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VENTURE CAPITAL AND STARTUP AGGLOMERATION

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ABSTRACT

The paper studies venture capital's role in the geographic clustering of high-growth startups. We exploit a rule change that disproportionately impacted U.S. regions that historically lacked VC financing via a restriction of banks to invest in the asset class. A one-standard-deviation increase in VCs' exposure to the rule led to an 18% decline in fund size and a 10% decrease in the likelihood of raising a follow-on fund. Startups were not wholly cushioned: financing and valuations declined. Startups also moved out of impacted states after the rule change, likely exacerbating existing geographic disparity in entrepreneurship.

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Data on banks investment in VC is available at https://github.com/michaelewens/Banks-In-VC

Entrepreneurship and innovation in the U.S. are geographically concentrated (Lerner, 2012; Chatterji, Glaeser, and Kerr, 2014; Chattergoon and Kerr, 2022). The concentration of entrepreneurial activities has important implications for economic performance and regional development and thus has also motivated many federal and local policies (Saxenian, 1994; Lerner, 2012). These policies include place-based programs, direct investments, grants, subsidized loans, education, and tax breaks (e.g., Chatterji et al., 2014). Effectively targeting these policy solutions demands a full accounting of the *drivers* of geographic concentration. While various explanations, including knowledge spillovers (e.g., Marshall, 1890; Jaffe, Trajtenberg, and Henderson, 1993), labor market pooling (e.g., Saxenian, 1994; Helsley and Strange, 2002), have been studied, one that remains under-explored is the availability of entrepreneurial finance. This paper investigates the role of the supply of risk capital – as measured by venture capital (VC) – in driving the spatial concentration of high-growth entrepreneurship in the U.S.

VC investors and their investment activity exhibit similar concentration as entrepreneurial firms. For example, VC funds based in California (CA), Massachusetts (MA), and New York (NY) accounted for 92% of the capital raised in the U.S. in 2018, and startups in these three states received 79% of the total venture capital invested in the same year (NVCA, 2019). Anecdotal evidence suggests that the lack of early-stage funding outside the significant capital clusters plays a part in explaining financing constraints faced by high-growth startups in those regions and has led to valuable investment opportunities unfunded.[1] However, identifying risk capital supply's role in explaining the agglomeration of high-growth startups is challenging. With strong preferences to invest locally (Chen, Gompers, Kovner, and Lerner, 2010), venture capital investors could concentrate in regions simply because they follow capital demand, i.e., they invest where the startups locate.

Uncovering the role of the venture capital supply in startup clustering requires exploring

[1] See, e.g., `https://hbr.org/2013/10/dont-build-your-startup-outside-of-silicon-valley`

how the capital is intermediated. As the primary financiers of innovative startups, VCs invest on behalf of institutional investors (i.e., limited partners or LPs) from which they raise capital. This financial intermediation implies that VCs' own investors could influence capital supply and its geographic allocation. Specifically, as documented by prior literature and confirmed by our analyses below, different types of limited partners are unequally distributed across the U.S. while exhibiting varying home bias (e.g., Hochberg and Rauh, 2013). These facts demonstrate a channel where some types of LPs are restricted in supplying capital to VCs, which can negatively affect VCs across regions. These restrictions, in turn, can impact startup financing constraints by geographies and, ultimately, the regional inequality in startup distribution. Importantly, this channel only exists if either LP capital or VC fails to move freely across geographies.

Connecting local capital supply to startup clustering requires an experiment that randomizes the former across regions while allowing one to track startups' capital raising and mobility choices across regional clusters. Because we are interested in some regions' persistent under-representation in high-growth entrepreneurship and innovation, this exogenous variation should also impact capital in high-financing constraint geographies (i.e., those outside the major capital centers). This experiment would allow the identification of the role of capital in explaining this under-representation. One potential source for such variation follows from the nature of VC financial intermediation: changes in the supply of their limited partners. Indeed, an extensive literature uses shifts in capital available from pension funds to explore the causal effects of changes to local VC financing (e.g., Kortum and Lerner, 2000; González-Uribe, 2020). Similarly, we approximate the ideal experiment by exploiting a 2013 legal change that restricted a narrow set of limited partners predominantly outside the VC financing clusters.

What might happen to VC fundraising and startup financing in the face of restrictions on LP capital? In a frictionless external finance market, VCs would find substitutes for the lost LPs, and researchers would observe no change in VC fundraising and startup financing. Recent experiences suggest this is a sensible prior, as VC and private equity (PE) fundraising have experienced significant growth in the last twenty years, while deregulation of the private markets has accelerated (Ewens and Farre-Mensa, 2020). Alternatively, VC fundraising in certain regions or industries may be constrained. First, LP investing exhibits home bias, and restricting LPs could negatively impact local VCs based in the same regions. Next, a market focus on established funds may also lead to constraints for some VCs. For example, though the total capital VCs raised has grown significantly in the past decade, only less than 20% went to first-time VC funds.[2] Finally, several papers (e.g., Kortum and Lerner, 2000; González-Uribe, 2020) explore the impact of VC investment or fund size. These studies' instrumental variable strategies rely on a VC fundraising channel where LPs become less (more) willing to invest in VC funds, implicitly assuming that VCs may be financially constrained. For these reasons, VCs could be constrained. A decrease in LPs investing in VC would worsen VCs' fundraising ability and startups' access to capital.

We test these hypotheses using a change in U.S. banking regulation from the Volcker Rule. Considered a legal overreach by many, the Volcker Rule (implemented in 2014 and effectively ended in mid-2019) prohibited banks and their affiliates from investing in or sponsoring venture capital funds.[3] As shown by Lerner, Schoar, and Wongsunwai (2007) and confirmed using Consolidated Reports of Condition and Income (i.e., Call Reports), banks as LPs are important sources of capital, providing between 4-8% of capital to VC funds in the years before the Volcker Rule passage. Based on administrative data reported by banks, our estimates find a significant variation in states' reliance on banks for the supply of capital before the Volcker Rule. Banks in Midwestern states provided as much as 30%

[2] Pitchbook-NVCA 2020 Q4 report.

[3] Small community banks (with less than $10 billion in assets and total trading assets and liabilities of no more than 5% of total consolidated assets) were exempt from the relevant sections of the rule after July 2019. The section was rescinded in October 2020.

of capital to VC funds, while banks provided less than 1% of capital in the VC hub states such as CA. This differential reliance translates into unequal exposure to the Volcker Rule's impact by state. Indeed, the lobbying arm of the venture capital industry, the NVCA, argues for just this view[4]:

> The loss of banking entities as limited partners in VC funds has had a disproportionate impact on cities and regions with emerging entrepreneurial ecosystems – areas outside of Silicon Valley and other traditional technology centers. The more challenging reality of venture fundraising in these areas of the country tends to require investment from a more diverse set of limited partners.

Although not an explicit part of the Rule, the law thus has the potential to impact the high-financing constraints area from our idealized experiment. We confirm that the rule change had the intended impact on banks' investments in VC. The fraction of banks holding VC investments decreased by about 40% from 2013 to 2018 after the Volcker Rule change.

Our empirical strategy first exploits the fact that the rule change unintentionally impacts regions of the U.S. differently depending on banks' roles as LPs. We first document that VCs in the Midwestern, Southern, and non-VC-hub states had higher bank exposure than other states before the Volcker Rule change. Next, differential exposure to the rule change based on bank LP activity will only manifest itself in VCs' fundraising when we incorporate one other well-documented fact: home bias by limited partners. Hochberg and Rauh (2013) and subsequent papers using LP supply shocks as instruments (e.g., González-Uribe, 2020) show that the largest LP class in the VC industry– pension funds – exhibits an abnormal propensity to invest in same-state VC funds. A similar analysis also indicates that other major LP types, including banks, have significant in-state overweighting in investing in VC funds. Suppose the Volcker Rule change was unexpected and the pre-2014 distribution of banks as LPs was not experiencing differential trends across regions. In that case, we can

[4] NVCA letter to federal regulators "Proposed Revisions to Prohibitions and Restrictions on Proprietary Trading and Certain Interests in, and Relationships With, Hedge Funds and Private Equity Fund", April 2020.

interpret our difference-in-differences coefficient estimates as causal.

Our analysis combines two datasets for the 2010–2018 sample period. The Call Reports form the basis of our data on banks' exposure to VC funds. Although we cannot directly observe a specific bank's position in a VC fund, these reports include "venture capital revenue," which consists of market value adjustments, gains, and losses on banks' venture capital investments. Two hundred thirty-one unique banks have reported venture capital revenue in 42 states from 2001 (the first year Call Reports data are available) to 2013 (the last year before the Volcker Rule change). We aggregate the data at the state level to create the primary bank exposure variable. VentureSource (formerly owned by Dow Jones, now CB Insights) and Pitchbook provide data on venture capital fundraising, startup financing, and other startup outcomes. The final sample includes 1,617 VC funds and 12,788 startups.

VC funding changes in several ways in states more exposed to the rule change. Two extensive margins exhibit declines: the number of VC funds closed and the probability that a pre-Volcker VC raised a follow-on fund. On the intensive margin, we find that total VC fund raised in the state-year falls, while funds that do successfully close are smaller (a one standard deviation increase in VCs' exposure to the loss of banks as LPs leads to an 18% decline in fund size). These results show that the treated VCs – those headquartered outside the major VC centers – faced financial constraints and that these VCs struggled to find alternative limited partners after the passage of the Volcker Rule. The declines also speak to a point raised in the last report on the Volcker Rule (Federal Register, 2014):[5]

> To the extent that banking entities may reduce their investments in venture capital funds that are covered funds, the potential funding gap for venture capital funds may also be offset, in whole or in part, by investments from firms that are not banking entities and thus not subject to section 13's restrictions.

Consistent with the comments cited in the report, our results show that VC funds in the impacted states found their "funding gap" only filled "in part".

[5] See Federal Register, Vol. 79, No. 21 January 31, 2014, Book 2 of 2, Pages 5535–6076.

