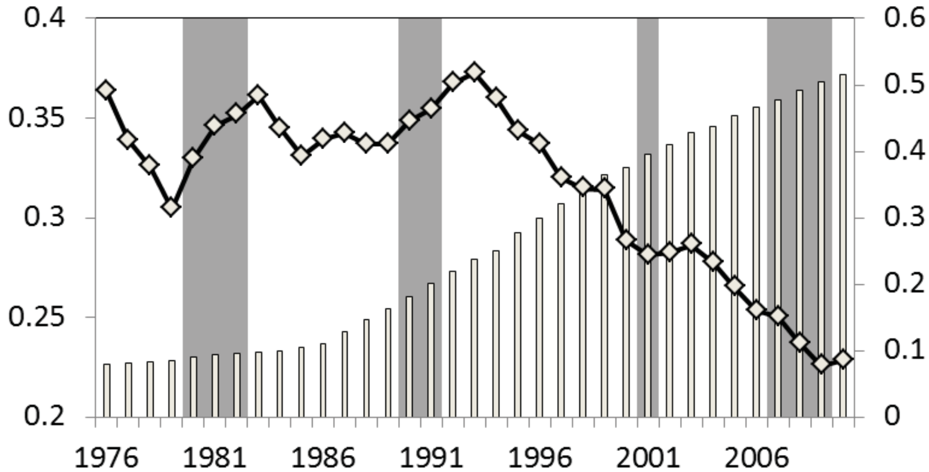

FIGURE 1: LIQUIDITY BUFFERS AND GEOGRAPHIC DIVERSIFICATION. Black line (left axis): average US commercial bank liquidity buffer (% total assets). White bars (right axis): US commercial banks with branches in multiple counties (share of all banks). Source: author's calculation based on Call Reports and Summary of Deposits data.

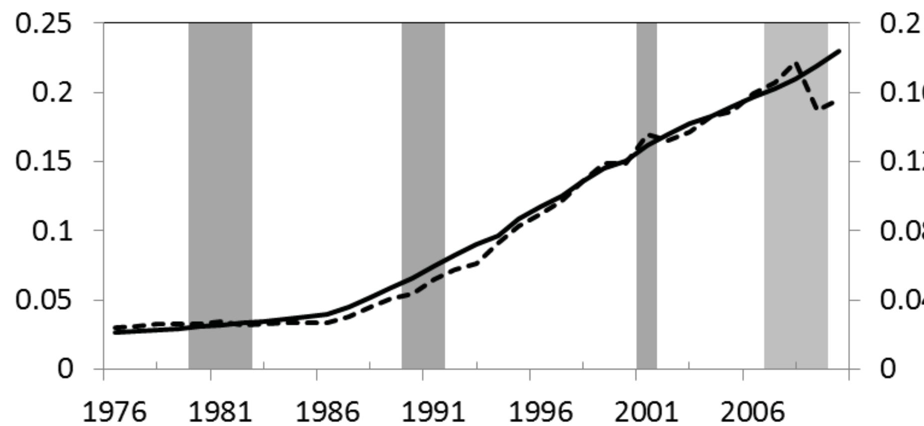

FIGURE 2: GEOGRAPHIC DIVERSIFICATION. Solid line (left axis): average US commercial bank *Diversification* (1-(sum of squared shares of total deposits held in given county)). Dashed line (right axis): average US commercial bank *Diversification Gain* (-1×(Mean standard deviation of county income growth in all counties in which the bank is active, minus same standard deviation assuming counties have zero correlation)). Source: author's calculation based on Call Reports and Summary of Deposits data.