We next investigate whether VC financing constraints spillover to local high-growth startups. In a world with perfect substitutes, entrepreneurs can supplement lower capital availability in a state-year with alternatives such as friends and family financing, angels, bank debt, government grants, or other private equity. However, if these capital sources are instead complementary to VC or already exhausted pre-2014, then the decline in VC will be unfilled. We find that startups raise 7% smaller financing rounds and they are more likely to raise capital before VC financing. Financed startups also have 7% lower pre-money valuations with no change in VC equity stakes. Thus, firm valuations fall with both financier and founder suffering value loss. The changes in valuation mirror the findings in Gompers and Lerner (2000), who show that VC inflows create demand pressure and valuation changes. These results indicate that VC financing constraints manifest as worse financing conditions for local startups and change the composition of financed startups.

The fact that startups suffer from the smaller local VC market (in terms of fundraising and valuations) suggests that non-local VCs are not filling the financing gap. One explanation for this behavior is information asymmetry. Here, when investors consider a geographically distant startup investment, they require a local VCs' informational advantage about the investment opportunity. Consistent with this hypothesis, we show that the larger the distance between a VC and a startup in its portfolio, the more likely the investment includes a local VC investor. Thus, startups faced with a depleted local VC supply after the Volcker Rule cannot simply rely on distant (untreated) VCs to fill the gap. One potential solution for affected startups is to move to the capital supply.

Our final analysis asks whether decreases in the supply of local VC funding impact high-growth startups' location choices. If so, we will have documented a channel – local VC funding constraints – for startup clustering. Any shifts after the Volcker Rule would thus exacerbate the agglomeration of U.S. high-growth startups. We find evidence that startups respond in this way. Using federal filings for securities exemption (Form Ds) data to track address changes, we follow startups before and after the rule change. Among startups five years or younger that move to California, the probability that they originate from one of the treated states with high bank exposure increases by about 60% after the passage of the Volcker Rule. After the rule change, a difference-in-differences estimation reveals that startups in high-exposure states are relatively more likely to move to VC hubs, including CA, MA, and NY. These mobility results show that the rule change impacted the allocation of startups across states. Importantly, these results also suggest that the supply of venture capital explains some of the observed startup agglomeration.

Our paper first contributes to the financial constraints, entrepreneurship, and venture capital literature. We extend the results on financial intermediary constraints in banking (e.g., Paravisini, 2008; Khwaja and Mian, 2008; Gilje, 2019), showing that despite the differences in the external financing market faced by VCs, these intermediaries face similar issues. Next, Kerr and Nanda (2009) find that bank deregulation and competition matters for high-growth startups, while banks often play a direct role in financing startups (Hellmann, Lindsey, and Puri, 2008). We show that banks' importance for startups also follows their support of startups' funders.

Our analysis also provides new evidence for the agglomeration of venture capital and entrepreneurship (e.g., Chen et al., 2010; Guzman, 2019) that guides policymaking (Lanahan and Feldman, 2015). Specifically, we document that venture capital fundraising and investments concentrate by states and regions. Complementing existing studies on the drivers of startup agglomeration (e.g., Chatterji et al., 2014), our work highlights the role of venture capital in driving high-growth entrepreneurship.

Last, we contribute to a literature that uses shocks to LPs or differences in LP commitments to explore the causal effects of VC financing. Nanda and Rhodes-Kropf (2013), Bernstein, Lerner, Sorensen, and Strömberg (2017), González-Uribe (2020), Ewens and Farre-Mensa (2020) and Kortum and Lerner (2000) each use this variation as a mechanism to understand the impact of VC on innovation, startup characteristics, knowledge sharing, and founder bargaining power. These papers argue that changes in LP supply or composition will first impact VC fundraising and ultimately, portfolio company outcomes such as the number of financings or their valuations. We take this first assumption head on, confirming the assumption in these identification strategies with our results showing VC constraints.

1 Data and Institutional Background

1.1 Data

1.1.1 Bank data

We use data collected from banks' Consolidated Reports of Condition and Income (i.e., Call Reports) to identify banks' engagement in VC investments. In 2001, *venture capital revenue* (or VC revenue) was added as a new category of non-interest income on the Schedule RI-Income statement of banks' Call Reports following the change of information collection made by the Federal Financial Institutions Examination Council (FFIEC). Since then, all U.S. banks have been reporting VC revenue on their Call Reports in each quarter.[6] According to the FFIEC, the reported VC revenue mainly includes market value adjustments, interest, dividends, gains, and losses on banks' VC investments, any fee income from VC activities, and the proportionate share of the income or loss from their investments in equity method investees such as VC funds. See Internet Appendix A for a detailed discussion on what constitutes VC revenue for different types of VC events and the data repository for the data used in the paper.

[6] This set of banks includes U.S. national banks, state member banks, and insured state nonmember commercial and savings banks.

1.1.2 Venture capital data

The commercial data provider VentureSource (formerly owned by Dow Jones, now CB Insights) provides information on venture capital financings, investors, and entrepreneurial firms.[7] A financing event – and thus its investors and startup – is included in the database if at least one of the investors is labeled as a venture capital firm. For our main analyses, we focus on the sample period of 2010–2018 around the implementation of the Volcker Rule in 2014. We start our sample from 2010 to avoid any overlap with the 2008 financial crisis (see relevant discussion below), and end our sample at 2018 because the rule's removal began in July 2019. In the VC fund analysis, we focus on VC funds with vintage year between 2010 and 2018. Because some less-populated U.S. states such as Montana and Wyoming have no VC activity or VC fundraising over the four-year period prior to the implementation of Volcker Rule (2010–2013), we exclude these states from all our analyses. The final sample includes 1,617 VC funds in 35 states. In our VC-backed startup analysis, we include the first round of VC funding, either a seed or Series A round that occurred between 2010 and 2018. We exclude financings greater than $100 million from our startup sample as they are more likely to involve non-VC-backed startups. Our focus is thus on first, early-stage financings of startups between 2010 and 2018. The final startup sample includes 12,788 entrepreneurial firms.

1.2 Volcker Rule and banks' VC investments

In the aftermath of the 2008 financial crisis, the Dodd-Frank Wall Street Reform and Consumer Protection Act (or the Dodd–Frank Act) was enacted to regulate the financial industry and prevent future financial crises. As part of the Dodd-Frank Act, the Volcker Rule

[7] The coverage of financing rounds is extremely comprehensive in VentureSource, particularly so during our period of analysis, because Form D filings were available on the SEC website since 2002, making it much easier for data providers to collect comprehensive information.

statute aims to protect bank customers by preventing banks from making certain types of speculative investments that are considered to have contributed to the 2008 financial crisis. The rule specifically prohibits banks and their affiliates from investing in or sponsoring a "hedge fund or a private equity fund" – referred to collectively as "covered funds".

After a long delay, U.S. financial services regulators eventually approved the final Volcker Rule on December 10, 2013.[8] Despite initial expressions of Congressional intent that VC funds should be excluded from covered funds,[9] the final implementation of the rule adopted a broad definition of covered funds. Except for a few exclusions and additions determined by the agencies, the definition includes any issuer that would be an investment company as defined in the Investment Company Act of 1940 but for sections 3(c)(1) or 3(c)(7) of that Act. Because all active VC funds use either the 3(c)(1) or 3(c)(7) exemption to avoid having to register and comply with the Investment Company Act's requirements, the adopted definition of "covered funds" includes VC funds in its category thus subjecting them to the restriction of the Volcker Rule.

Although prohibited from engaging in VC fund activities by the Volcker Rule, banks and their affiliates have long been making VC investments in the U.S. (Hellmann et al., 2008). Prior to the passage of the Gramm-Leach-Bliley Act in November 1999, banks usually make private investments through two loopholes. First, the Small Business Act of 1958 authorizes banks and bank holding companies to own and operate "Small Business Investment Corporations" (SBICs) as their wholly owned subsidiaries to make equity investments. Second, Section 4(c)(6) of the Bank Holding Company Act of 1956 allows banks to make

[8] The relevant regulators are the Office of the Comptroller of the Currency, the Board of Governors of the Federal Reserve System, the Federal Deposit Insurance Corporation, the U.S. Securities and Exchange Commission, and the U.S. Commodity Futures Trading Commission. See the news release of final rules at: `https://www.sec.gov/news/press-release/2013-258`.

[9] For example, Senator Chris Dodd (D-CT), one of the authors and namesakes of the Dodd-Frank Act states: "...properly conducted venture capital investment will not cause the harms at which the Volcker Rule is directed. In the event that properly conducted venture capital investment is excessively restricted by the provisions of section 619, I would expect the appropriate Federal regulators to exempt it using their authority under section 619(J)."

VC investments at the bank holding company level, including either direct equity investments in portfolio companies, as long as their position does not exceed more than 5% of the outstanding voting equity or indirect investments through limited partnerships.[10] The Gramm-Leach-Bliley Act of 1999 repealed part of the Glass-Steagall Act of 1933, further relaxing constraints on banks' ability to invest in VC.

Prohibiting banks from continuing to invest in VC created an unintended challenge for the VC industry. In contrast to the other asset classes covered by the rule, VC funds typically make illiquid and long-term equity investments into startups and work alongside them to build successful companies. This asset class therefore does not generate the excessive risk typically associated with proprietary trading which the Volcker Rule aims to eliminate.[11] Therefore, many practitioners argue that pooling VC funds with private equity and hedge funds, which bars banks from investing in VC funds, is a legal overreach on the part of financial regulators; it may also go against congressional intent.[12]

Using banks' VC revenue information, we show in Figure 1 that the number of banks with any VC revenue drops sharply by more than 50% following the implementation of the Volcker Rule.[13] In Figure IB.1, we further plot the number and fraction of banks with negative VC revenue and find a temporary and immediate increase after the implementation of the Volcker Rule. This finding suggests that some banks may have chosen to sell their

[10] The reported VC revenue in Call Reports could come from both banks' direct investments in VC-backed startups and also indirect investments through VC funds, where only the second type of VC investments are impacted by the Volcker Rule. Unfortunately, the data do not allow us to separate the two types of VC investments. Under the assumption that banks' investment strategies for the two types of investments do not vary systematically across states, the reported VC revenue is able to reflect the correct sorting of states in terms of their reliance on banks for the supply of capital through VC funds.

[11] VC funds are also different in other dimensions. For instance, they have limited use of leverage compared to buyout funds. The VC industry, with approximately $450 billion under management in 2019 (NVCA, 2020), is also far smaller than other asset classes such as hedge funds.

[12] See e.g. NVCA letter to federal regulators "Re: Proposed Revisions to Prohibitions and Restrictions on Proprietary Trading and Certain Interests in, and Relationships with, Hedge Funds and Private Equity Funds", October 17, 2018.

[13] The number of banks with VC revenue did not drop to 0 after the Volcker Rule because some banks may still use loopholes such as SBICs to invest in VC as discussed in Subsection 1.2.

investment positions in VC funds at a loss after the implementation of the Volcker Rule. These results imply that banks' investing through VC funds as LPs is the main channel through which banks engage in VC investment activity.

2 Estimation Strategies

2.1 The importance of banks for VCs

Prior to the Volcker Rule, banks were an important source of capital for the VC industry.[14] Using VC revenue reported in Call Reports, we can estimate banks' investment position in VC and their capital share in total VC funds raised. For a given group of U.S. states, we first estimate the aggregate of banks' net profits in VC investments (the difference between positive and negative VC revenue) in each year and then back out banks' investment position in VCs in a given year from their net profits by assuming a fixed annual return of 5%.[15] We then scale this estimated bank investment position by the aggregate of venture capital raised over a fixed window in the past (e.g., five years) to arrive at banks' capital share at a given year. The VC industry is highly cyclical (see e.g. Gompers, Kovner, Lerner, and Scharfstein, 2008), so we perform this estimation only when banks' estimated profits are positive.[16] Specifically, we estimate banks' investment position in VC and their capital share in total venture capital raised in each year over 2005–2007, a relatively stable period between two economic crises. Last, we average our estimates over these three years to derive a less noisy measure of banks' investment position in VC and their capital share in total venture capital raised. The estimation, reported in Table 1, suggests that banks had an annual investment

[14] Banks' involvement in VC is not random, Table IB.1 shows that the average bank engaging in VC investments is 40 times larger than an average bank that is not involved in VC investments.

[15] Our results remain robust if we use a similar annual return below 20%.

[16] It is possible to back out banks' investment position from investment profits only when the (estimated) profits, either positive or negative, are significantly different from zero. Therefore, our estimation does not rely on the specific sign of the profits.

position of about $10 billion in the VC industry (the first column), constituting about 7% of all venture capital raised in the U.S. (the third column) prior to the Volcker Rule. Our estimates are consistent with several other sources. For example, using a large dataset from an earlier period (1991–1998), Lerner et al. (2007) find that banking and finance companies represent the sixth largest investor class in PE and VC funds, accounting for about 4% of all LP investors in VC funds and 8% of all LP investors in both PE and VC funds.[17] Additionally, a Preqin Special Report released prior to the Volcker Rule documents that banks account for about 8% of the total capital invested in private equity, making them the fifth most significant investor type.[18] Overall, these estimates show clearly that banks provided meaningful capital to the VC industry prior to the Volcker Rule and that the Call Reports are an ideal primary source for our analysis.

2.2 Construction of the treatment variable

Our goal is to create a variable that approximates the relative exposure of a VC firm or fund to the Volcker Rule change. We use the differences across states in local banks' investing in VCs prior to the Volcker Rule as our proxy.[19] Banks in different regions vary by their size and survival time (see Table IB.1). In addition, it takes time to observe banks' VC revenue after they make VC investments. To better capture the stable capital flow from banks to VC funds over time in a given state, we first aggregate the number of bank-years with VC revenue over the period 2001–2013. We then scale this number by the number of VC funds raised over the same period in the state to construct our state-level measure of VC funds'

[17] These estimates are likely underestimates because the data came before the Gramm-Leach-Bliley Act, which further relaxed constraints on banks' ability to invest in VC.

[18] See "Preqin Special Report: Banks as Investors in Private Equity", 2012.

[19] We do not observe the composition of banks' within- vs. out-of-state VC investments. As long as the relative fraction is constant across states, our measure is able to capture variation in local VCs' bank exposure. However, it could be the case that banks in states with low VCs are more likely to invest in out-of-state VC funds due to limited local investment opportunities. In this case, the true bank exposure is lower than our measure, and the true coefficient would be larger than what our estimation suggests.

bank exposure prior to the implementation of the Volcker Rule – "Bank Expo". Although the Volcker Rule took time to implement, as shown in Figure 1, there is no evidence that banks or the VC industry anticipated the change nor that they adjusted their allocations in advance of the change. Therefore, the "Bank Expo" variable we construct is plausibly exogenous, and we use it as the main treatment variable in our diff-in-diff analyses throughout the paper. Based on this continuous measure, we also construct a binary treatment variable for use in some additional tests: "High Expo", a dummy variable indicating whether a state's bank exposure is above the sample median among all states in our sample. The first two columns of Table 2 present these measures by state.

The bank exposure variable captures the intended variation. First, using the same approach as in Subsection 2.1, we estimate banks' capital share in total VC funds raised for the group of states with high bank exposure and the group of states with low bank exposure. We find that banks' capital share in total VC funds raised is much higher in the high bank exposure group than in the low bank exposure group, regardless of how we scale bank capital to derive banks' capital share (Table 1). Second, we correlate the bank exposure variable with state-level attributes, including GDP growth and GDP per capita, and find no correlation, suggesting that states with different bank exposure do not differ significantly in other economic conditions that are not directly related to VCs (Figure IB.2).[20]

2.3 The high bank exposure of VCs based in non-VC hubs

We next examine variation in VCs' bank exposure across the U.S. First, we find that VCs' bank exposure differs significantly across regions. Specifically, Panel A of Figure 2 shows that the Midwest and South have higher bank exposure than other regions prior to

[20] In unreported results, we also correlate the bank exposure variable with more state-level attributes that are commonly used in the literature (e.g., Gompers and Lerner, 1998). These include state capital gain tax rate, per capita state/academic R&D expenditure, and education (percent of adults completing some college or associate's degree), and we find weak or no correlation.

the Volcker Rule, despite the fact that these regions have a small VC industry presence (Figure IB.3). Similarly, non-coastal states typically have higher bank exposure than the coastal states (Figure 2 Panel B). Second, we find that states outside traditional VC hubs have much higher bank exposure, while traditional VC hubs such as the top three VC states (CA, MA and NY) all rely little on banks for capital and have very low bank exposure (Table 2).

We also formally estimate the relation between VCs' bank exposure and the size of a local VC market. We define a VC "imbalance" measure at the state level and correlate it with the bank exposure variable. Specifically, imbalance measures the relative ratio in VC activity per capita in a given state over the VC activity per capita in the U.S. in each year averaged over 2001–2013 (Klein, 2018). We compute the VC imbalance measure for three activities: the number of VC funds and amount of venture capital raised and the number of startups funded by VCs (columns (3) - (5) of Table 2). Regardless of how we measure VC activity, we find a robust negative correlation of about -0.3 between the imbalance measure and the bank exposure variable (also see a plot in Figure 3).[21] These results confirm that states with small VC markets relative to their size have higher bank exposure pre-Volcker Rule. In addition, we also compute VC imbalance at the region-year level, and find that regions with high bank exposure (i.e., Midwest and South) have historically low VC development (Table 2). The negative correlation between the development of a local VC market and our treatment variable (i.e., VCs' bank exposure prior to the Volcker Rule) is a key feature of our empirical setting, and underpins our analysis of the relation between the supply of venture capital and startup clustering.

[21] To better understand how our bank exposure variable correlates with state VC market, we also compute state-level imbalance measures based on the distribution of LPs (both all LPs and the largest LP type – pension funds), patents and high-skill employment, and report them in columns (6)-(9) of Table 2.

2.4 Estimation strategy

Given the regional differences in banks' involvement in VC and LPs' tendency to invest in local VC funds, we expect that the implementation of the Volcker Rule differentially impacts VCs across U.S. states. Hochberg and Rauh (2013) show that institutional LP investors such as public pension funds exhibit substantial home-state bias in private equity investments and that the home-state bias is greater in VC funds than in buyout funds. Confirming their findings, we show that banks also exhibit a strong home-state bias in investing in VC funds (see Table 6 Panel A and more discussion below). It has also been well documented that VC investors invest locally (see e.g., Chen et al., 2010). Therefore, we expect home bias of both LPs and VCs to interact with regional variation in banks as LPs to generate regional differences by bank exposure to the Volcker Rule.

We exploit this cross-sectional heterogeneity in VCs' bank exposure across states to identify the impact of the Volcker Rule on VC fundraising, startup financing, and startup location choice. Our estimation strategy is a standard difference-in-differences (or diff-in-diff) regression. Given the timing of the implementation of the Volcker Rule, our analysis compares the outcomes of interest between 2010–2013 with that between 2014–2018.[22] Estimations have different units of analysis including state-year, VC fund, and VC-backed startup level. In these analyses, our regression framework takes similar forms. Using the analysis of startup financing as an example, we conduct the following estimation:

$$Y_{it} = \beta_1 Bank\,Expo_i * Post_t + \beta_2 X_i + \gamma_t + \epsilon_{it} \tag{1}$$

where X_i are entrepreneurial firm characteristics at the time of the investment, including

[22] As argued by Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018), it is difficult to point to a single date when the effects of the Volcker Rule became binding. Though the Volcker Rule became effective on April 1, 2014, the final rules to implement it were released on December 10, 2013, which then made clear the prohibition of banks from investing in VC funds. Conducting all our analyses at the year level, we choose 2014 as the beginning of the "Volcker period". This is also consistent with existing literature studying the Volcker Rule (see e.g. Bao, O'Hara, and Zhou, 2018; Bessembinder et al., 2018).

state fixed effects, industry group fixed effects, Series A or Seed round fixed effects, and startup age fixed effects; γ_t are year fixed effects corresponding to the year of investment. The main coefficient of interest (β_1) is the interaction between "Bank Expo" and "Post" (equal to one for 2014 on).