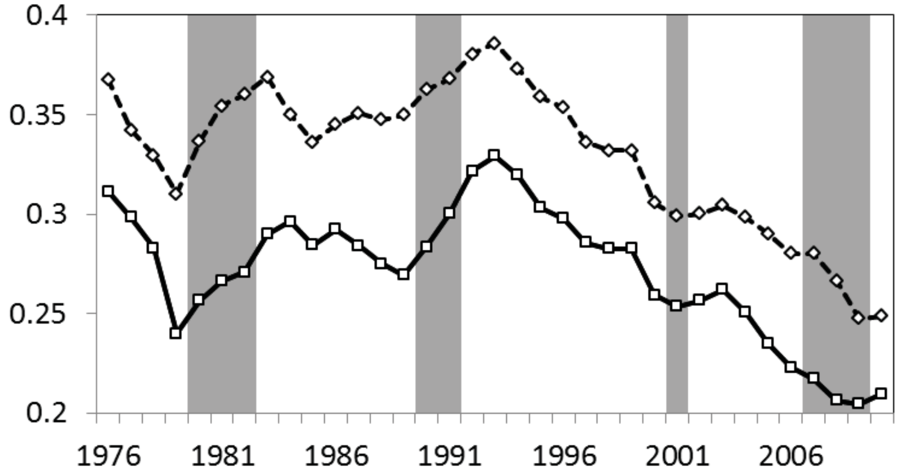

FIGURE 3: DIVERSIFIED AND NON-DIVERSIFIED BANKS' LIQUIDITY BUFFERS. Solid line: average US multi-county bank liquidity buffer (% total assets). Dashed line: average US single-county bank liquidity buffer (% total assets). Multi-county banks are defined as banks with branches in more than one county in a given year. Single-county banks are defined as banks with branches in one single county. Source: author's calculation based on Call Reports and Summary of Deposits data.

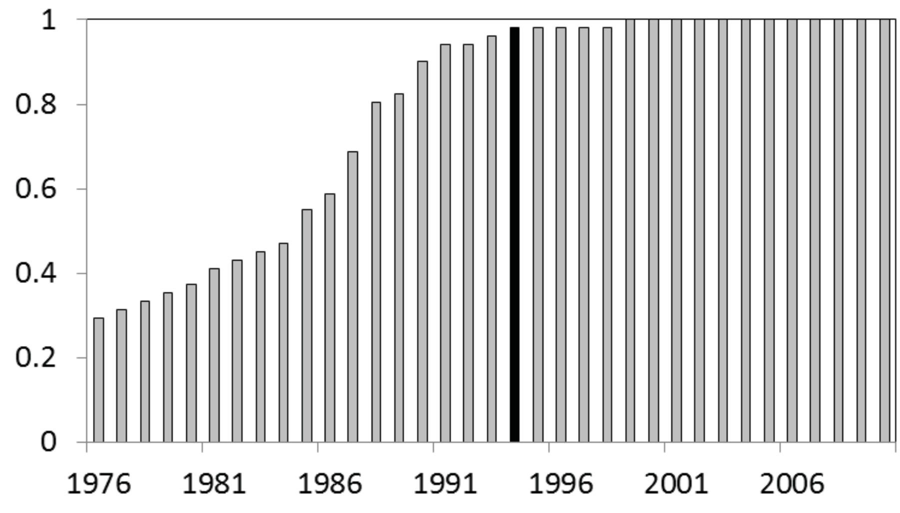

FIGURE 4: INTRASTATE BRANCHING DEREGULATION. Percentage share of US states where intrastate branching is permitted. Source: author's calculations based on data from Goetz (2012).