As mentioned earlier, we use the continuous treatment variable "Bank Expo" as our main treatment variable. The continuous variable captures a richer cross-state variation in VCs' bank exposure than a binary alternative. For example, Arkansas has bank exposure almost fifty times as high as Alabama, but both would be assigned the same high bank exposure group (see Table 2). On the other hand, Alabama has very similar bank exposure to Virginia, but they would be assigned different bank exposure groups.

As with any difference-in-differences estimation strategy, our key identifying assumption is parallel trends – that is, the states with low bank exposure provide an appropriate counterfactual for what would have happened to the states with high bank exposure had they not been negatively impacted by the Volcker Rule. While the parallel trends assumption cannot be tested, we aim to validate it in several ways. First, in our main analyses (see Table 4 Panel C), we show in dynamic specifications that there is no evidence of pre-trends for VC fundraising activity across states over time, and the timing of the drop in the aggregate of VC fundraising activity is consistent with the implementation of the Volcker Rule. Second, in Figure 4, we show that the number of VC funds in states with high bank exposure evolves similarly to that in states with low bank exposure over the pre-Volcker Rule period (2010–2013). Only after the implementation of the Volcker Rule does the trend diverge. This provides further support for the parallel trends assumption.

Our identification also assumes that no other change in 2014 impacted VC activity across the states in precisely the same way as we have identified through bank exposure. One such potential channel is the 2008 financial crisis. We thus start our sample from 2010 to avoid any overlap with the financial crisis period. This approach also follows Ewens, Nanda, and

Rhodes-Kropf (2018) who show that the impact of the financial crisis on the VC industry was mostly confined to 2009.[23] Additionally, in all of our main diff-in-diff analyses, we conduct tests over a narrower period between 2011 and 2017, and find similar results.[24] Finally, all specifications include year fixed effects. Thus, alternative explanations must include a reason why states experienced differential impacts in the manner that we document.

3 Impact on VC Fundraising Activity

We first document that the implementation of the Volcker Rule negatively impacts VC fundraising activity, suggesting that the VC funding gap left by the loss of banks as LPs is not fully filled by other types of LPs.

3.1 Aggregate of VC fundraising activity

First, we provide descriptive evidence of the impact of the Volcker Rule on VC fundraising activity by calculating the number of newly raised VC funds in the high-exposure and low-exposure states over the 2010–2018 period. Figure 4 shows a marked difference in the number of newly raised VC funds across the two groups of states in the post-Volcker period, while they evolve similarly prior to the rule change. This result suggests a sharp shift in VC fundraising activity depending on the states' bank exposure prior to the implementation of the Volcker Rule.

We next test for the change in VC fundraising activity in the regression context of Eq. (1) using state-year observations over the 2010–2018 period. We measure VC fundraising activity using the number of VC funds and the dollar amount of venture capital raised in

[23] Ewens et al. (2018) document that while there was a 25% drop in the number of venture deals from 2008 to 2009, deal volume actually increased from 15% from 2009 to 2010.

[24] In Panel A of Table IB.3, we focus on just the two-year period of 2013–2014 and still find that the number of VC funds, especially small VC funds, falls post-Volcker Rule in states that are more impacted by the rule change.

a given state-year (see related summary statistics in Table 3). Panel A of Table 4 reports the estimation results. Columns (1) - (4) have the natural log of one plus the number of VC funds raised as the dependent variable, while columns (5) - (8) have the natural log of one plus the aggregate amount of venture capital raised as the dependent variable. For each dependent variable, the first column includes state and year fixed effects, the second column adds time-varying, state-year level controls,[25] the third column excludes the state of California from our sample, and the fourth column focuses on a narrower sample period of 2011–2017 around the Volcker Rule passage.

Panel A of Table 4 shows that there is a significant decrease in the number of VC funds and total venture capital raised after the Volcker Rule in states with higher bank exposure compared to states with lower exposure. The estimates in columns (2) and (6) suggest a one standard deviation increase in bank exposure leads to about 12% fewer VC funds and 8% less total venture capital raised in the state after the implementation of the Volcker Rule.[26] This drop also represents about 0.6 VC funds and $56 million in a state per year. The estimates in Panel A of Table 4 also show that our baseline results are robust to the exclusion of CA-based VC funds, which account for about 45% of all U.S. VC funds (see columns (3) and (7)). Lastly, our results are also robust to the restriction to a shorter sample period 2011–2017 around the implementation of the Volcker Rule in 2014 (see columns (4) and (8)). This suggests that our baseline results are also not driven by the years either at the beginning or the end of our sample period. These results are robust to our treatment of the

[25] Following Gompers and Lerner (1998), we control for lagged state GDP growth and log of state GDP per capita.

[26] To calculate the percentage change in the outcome variable of interest, e.g., the number of VC funds raised, consider the regression: $Ln(1 + Y) = a + bX + u$. For each unit of change in X, the change in Y, ΔY, approximately satisfies $(1 + Y + \Delta Y)/(1 + Y) = \exp(b)$. Solving the equation yields $\Delta Y/Y = [\exp(b) - 1](1 + 1/Y)$. Thus, for each unit change in X, Y changes by $100 * [\exp(b) - 1](1 + 1/Y)$ percent. Further assume the standard deviation of X is σ, then a one standard deviation change in X corresponds to the changes in Y by $\sigma * 100 * [\exp(b) - 1](1 + 1/Y)$ percent. In our setting, the standard deviation of our treatment variable "Bank Expo" is different across the regression samples due to different units of observation (Table 3), and we use the regression-specific variation whenever reporting magnitudes.

count dependent variable (e.g, use of Poisson or inverse hyperbolic in Table 4 Panel B) and a log transformation of the treatment variable (columns (3) and (4) of Table 4 Panel B).[27] Overall, the state-year level regression results show that the implementation of the Volcker Rule has a significant and direct impact on the supply of venture capital.

As discussed earlier, the diff-in-diff framework requires the parallel trends assumption to make causal inferences. Because the assumption is not directly testable, researchers usually inspect the pre-treatment outcome-variable trends of the treated and control groups to determine whether this assumption is empirically violated. We examine pre-treatment trends of the outcome variables using the estimation of a dynamic version of Eq. (1). Specifically, we replace the single interaction variable in Eq. (1) with a set of interaction variables between the bank exposure variable and year dummies where the interaction term for 2013 is omitted. The first two columns of Table 4 Panel C show that the pre-treatment coefficients are insignificant for all of 2010–2012 when we use the same dependent variables as those in Panel A. In columns (3) - (5), we further partition the VC funds into three identical groups according to their size in each state and consider the number of VC funds in each group as the outcome variables. We again find that the coefficients are insignificant for all of 2010–2012 in all three columns. Taken together, the results in Panel C of Table 4 corroborate the validity of our diff-in-diff specification.

To further validate our diff-in-diff model, we conduct falsification tests with economic variables that are not directly related to VC fundraising and presumably also less impacted by the Volcker Rule. We estimate the diff-in-diff model specified in Eq. (1) using six economic variables in three categories: IPOs of VC-backed companies, patents filed by VC-backed companies, and state GDP. The results in Table IB.4 show that the coefficients on the interaction variable are insignificant throughout the six columns. We conclude that

[27] To provide additional robustness checks, we also re-estimate our baseline regression by excluding one state at a time from our main regression sample. The coefficients are plotted in Figure IB.4, showing that our main results are not driven by any single state.

our baseline results are unlikely to be driven by the heterogeneity between the treated and control states. Overall, these results imply that local banks were a critical source of capital for local VCs.

3.2 VC fundraising activity at the fund level

Having found a decline in the aggregate of VC fundraising activity in states most exposed to the Volcker Rule, we now explore its impact on the average size of a VC fund raised. Panel A of Table 5 reports the VC fund level regression results estimated from Eq. (1) with the natural log of fund size as the dependent variable. Columns (1) - (3) include all VC funds that were closed over the 2010–2018 sample period. To control for the cyclicality of overall VC fundraising activity and the cross-sectional heterogeneity in VC firms' ability to raise funds, we include VC fund vintage year fixed effects and VC firm fixed effects in all the columns.[28] In addition, as VC fund size typically increases as a function of the fund sequence within a VC firm, we add VC fund sequence fixed effects in column (2). We further add time-varying, state-year level controls in column (3). The results in the first three columns of Panel A suggest that the average VC fund size falls after the implementation of the Volcker Rule. The economic magnitude is large. For a one standard deviation increase in bank exposure in a state, e.g., moving from New York to Wisconsin (Table 2), the average VC fund size is about 18% smaller conditional on being raised. These estimates are robust to the exclusion of California (column (4)), narrowing the analysis to 2011–2017 (column (5)), and only considering VC firms with funds before and after the rule change (column (6)).

Lastly, we also estimate the within-VC firm effect of the Volcker Rule by examining whether VC firms from the pre-Volcker era experience a decline in the likelihood of raising a follow-on fund. We consider changes in VC firms' probabilities of raising a follow-on

[28] The VC industry is highly cyclical (see e.g. Gompers et al., 2008), while VC firms' ability to raise big funds varies considerably (Pitchbook-NVCA 2020 Venture Monitor).

fund across states in the post-Volcker period conditional on having raised a fund over the pre-Volcker period 2010–2013. Table 5 Panel B reports the estimation results, where the dependent variables are indicators of whether a VC firm has raised a new fund up to a certain year over the post-Volcker period. Over different post-Volcker windows, the results in Panel B all suggest that conditional on raising a VC fund over the pre-Volcker period, higher bank exposure leads to a lower probability of raising a follow-on fund over the post-Volcker period. This within-VC firm evidence further suggests that VC firms raise not only smaller, but also fewer funds.