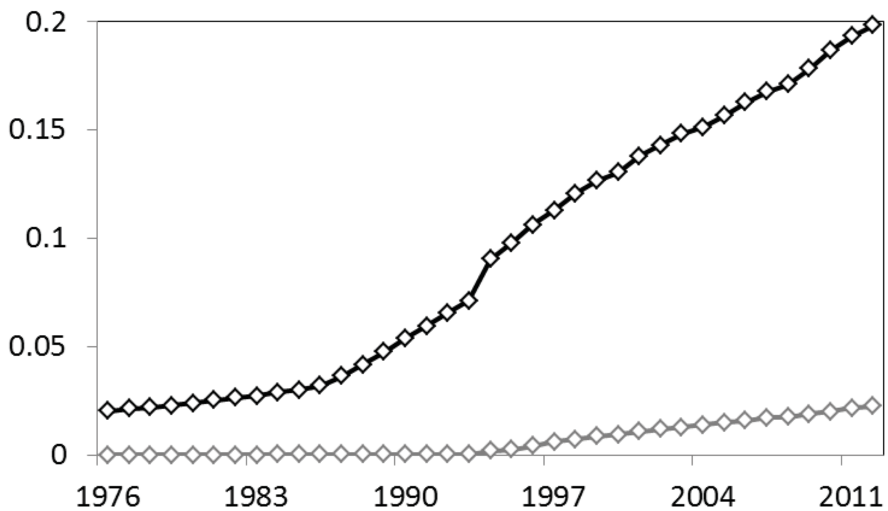

FIGURE 5: INTRASTATE AND INTERSTATE EXPANSION. Black line: percentage of a bank's total deposits held outside of its home county (mean percentage for all US commercial banks). Gray line: percentage of a bank's total deposits held outside of its home state (mean percentage for all US commercial banks). Source: author's calculations based on Summary of Deposits data.

Table 1: Variable Definitions

Dependent variables:	
Liquidity	Marketable securities and Federal Funds (% total assets)
Loans	Total loans (% total assets)
C&I Loans	Commercial and industrial loans (% total loans)
Single-family mortgages	Single-family mortgages (% total loans)
Other mortgages	Non-single-family mortgages (% total loans)
Liquidity Creation	1/2*(illiquid assets and guarantees+liquid liabilities)-1/2*(liquid assets+illiquid liabilites+equity-liquid guarantees and derivatives). See Berger and Bouwman (2009) Table 1 for details.
Diversification proxies:	
$Diversification$	1-(sum of squared shares of total deposits held in given county)
Diversification Gain	-1×(Mean standard deviation of county income growth in all counties in which the bank is active, minus same standard deviation assuming counties have zero correlation)
Baseline Controls:	
$Letters$	Letters of credit (% total assets)
Securitization Potential	Weighted sum of shares of given loan type (% total loans) multiplied by aggregate share of loans of this type sold into secondary markets
$Size$	Log total assets
BHC	1 if affiliated to a Bank-Holding Company, 0 otherwise
$Capital$	Total equity (% total assets)
$Deposits$	Total deposits (% total assets)
Deposit Costs	Interest expenses (% total deposits)
$Profitability$	Total income (% total assets)
$Competition$	Average county Herfindahl Index of banks' deposit share weighted by b's share of deposits in given county
Funding Opp.	Average county total deposit growth weighted by b's share of deposits in given county
Investment Opp.	Average county income growth weighted by b's share of deposits in given county
$Z - Score$	Distance from default
Competitors' div.	Mean *Diversification* in a county weighted by share of total county branches (bank-year mean weighted by share of county for the bank)

Notes: This table reports definitions for the main bank-year variables of interest.

TABLE 2: SUMMARY STATISTICS (1976-2006)

	Single-county banks			Multi-county banks		
	Mean	Std	Obs	Mean	Std	Obs
Dependent variables:						
Liquidity	0.34	0.15	294,580	0.27	0.13	76,041
Loans	0.55	0.15	294,580	0.63	0.13	76,041
C&I Loans	0.32	0.21	294,109	0.23	0.16	73,520
Single-family mortgages	0.24	0.18	294,109	0.29	0.19	73,520
Other mortgages	0.20	0.14	294,109	0.27	0.17	73,520
Liquidity Creation	0.16	0.55	185,230	0.27	0.17	62,336
Diversification proxies:						
$Diversification$	0	0	298,067	0.39	0.22	77,127
Diversification Gain	0	0	291,915	0.003	0.003	72,983
Baseline controls:						
County volatility	4.26	3.87	291,915	2.76	2.27	72,983
Letters	0.003	0.015	296,700	0.005	0.011	76,018
Securitization Potential	0.10	0.11	298,073	0.18	0.11	77,130
Size	10.38	1.04	298,073	11.77	1.46	77,130
BHC	0.54	0.498	298,073	0.76	0.43	77,127
$Capital$	0.10	0.05	298,073	0.09	0.03	77,130
$Deposits$	0.87	0.08	298,073	0.85	0.08	77,130
$DepositCosts$	2.40	1.37	295,666	1.94	2.47	76,087
$Profitability$	0.49	1.05	296,532	0.5	0.47	76,565
$Competition$	23.58	15.69	298,073	22.43	12.14	77,130
Funding Opp.	4.19	21.82	289,130	3.44	13.71	72,441
Investment Opp.	0.75	1.88	289,130	0.79	1.28	72,441
$Z - Score$	2.21	0.75	279,305	2.13	0.56	75,228

Notes: This table reports summary statistics for the main bank-year variables of interest. The sample includes all US commercial banks from 1976 to 2006. Single-county banks are defined as banks with branches in a single county in a given year. Multi-county banks have are defined as banks with a branch in more than one county in a given year. "Mean" is the sample mean; "Std" is the sample standard deviation; "Obs" is the sample number of observations.

TABLE 3: LIQUIDITY BUFFER AND GEOGRAPHIC DIVERSIFICATION: OLS ESTIMATES (1976-2006)

	(1)	(2)	(3)	(4)	(5)	(6)
Diversification	-0.14***	-0.05***	-0.28***	-0.06***	-0.08**	-0.04***
	(0.004)	(0.005)	(0.025)	(0.008)	(0.012)	(0.01)
BHC Diversification					-0.02***	
					(0.003)	
Diversification Gain						-3.89***
						(0.61)
Diversification × Size			0.02***			
			(0.002)			
Diversification × BHC				0.02***		
				(0.01)		
Diversification × BHC Div.					0.08***	
					(0.02)	
Div. × Div. Gain						5.16***
						(1.17)
Bank-year controls	No	Yes	Yes	Yes	Yes	Yes
Bank FE	No	Yes	Yes	Yes	Yes	Yes
State-Year FE	No	Yes	Yes	Yes	Yes	Yes
Observations	367,629	330,994	330,994	330,994	199,024	328,497
R^2	0.031	0.68	0.68	0.68	0.70	0.68

Notes: This table reports the results of a bank-year level regression of *Liquidity* (marketable securities and federal funds over total assets) against *Diversification* (1-(sum of squared shares of a bank's total deposits held in given county)) and other controls. Bank-year controls included but not reported are: (Log) total assets, BHC dummy, capitalization, deposit funding, net income, competition, local deposit growth, local income growth, Z-score, competitors' diversification, letters of credit, and loan portfolio liquidity; see Table 1 for definitions. The sample includes all US commercial banks from 1976 to 2006. Standard errors are clustered by bank. T-statistics are reported in parentheses. *, ** and *** indicate significance at 10, 5 and 1%.

TABLE 4: LIQUIDITY BUFFER AND GEOGRAPHIC DIVERSIFICATION; IV ESTIMATES (1976-1993)

Panel A: County Branches Share and Distance from Headquarter	
	(1)
Log(Distance)	-2.12***
	(0.01)
Observations	7,947,028

Panel B: Liquidity Buffer and Branch Diversification				
	(1) OLS	(2) Reduced Form	(3) IV Stage 1	(4) IV Stage 2
Diversification	-0.015***			-0.38***
	(0.01)			(0.14)
Predicted Diversification		-2.40***	7.34***	
		(0.85)	(1.46)	
Bank-year controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	204,795	204,795	204,795	204,795
Kleibergen-Paap				19.84

Notes: Panel A reports the results of a fractional logit regression of the share of a bank's branches in a given county and year, on the log distance between a given county and the bank's home county. The sample includes all banks whose home state permits intrastate branching in a given year. Column 1 in Panel B reports the results from an OLS regression of *Liquidity* (marketable securities and federal funds as % total assets) on $Diversification$ (1-(sum of squared shares of a bank's total deposits held in given county)); Column 2 reports the results from an OLS regression of *Liquidity* on *Predicted Diversification* (the instrument for *Diversification* based on the interaction between distance from headquarters and intrastate branching regulation); Columns 3 and 4 report the results from the first and second stage of an IV regression of *Liquidity* on $Diversification$. Bank-year controls included but not reported are: (Log) total assets, BHC dummy, capitalization, deposit funding, net income, competition, local deposit growth, local income growth, Z-score, competitors' diversification, letters of credit, and loan portfolio securitization potential; see Table 1 for definitions. The sample includes all US commercial banks from 1976 to 1993. Standard errors are clustered by bank. T-statistics are reported in parentheses. *, ** and *** indicate significance at 10, 5 and 1%.