3.3 LP home bias and availability of alternative LPs

The implementation of the Volcker Rule negatively impacted VC fundraising activity, suggesting that no other institutional investors stepped in to substitute for banks' capital. This section explores this issue directly. We begin with examining LP's home bias in investing in VC funds using data from Preqin.[29]

A combination of unequal distribution of LPs across U.S. (see columns (6)-(7) of Table 2) and geographic frictions (e.g., LP home bias) could prevent non-local LPs from filling the gap left by bank LPs. This in turn could drive the decline in post-Volcker VC fundraising activity in states outside the major VC hubs. Following Hochberg and Rauh (2013), we compute LP home bias as LP's in-state overweighting in VC investments for all major LP types. LP's in-state overweighting is defined as the share of LP's in-state investments against two benchmarks: 1, the share of all investments that are in the state of the given LP in the preceding five years (BM1); 2, the share of all non-in-state investments that are in the state of the given LP in the preceding five years (BM2). The investment-level estimates in columns (1)-(3) of Table 6 Panel A show that bank LPs on average make 23.2% of their investments into VCs in their home state, which is 11.5% higher than the average share

[29] In untabulated results, the results hold using Pitchbook.

of all VC investments made in that state, and 11.9% higher than the average share of all out-of-state investments made in the state. Thus, bank LPs have significantly higher in-state weighting when making VC investments. Indeed, the magnitudes of banks' in-state weighting are even larger than those of pension funds (both public and private pension) (see rows 2 and 3). In the last three columns of Table 6 Panel A, we conduct the estimation at the LP-year level, and find similar results. Overall, the active LP types in VC investing – including banks – exhibit significant home bias. This bias is a clear mechanism limiting the flow of LP capital from the major VC centers to the regions impacted by the loss of bank LPs.[30]

We next directly examine whether the availability of alternative local LPs attenuates the impacts documented above. If a region also has a relatively smaller stock of alternative local LPs who can substitute for lost bank LPs, then these regions will experience larger negative impacts post-rule passage. As pension funds and endowments collectively contribute to about 70% of PE allocations, they provide a measure of alternative LP availability. Specifically, we construct a proxy of alternative LP assets at the state level as the total assets under management (AUM) of pension fund and endowment LPs located in a state scaled by state GDP in 2013 (the last year prior to the implementation of the Volcker Rule). Equipped with the proxy, we re-examine our findings in Table 4 and conduct a split-sample analysis of VC fundraising activity for states with large LP assets vs. small LP assets.

The results are reported in Table 6 Panel B, where the dependent variable is the log of one plus the number of VC funds raised in a given state-year. Coefficient estimates for the interaction term in columns (1) and (2) are negative in both, but only statistically significant in the second column for states with few LP assets (i.e., states with LP assets below the

[30] In Table IB.5, we also collect information for GPs at the individual level from LinkedIn for a subset of states in our sample, and then compare GPs' prior finance background and work experience across states. We find that GPs in states with higher bank exposure have less finance background and work experience relative to their counterparts in VC hub states. These results suggest that VCs in the non-clustered states may find it difficult to substitute bank LPs after the Volcker Rule because of their worse financial networks.

sample median). Thus, the decline in VC fundraising activity is concentrated in states with fewer alternative LP assets. Columns (3) and (4) study aggregate amount of venture capital raised in a given state-year. Again, states with fewer LP assets experience a larger decline in VC fundraising activity following the Volcker Rule.

In sum, the results in Table 6 show that major LPs including banks exhibit home bias in investing, which reduces VCs' ability to raise capital from LPs outside of their home states after they lose banks as their LPs. Moreover, the negative effects of the Volcker Rule on VC fundraising are more severe for states with a lower pool of alternative LPs, indicating that VCs located in these states are more constrained in finding substitute LPs. These two factors can help explain why the passage of the Volkcer Rule had a negative impact on VC fundraising. Likely not by design, this impact was concentrated outside traditional VC hubs and could thus impact high-growth startups in those regions. We examine that issue next.

4 Impacts on Startup Financing

We turn next to understanding the impact of the Volcker Rule on financing local high-growth startups across regions. The reduced supply of venture capital may be substituted by other sources of early-stage capital such as friends and family financing, angels, bank debt, government grants, or other private equity. In this scenario, we may not see changes in startup financing. However, if these alternative sources of capital are complementary to VC or already exhausted pre-2014, we could observe changes in various aspects of startup financing including the amount of capital raised, startup valuation, investor syndication, and the composition of startups funded.

4.1 Capital raised

We first examine the impact of the Volcker Rule on the amount of capital a startup raises in its first round of VC financing. We estimate Eq. (1) with the natural log of the investment size in startups' first round of VC financing as the dependent variable at the startup-level, and report the regression results in Panel A of Table 7. The sample in columns (1) - (3) includes all VC-backed startups that have raised their first VC funding between 2010 and 2018 and also have disclosed funding size. We include state and financing year fixed effects in column (1). We add industry group, the specific round (either Seed or Series A), and startup age fixed effects in column (2). We further add time-varying, state-year level controls in column (3). The results in the first three columns of Panel A show that there is a significant decrease in the amount of capital invested by VCs in startups' first financings following the implementation of the Volcker Rule. In particular, a one standard deviation increase in bank exposure leads to a smaller average amount of capital invested of about 7% (column (2)). This difference represents a $0.4 million dollar fall in the average amount of capital invested in the first round of funding.[31]

In the remaining columns of Panel A, we consider a few robustness tests for the main specification. In column (4), we exclude startups headquartered in CA from our sample. The coefficient estimate increases slightly in magnitude, suggesting that our result is not driven by startups located in CA. In column (5), we focus on a shorter sample period of 2011–2017 around the implementation of the Volcker Rule. The coefficient in column (5) is almost identical to the one in column (2) with the same specification. This suggests our result is not driven by events either at the beginning of our sample period, such as the 2008 financial crisis, or at the end of our sample period.[32]

[31] Figure IB.5 plots the coefficients estimated from a dynamic specification of Eq. (1) and demonstrates that there is no observable pre-trend and that the timing in the falling of deal size is consistent with the implementation of the Volcker Rule.

[32] In Panel B of Table IB.3, we also examine the changes in the aggregate of capital invested in all initial VC financings and consistently find that the total initial capital invested in startups located in high exposure

Taken together, the results in Table 7 Panel A show that startups inherit their VC investors' financial constraints and raise less money after the Volcker Rule.

4.2 Additional financing characteristics

Other startup financing characteristics could change when the supply of VC falls. We first look at startup valuation, which is an important metric of the interaction between the supply of and demand for venture capital (Gompers and Lerner, 2000). Changes in valuation can reveal changes in either supply or demand, and also in the bargaining power of VCs and entrepreneurs.

Using the natural log of startup pre-money valuation at the time of their first VC funding as the dependent variable,[33] we estimate a similar regression as those in Table 7 Panel A, and report the estimation result for startup valuation in the first column of Table 7 Panel B. The result suggests that there is a significant decrease in the pricing of startups post implementation of the Volcker Rule.[34] In particular, for a one standard deviation increase in bank exposure in the home state, the average price of startups in their first funding is about 7% smaller. This difference represents a $1.1 million fall in the pricing of startups in their first round of funding. Therefore, consistent with our results in Table 7 Panel A, the result with startups' valuation in Panel B indicates that startups inherit their VC investors' financial constraints and face worse financing conditions after the Volcker Rule.

A comparison of the economic magnitudes estimated for startups' first capital raised and

states were lower relative to those located in low exposure states post-Volcker Rule.

[33] The pre-money valuation is defined as the product of the price paid per share in the financing round and the shares outstanding prior to the financing round, expressed in millions of 2019 dollars. The pre-money valuation is the perceived NPV of the company before the capital injection, and hence it more accurately measures financing conditions faced by startups than post-money valuation.

[34] The regression sample consists of 5,903 VC-backed startups with reported valuations that have raised their first VC funding between 2010 and 2018 in the VentureSource database. Valuation revelation is non-random (Ewens and Farre-Mensa, 2020) so the results use a positively selected set of startups. For these tests, we believe this attenuates our ability to find impacts because relatively higher valuation are most likely to be reported.

pre-money valuation shows that both fall at equal rates in response to the rule change. Since the fraction of equity shares sold to VC investors is equal to the amount of capital raised divided by the sum of pre-money valuation and the amount of capital raised, a similar rate of drop in pre-money valuation and first capital raised indicates that the fraction of equity shares sold to investors should not change. The estimation result in the second column of Panel B of Table 7 confirms this prediction.[35] Thus, the decline in VC availability resulted in value loss to both founders and VC investors.

We also want to understand whether the decline in capital is driven by fewer VC investors investing or less capital invested by participating investors. To answer this question, we estimate Eq. (1) using the natural log of syndication size – the number of investors in the financing – in startups' initial VC financing round as the dependent variable. Syndication is common among VC investments, e.g., there are on average almost three VC investors in the first round of VC financing in our sample (see Table 3).[36] The third column of Table 7 Panel B shows that the number of VC investors that co-invest in a startup's first financing falls in states with higher bank exposure post rule change.[37] This decline in the number of investors in startups is consistent with previous results showing fewer VC funds after the rule change.

Last, we study the changes in the characteristics of startups receiving their first VC funding. A decrease in the supply of venture capital could lead VCs to invest in startups at earlier stages because those firms require less capital. Early-stage startups are also riskier, so if the set of startups demanding venture capital is unchanged, then VCs may choose to invest

[35] Since post-money valuation is the sum of pre-money valuation and the amount of capital raised, a similar rate of drop in pre-money valuation and capital raised indicates that post-money valuation should also fall by about 7%, which is indeed what the estimation in Table IB.6 suggests.

[36] Syndication is believed to bring a number of benefits to investors such as leading to better selection of investments, and it has been studied extensively in the literature (see e.g. Lerner, 1994; Nanda and Rhodes-Kropf, 2019).

[37] In Table IB.6, we also find that conditional on financing, the average amount of capital invested per investor also falls after the implementation of the Volcker Rule.

in startups with proven track records. Since startups typically lack products and revenue at the time of their first VC financing, an important track record is whether a startup has received funding from early-stage investors such as angels or accelerators (Kerr, Lerner, and Schoar, 2014; Hochberg and Fehder, 2015; González-Uribe and Leatherbee, 2018). To assess the changes in the characteristics of startups funded by VCs, we estimate Eq. (1) with a dummy variable for whether the startup raised pre-VC financing. The result (column (4) of Table 7 Panel B), shows that VCs are more likely to invest in startups that have received pre-VC funding after the Volcker Rule in the states more exposed to the rule change. The result suggests that VC investment strategies shifted towards safer startup investments after the rule change.