Table 5: Loans, Liquidity Creation and Geographic Diversification: OLS and IV Estimates

	OLS (1976-2006)	OLS (1976-1993)	IV (1976-1993)	OLS (1976-2006)	OLS (1976-1993)	IV (1976-1993)	OLS (1976-2006)	OLS (1976-1993)	IV (1976-1993)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:		Loans			C&I Loans			Single-family mortgages	
Diversification	0.03***	0.012**	0.48***	-0.04***	-0.03***	0.41**	0.15***	0.007**	-0.29***
	(0.005)	(0.005)	(0.002)	(0.005)	(0.005)	(0.16)	(0.003)	(0.003)	(0.10)
Observations	330994	204795	204795	330994	204795	204795	330994	204795	204795
R^2	0.68	0.72	0.04	0.82	0.87	0.12	0.93	0.71	0.59
	(10)	(11)	(12)	(13)	(14)	(15)			
Dependent variable:		Other mortgages			Liquidity Creation				
Diversification	0.009*	0.005	0.18	0.03***	0.02***	0.40***			
	(0.005)	(1.05)	(1.56)	(0.003)	(0.01)	(0.12)			
Observations	330994	204795	204795	234685	113070	112600			
R^2	0.77	0.71	0.26	0.92	0.92	0.26			

Notes: This table report the results of regressions of total loans (% total assets; columns 1-3) commercial and industrial loans (% total loans; columns 4-6), single-family mortgages (% total loans; columns 7-9), other (non-single family) mortgages (% total loans; columns 10-12), and net liquidity creation (1/2*(illiquid assets+liquid liabilities+illiquid guarantees)-1/2*(liquid assets+illiquid liabilites+equity-liquid guarantees-liquid derivatives); columns 13-15) on $Diversification$ (1-(sum of squared shares of a bank's total deposits held in given county)). Columns 1, 4, 7, and 10 report the results of OLS regressions for the 1976-2006 period. Columns 2, 5, 8, and 11 report the results of OLS regressions for the 1976-1993 period. Columns 3, 6, 9, and 12 report the results of IV regressions for the 1976-1993 period. Column 13 reports the results of an OLS regression for the 1984-2006 period; column 14 reports the results of an OLS regressions for the 1984-1993 period; column 15 reports the results of an IV regression for the 1984-1993 period. Bank-year controls included but not reported are: (Log) total assets, BHC dummy, capitalization, deposit funding, net income, competition, local deposit growth, local income growth, Z-score, competitors' diversification, letters of credit, and loan portfolio securitization potential; see Table 1 for definitions. Standard errors are clustered by bank. T-statistics are reported in parentheses. *, ** and *** indicate significance at 10, 5 and 1%.

TABLE 6: LIQUIDITY BUFFERS, DIVERSIFICATION, AND THE CRISIS (2006Q1-2009Q2)

	(1)	(2)	(3)	(4)
Panel A: Liquidity Buffers and Diversification				
Diversification	-0.02*	-0.037**	-0.036***	-0.034***
	(0.01)	(0.01)	(0.01)	(0.01)
Diversification × Crisis 1		0.007***	0.007***	0.007***
		(0.002)	(0.002)	(0.002)
Diversification × Crisis 2		0.011***	0.012***	0.011***
		(0.004)	(0.004)	(0.004)
Bank controls	Yes	Yes	Yes	Yes
Bank × Crisis controls			Yes	Yes
Additional Bank × Crisis controls				Yes
State-Quarter Fixed Effects	Yes	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes	Yes
Observations	82,213	82,213	82,213	82,213
R^2	0.91	0.91	0.91	0.91
Panel B: Loans and Diversification				
Diversification	0.10***	0.11***	0.11***	0.11***
	(0.016)	(0.016)	(0.016)	(0.016)
Diversification × Crisis 1		-0.01***	-0.006**	-0.005*
		(0.003)	(0.003)	(0.003)
Diversification × Crisis 2		-0.008**	-0.006	-0.005
		(0.004)	(0.004)	(0.004)
Bank controls	Yes	Yes	Yes	Yes
Bank × Crisis controls			Yes	Yes
Additional Bank × Crisis controls				Yes
State-Quarter Fixed Effects	Yes	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes	Yes
Observations	82,213	82,213	82,213	82,213
R^2	0.94	0.94	0.94	0.94

Notes: Panel A reports the results of bank-quarter-level OLS regressions of *Liquidity* (marketable securities and federal funds as % total assets) on *Diversification* (1-(sum of squared shares of a bank's total deposits held in given county)) and crisis dummies. Panel B reports the results of OLS regressions of bank loans (total loans as % total assets) on *Diversification* and crisis dummies. *Crisis 1* is 1 between 2007q3 and 2008q2, and 0 otherwise. *Crisis 2* is 1 between 2008q2 and and 2009q2, and 0 otherwise. Bank-year controls included but not reported are: (Log) total assets, BHC dummy, capitalization, deposit funding, net income, competition, local deposit growth, local income growth, Z-score, competitors' diversification, letters of credit, and loan portfolio securitization potential; see Table 1 for definitions. Bank x Crisis controls are the interaction between these controls and the two crisis dummies. Additional bank controls in column 4 are: reposessed real estates (% loans), core deposits (% total assets), return on equity, chargeoffs (% total assets). Additional Bank x Crisis controls are the interaction between these controls and the two crisis dummies. All banks active from 2006q1 to 2009q2 are included. Standard errors are clustered by bank. T-statistics are reported in parentheses. *, ** and *** indicate significance at 10, 5 and 1%.

A Robustness

Table 7 reports the main parameter of interest β_1 (the sensitivity of liquidity holdings to geographic diversification) obtained under different perturbations of the baseline OLS and IV models. The first row of the table reproduces the β_1 obtained in the baseline OLS and IV regressions to ease comparison.

I start by exploring three different diversification proxies. I first use *Diversification Gain* as an alternative to *Diversification* (see section 2.2 for measurement details). Both the OLS and IV results are negative and strongly significant. I then re-compute *Diversification* using the dispersion of bank branches across (i) zip codes and (ii) metropolitan statistical area, instead of counties. The OLS results remain the same. (I cannot run IV regressions because the instrument is specific to expansion across counties.)

A growing number of banks became affiliates of Bank-Holding Companies (BHCs) during the sample period. The baseline approach still considers individual banks, not BHCs, because banks must hold adequate liquidity and capital on a standalone basis and there are important restrictions to liquidity transfers across affiliates of the same BHC. This said, affiliates can receive some liquidity support from their parent (Houston et al., 1997; Ashcraft and Campello, 2007). I thus repeat the baseline regression at the BHC level. I do so by aggregating individual balance-sheet, income-statement and branching data by financial high holder and year. The findings are qualitatively similar, but the economic magnitude is somewhat smaller. The IV results remain comparable in terms of economic magnitude, but they are statistically insignificant. One explanation is that the instrument fails to account for out-of-state expansions; this is without consequences in bank-level regressions because banks hardly ever expanded out of their home state (see Figure 5). But this is not true for BHCs. Thus, the county-level instruments used in this paper are appropriate for a study of the average US commercial bank, whereas state-level instruments are appropriate for studies of the subset of public US banks, like that of Goetz et al. (2013).

Next, I check alternative samples of banks. I start by dropping all banks present in one county only. This removes the large number of banks for which $Diversification$ is equal to zero. Next, I drop the 1% largest bank every year. These two changes do not alter the OLS and IV results; the key conclusion is not driven by the smallest or largest banks. Finally, I cluster standard errors by state instead of banks. The OLS and IV results remain significant.

A.1 Year-by-Year OLS Regressions

The sample period has seen a number of important changes with potential impact on liquidity management, including the rise of securitization or the Basel I accord. This begs the question of whether the paper's main result is specific to a given period. To test this idea, I run the following cross-sectional variant of the baseline model:

$$Liquid_i = \alpha + \beta_1 \cdot Diversification_i + \beta_2 \cdot Controls_i + \epsilon_i. \tag{7}$$

separately for each year between 1976 and 2006 using OLS, clustering standard errors by state.