In Table IB.6, we also look at additional characteristics of VC-backed startups including whether a startup has a serial entrepreneur in its founding team as well as the startup's age at its first VC funding (Gompers, Kovner, Lerner, and Scharfstein, 2010). Results are broadly consistent with those in Table 7. For example, VCs invest in slightly younger startups post-Volcker Rule in more affected states. Overall, the results suggest that VCs have shifted their investment strategies towards startups that are slightly younger, have better track records, and likely demand less capital.

The collection of results demonstrate that startups outside the traditional VC hubs absorb some of their VC investors' financing constraints.

5 Implications for Startup Clustering

High-growth entrepreneurship is highly concentrated by geography. The changes documented thus far provide an opportunity to assess the role of the constraints on local capital supply in this concentration of startups. We begin by examining how local investor syndicate with remote VCs to understand how capital moves across (state) borders. We then explore the connection between local financing constraints, startup mobility, and startup clustering.

5.1 VC markets outside the traditional VC hubs

A simple explanation for the decline in local capital supply is that non-local VCs – particularly those from the VC hubs – failed to fill the gap left by local smaller VC funds. To assess this we study how local and remote VCs syndicate.

Early-stage investing involves high information asymmetry, and thus requires pre-investment intensive screening and frequent post-investment monitoring (e.g., Lerner, 1995). These actions can help explain why VC investing exhibits strong local bias (e.g., Chen et al., 2010) and why VCs that invest at a distance are sensitive to the cost of these interactions (Bernstein, Giroud, and Townsend, 2016). We thus predict that when VCs invest remotely, their financings attempt to mitigate the geographic disadvantages. One of the mechanisms to address the information gaps is co-investing (syndication) with VCs local to the startup.

To test this, we study the correlation between having a local VC syndicate and the average distance of out-of-state VC investors to a startup. The regression asks whether the likelihood a startup raising capital has a local VC depends on the distance between it and any of its non-local VCs (measured as the average geodesic distance in miles between the out-of-state VC investors and the focal startup). Table 8 presents the results. Column (1) shows that the longer distance a startup is from non-local VCs in its syndicate, the more likely a local VC is involved. Here, a 10% increase in the distance between out-of-state VCs and startups is associated with a 0.5% percent increase (relative to the mean) in the likelihood of syndicating with local VCs. The remaining columns of Table 8 show that these results are robust to controls, sub-samples, and fixed effect inclusion. These estimates provide a mechanism that can explain why the loss of local capital cannot be easily substituted with distant VC.

To provide more direct evidence on how the Volcker Rule impacts the availability of local vs. non-local VCs, we also estimate diff-in-diff regressions at the startup level with the presence of in-state vs. out-of-state VCs as the dependent variables. Table 9 reports the regression results estimated from Eq. (1). The dependent variable is a dummy variable indicating whether a startup has raised first-time capital from a same-state investor (columns (1)-(3)), and from an out-of-state investor (columns (4)-(6)). The results in the first three columns show that the Volcker Rule negatively impacted local VC supply for exposed startups. In contrast, the estimations in columns (4)-(6) suggest that the Volcker Rule had no significant impact on the availability of out-of-state VCs. Thus, VCs outside the traditional VC hubs did not step in to fill the gaps left by the local VCs in the affected regions.

Taken together, these results confirm our earlier findings that the Volcker Rule negatively impacted the supply of local venture capital, while demonstrating the role of out-of-state VCs' reliance on local VCs for remote investments. Our findings also shed light on a special role played by local VCs outside the traditional VC hubs, i.e., serving as co-investors of remote VCs.

5.2 Startup mobility

Our final tests ask whether the decreased supply of local VC impacts startup location choice and ultimately, startup clustering. We first study whether startups in states with high bank exposure (and increased financing constraints) are more likely to move to the largest VC cluster in the US – California (also see Guzman, 2019). To do so, we construct a sample of startup mobility using address information on Form D filings (exemption from registration requests used by VC-backed startups). The Form D data provides detailed information on the startup's principal place of business, industry and incorporation year among those that have raised or seek to raise private capital. A startup moves to CA if it files two consecutive Form Ds with the first showing a non-CA headquarter state and the second showing CA as the headquarter state.[38] Figure 5 provides descriptive evidence that mobility responds to worse financing conditions. It depicts the fraction of young firms moving from high-exposure (treated) states to CA each year among all similar firms moving to CA. Among all startups within five years old that move to California, the probability that they originate from one of the treated states increases by about 60% after the implementation of the Volcker Rule.[39] The results in Figure 5 show that the decrease in capital availability correlates with startups' relocation to states that were relatively less exposed to the rule change.

We next study startups' migration to VC hubs using a diff-in-diff analysis at the startup-year level with a sample that includes both startup movers and non-movers. Specifically, we include all startups that are at most five years old in 2014 when the Volcker Rule passes (i.e., those incorporated during 2009–2013) and track them over the period of 2010–2018. The results, reported in the first two columns of Panel A of Table 10, show that the startups headquartered in states with higher bank exposure prior to the Volcker Rule are more likely to move their headquarters to California, a state with the most abundant venture capital supply and little Volcker Rule exposure. The results are unchanged when we consider startup migration to VC hubs defined as the top three VC states including CA, MA and NY (columns (3)-(4)).[40] As a placebo test, columns (5) - (6) consider startup migration to any other state. Reassuringly, startups headquartered in states with higher bank exposure have a similar likelihood to move across states compared to other startups around the Volcker Rule. Panel B of Table 10 considers an alternative measure of startup mobility using quarterly address changes observed in VentureSource. The results are unchanged. These mobility results show

[38] Therefore, our sample of startups is conditional on having raised or seeking to raise at least two rounds of financings, i.e. filing two Form Ds.

[39] As a robustness check, we also examine a sample of startups that move to California within five years of filing their first Form D, and see a similar pattern.

[40] Various VC metrics such as capital under management, capital commitments and total VC investments all consistently show that CA, MA and NY are the top three VC states. For example, in 2013, the year before the passage of the Volcker Rule, capital under management in the top three states are $94,076.6, $32,636.6, and $19,480.4 million, while the fourth state CT has $5,818.1 million (NVCA, 2014).

that a decrease in the supply of venture capital in regions outside the traditional VC hubs drives some local startups to relocate to VC hubs. These moves exacerbate startup clustering while highlighting the role of local risk capital in startup agglomeration.

6 Conclusion

We investigate venture capital firm financing constraints and their impact on local startups' financing and mobility. Following the implementation of the Volcker Rule in early 2014, banks were prohibited from investing in VC funds as limited partners.[41] Their participation was predominantly in VC funds outside the VC hubs of California, Massachusetts and New York. Thus, this rule change disproportionately impacted regions where policymakers had worked hard to fill in funding gaps for both VCs and startups. The rule change led to fewer and smaller VC funds, while startups in the impacted states raised less money at worse valuations, and became more likely to relocate to VC hubs. The results show that VCs in the treated states are financially constrained and that startups can not completely cushion themselves. These negative impacts were predicted by several institutions during the finalizing of the Volcker Rule and motivated a strong lobbying effort by the VC industry. Starting in July 2019 with community banks and again in late 2020 for all banks, the SEC and Treasury scaled back these restrictions. With some time (ignoring the confounding Covid crisis), we may be able to disentangle whether this return to normal regulation will positively impact the effected states.

[41] In Table IB.7, we also find no conclusive evidence that banks substituted VC funds with SBIC funds to continue providing capital for startups.

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7 Figures and Tables

Figure 1: Number and fraction of banks with VC revenue by reporting year

This figure plots the number and fraction of banks with VC revenue by reporting year from 2001 to 2018. The data come from banks' Call Reports. The vertical line represents the year 2013, the last year before the implementation of the Volcker Rule.