Figure 6 plots the β_1 obtained for each year, along with its 5% confidence intervals. The results show that the relationship between diversification and liquidity remains negative and significant for all but one year (1982). The link between diversification and liquidity is thus not specific to a particular period.

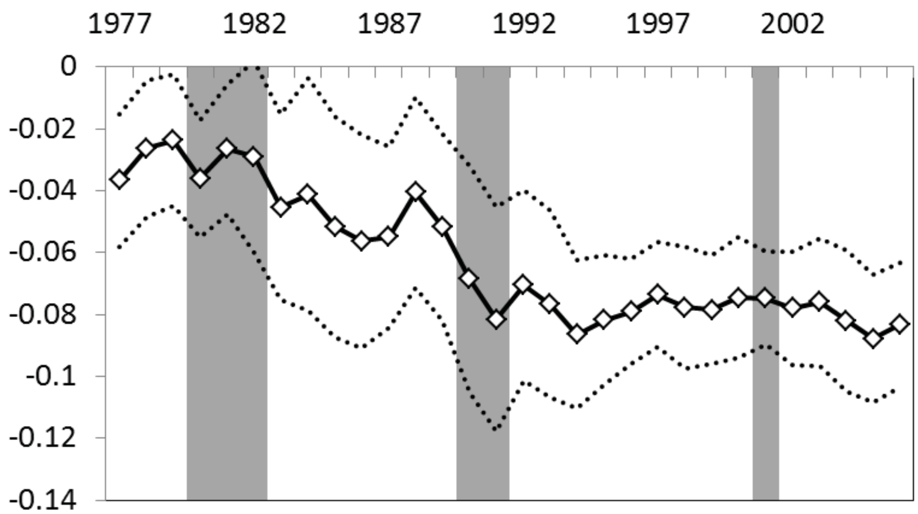

FIGURE 6: RELATIONSHIP BETWEEN DIVERSIFICATION AND LIQUIDITY BUFFERS. Solid line: parameter estimate of β_1 in an OLS year-by-year regression of: $Liquid_i = \alpha + \beta_1 \cdot Diversification_i + \beta_2 \cdot Controls_i + \epsilon_i$. Dashed lines: bottom and top 5% confidence intervals for β_1. Source: author's calculations based on Call Reports and Summary of Deposits data.

TABLE 7: LIQUIDITY BUFFER & GEOGRAPHIC DIVERSIFICATION: ROBUSTNESS CHECKS

	(1) β_1(OLS)	(2) β_1(IV)	(3) Observations (OLS)
Baseline	-0.045***	-0.38***	367,629
	(0.005)	(0.14)	
Diversification Gains as diversification proxy	-3.18***	-2.80***	367,629
	(1.11)	(0.36)	
Metropolitan Statistical Area diversification	-0.05***		338,186
	(0.005)		
Zip code diversification	-0.06***		338,186
	(0.004)		
BHC-level regression	-0.05***	-0.25	273,543
	(0.004)	(0.16)	
Drop single-county banks	-0.04***	-0.51**	66,264
	(0.008)	(0.24)	
Drop 1%-largest banks	-0.05***	-0.15***	328,163
	(0.005)	(0.05)	
State clustering	-0.05***	-0.38*	367,629
	(0.008)	(0.24)	

Notes: This table reports the results of OLS (column 1) and IV regressions (column 2) of bank liquidity buffer on geographic diversification as proxied by *Diversification*. The dependent variable *Liquidity* is defined as marketable securities and federal funds, as share of total assets. $Diversification$ is one minus the sum of squared shares (Herfindahl index) of a bank's total deposits held in given county. Bank-year controls included but not reported are: (Log) total assets, BHC dummy, capitalization, deposit funding, net income, competition, local deposit growth, local income growth, Z-score, competitors' diversification, letters of credit, and loan portfolio securitization potential; see Table 1 for definitions. The sample includes all US commercial banks from 1976 to 2006. Standard errors are clustered by bank. T-statistics are reported in parentheses. *, ** and *** indicate significance at 10, 5 and 1%.