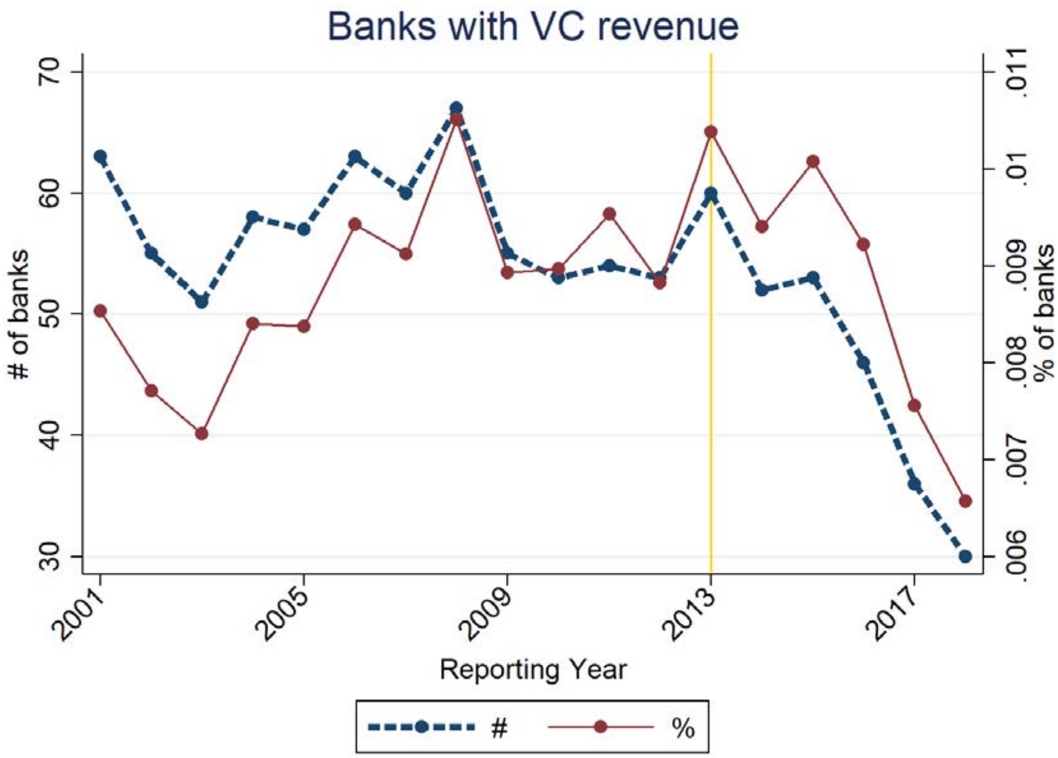
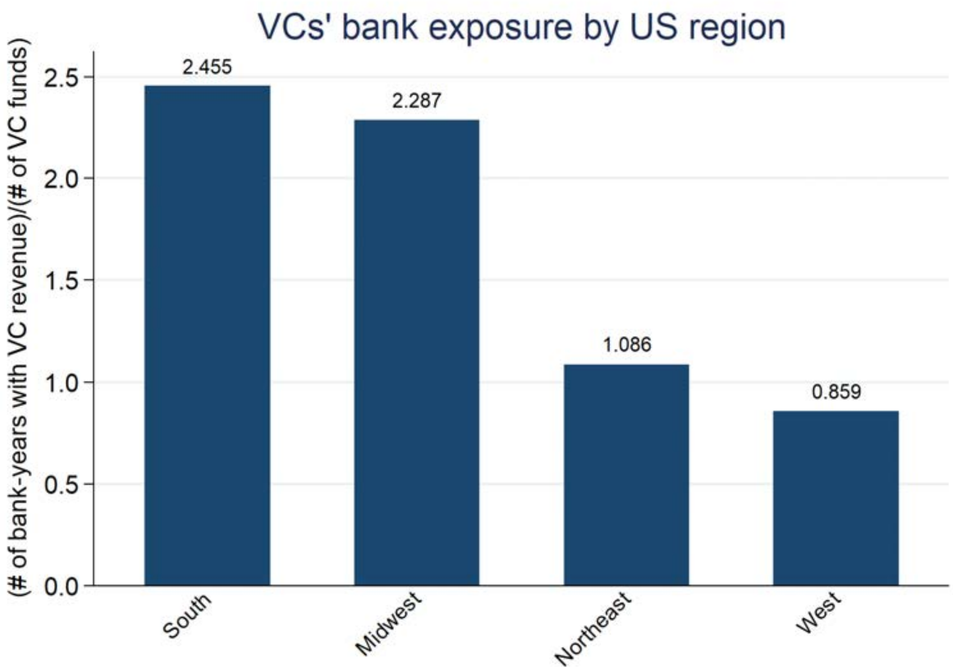


Figure 2: Bank exposure

Panel A plots the average bank exposure by U.S. region. Bank exposure is computed at the state level as the number of bank-years with VC revenue over the 2001–2013 period scaled by the number of VC funds raised in the state during the same period. Panel B presents the U.S. state map that shades each state and the District of Columbia according to our measure of bank exposure. States that do not have any VC funds raised over the 2010–2013 period are white.

Panel A: Bank exposure by U.S. region



Panel B: Bank exposure by U.S. state

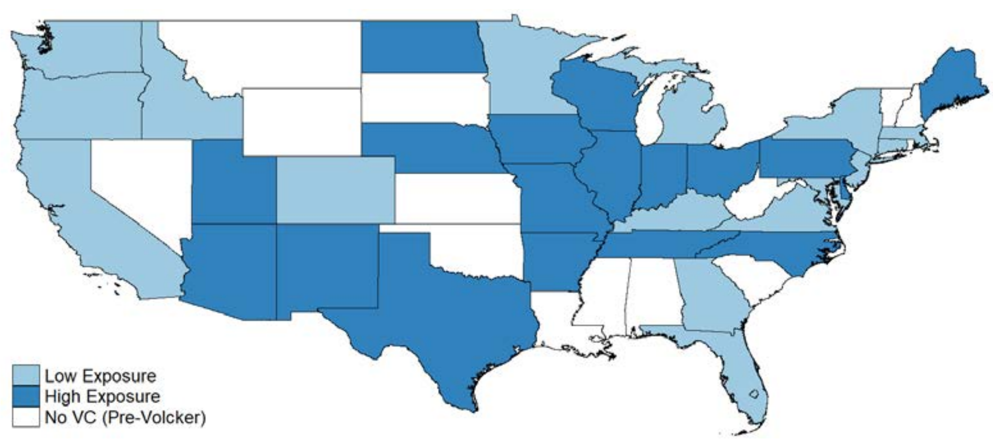


Figure 3: Bank exposure and VC imbalance

This figure presents the scatter plots of the bank exposure variable against state-level VC imbalance as measured by the relative ratio of the number of VC funds raised per capita in a given state over the number of VC funds raised per capita in the US over the 2010–2013 period. The correlation between bank exposure and VC imbalance is −0.30.

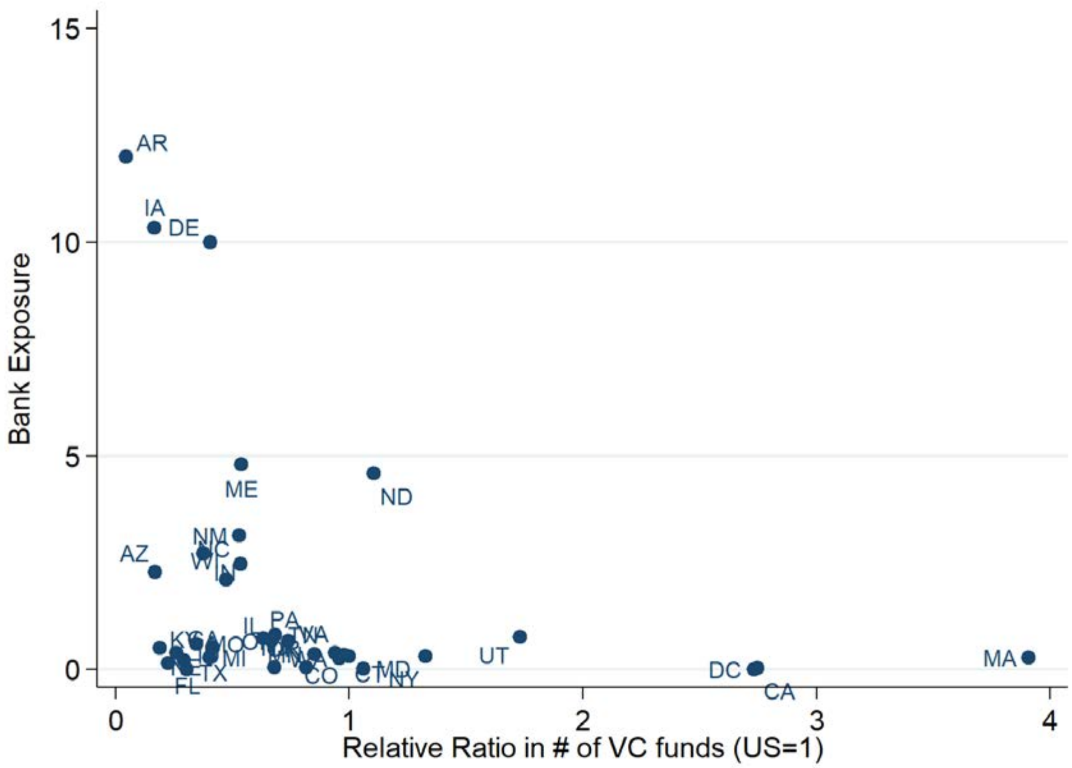


Figure 4: Number of VC funds by vintage year and bank exposure

This figure plots the number of VC funds raised by vintage year for the group of high and low bank exposure states, respectively. The sample includes all VC funds raised between 2010 and 2018 in the VentureSource database. A state is classified as a high exposure state if its bank exposure is above the median exposure of all states in our sample. The vertical line represents the year 2013, the last year before the implementation of the Volcker Rule.

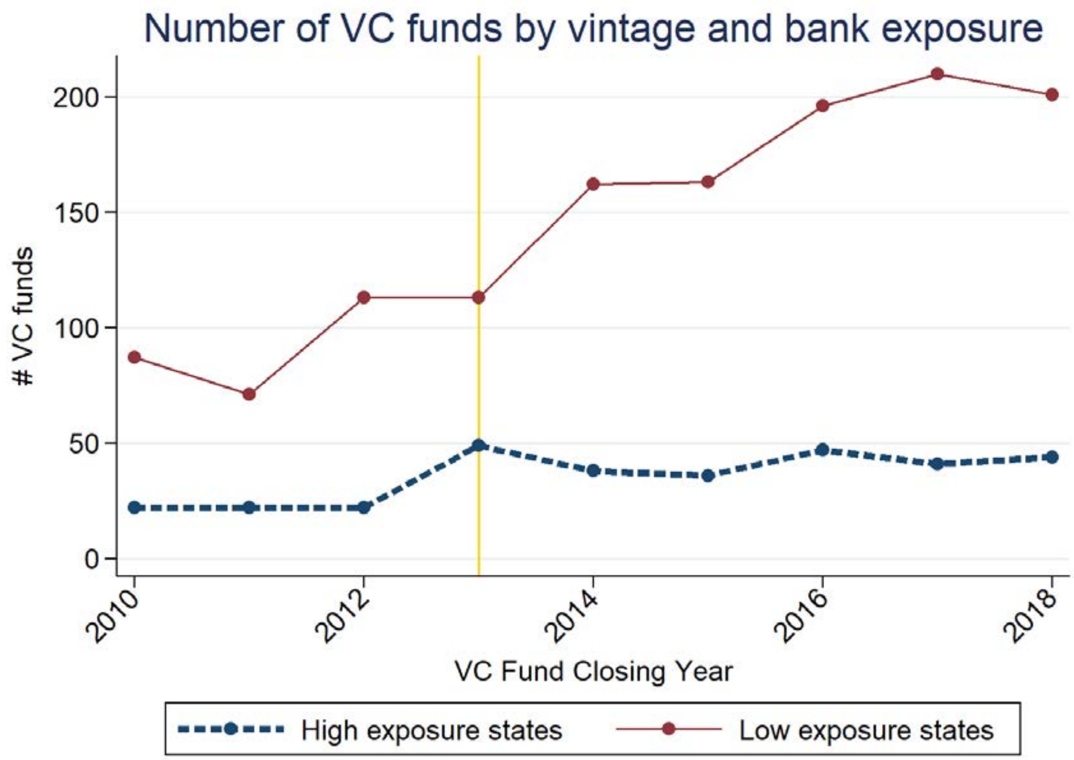


Figure 5: Startup migration from high-exposure states to California

This figure plots the fraction of startups moving from high-exposure (treated) states to CA each year among all similar startups moving to CA. The sample is derived from Form D filings. A startup's relocation across states is measured using its two consecutive Form D filings that show different headquarter states, and the filing date of the second Form D is defined as the moving time (i.e. "moving in" time). The blue dashed line is plotted using the sample of movers that migrated within five years old as indicated in their Form D filing; the red solid line is plotted using the sample of movers that migrated within five years of filing their first Form D.

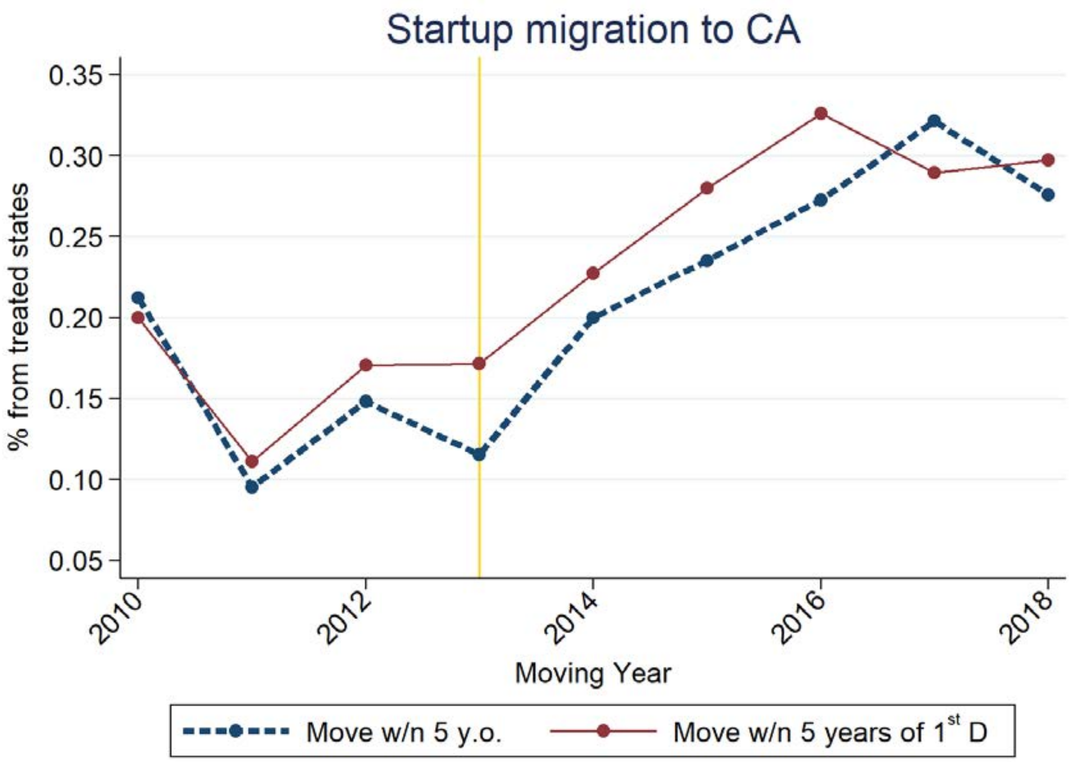


Table 1: Estimation of banks' capital share in total VC funds raised

This table estimates a snapshot of banks' investment position in VC and their capital share over total VC funds raised for different groups of U.S. states. The estimation is based on banks' VC revenue data extracted from Call Reports, and has the following procedure: (1) for a given group of U.S. states, we estimate the aggregate of banks' net profits from their VC investments using their VC revenue in each year; (2) we then back out banks' investment position in a given year by assuming a fixed annual return of 5%; (3) we scale this estimated banks' investment position by the aggregate of venture capital raised over a fixed window in the past to derive banks' capital share in total venture capital raised in a given year; (4) lastly, we take the annual estimate of banks' investment position and their capital share derived from the previous three steps, and average them over the 2005–2007 period. Column (1) reports the estimated banks' investment position in billions of 2019 dollars. Columns (2) - (4) report the estimated banks' capital share over total VC funds raised in the past 3, 5 and 7 years, respectively. "High Exposure States" are states with VCs' bank exposure above the sample median.

	Bank Capital	Bank Capital Share in VC funds		
	Dollars in VC Funds (Billions)	% of Fund $s over [t-2,t]	% of Fund $s over [t-4,t]	% of Fund $s over [t-6,t]
US	9.9	11.9%	6.8%	3.1%
High Exposure States	8.5	79.4%	44.4%	22.0%
Low Exposure States	1.3	1.9%	1.0%	0.5%
South	5.0	58.2%	31.8%	13.2%
Midwest	2.8	34.9%	23.3%	12.0%
Northeast	1.9	8.1%	4.0%	1.9%
West	0.2	0.4%	0.3%	0.2%

Table 2: Bank exposure and VC activity by state

This table reports our treatment variables on VCs' bank exposure by U.S. state (columns (1)-(2)) and each state's relative ratio in certain VC-related activity (columns (3)-(9)). For each state and year, a relative ratio is computed as the ratio of a certain VC-related activity per capita in the given state over the activity per capita in the US in that year. Then the annual ratios are averaged over the 2001–2013 period for each state. The relative ratios are computed for the following VC-related activities: the number of VC funds and amount of venture capital raised (columns (3)-(4)), the number of VC-backed startups funded (column (5)), the number of all LPs and pension fund LPs investing in VC (columns (6)-(7)), and the number of patents and high-skill employment (columns (8)-(9)). The mean of the treatment variables and the relative ratios are also reported for high- and low-exposure states, and each U.S. region.

	Treatment Variables		Relative Ratio in VC Activity			Relative Ratio in Capital Supply		Relative Ratio in Capital Demand	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
STATE	Bank Exposure	High Exposure	VC Funds	VC Capital	VC-bkd Startups	All LPs	Pension LPs	Patents	High-Skill Emp
AR	12.00	1	0.04	0.00	0.06	0.07	0.00	0.10	0.22
IA	10.33	1	0.17	0.01	0.06	0.58	0.95	0.64	0.53
DE	10.00	1	0.41	0.18	0.66	3.58	4.81	6.13	2.49
ME	4.80	1	0.54	0.19	0.23	0.46	0.08	0.23	0.63
ND	4.60	1	1.11	0.10	0.00	0.31	0.68	0.16	0.92
NM	3.14	1	0.53	0.05	0.34	1.14	0.78	0.36	1.64
IN	2.71	1	0.38	0.12	0.23	0.50	0.55	0.52	0.87
NC	2.49	1	0.54	0.22	0.31	0.81	0.90	0.49	0.71
AZ	2.29	1	0.17	0.02	0.27	0.27	0.44	0.35	1.54
WI	2.11	1	0.47	0.13	0.24	0.81	0.56	0.66	0.47
TN	0.81	1	0.68	0.21	0.33	0.36	0.50	0.26	0.37
UT	0.77	1	1.73	0.82	0.70	0.64	0.29	0.66	1.11
PA	0.73	1	0.63	0.41	0.68	1.64	1.15	0.55	0.89
IL	0.69	1	0.67	1.02	0.47	1.18	1.46	0.96	0.83
OH	0.67	1	0.74	0.14	0.29	0.87	0.60	0.65	0.54
MO	0.61	1	0.35	0.17	0.13	0.79	0.36	0.42	0.78
TX	0.51	1	0.42	0.23	0.41	0.54	1.07	0.92	0.80
NE	0.50	1	0.19	0.01	0.13	0.60	0.63	0.25	0.57
VA	0.40	0	0.94	0.42	0.53	0.27	0.43	0.34	0.96
GA	0.39	0	0.26	0.09	0.40	0.28	0.36	0.52	0.58
MN	0.36	0	0.85	0.39	0.37	1.92	1.74	1.57	0.74
CT	0.35	0	0.98	2.00	0.77	1.51	1.20	1.83	2.03
NY	0.32	0	1.33	1.31	1.46	1.85	1.28	1.47	0.59
CO	0.31	0	1.00	0.64	1.08	0.58	0.77	0.65	1.34
MI	0.28	0	0.40	0.12	0.25	1.27	1.65	1.20	0.45
MA	0.28	0	3.91	5.55	3.91	3.32	3.76	2.04	2.02
WA	0.27	0	0.96	0.85	1.49	0.69	0.72	1.57	2.45
KY	0.22	0	0.29	0.12	0.16	0.35	0.30	0.27	0.18
FL	0.16	0	0.23	0.03	0.17	0.23	0.05	0.27	0.54
OR	0.05	0	0.82	0.12	0.56	0.67	0.69	0.62	1.20
NJ	0.05	0	0.68	1.04	0.49	1.13	1.38	1.31	1.61
CA	0.04	0	2.75	3.27	3.52	1.12	1.26	1.96	1.63
MD	0.02	0	1.06	2.94	0.46	1.42	0.84	0.51	1.54
ID	0.00	0	0.31	0.04	0.09	0.17	0.39	2.55	1.43
DC	0.00	0	2.73	3.55	2.35	15.15	8.60	4.70	2.79
High Expo	3.32	1	0.53	0.29	0.36	0.81	0.87	0.67	0.79
Low Expo	0.21	0	1.36	1.53	1.48	1.14	1.10	1.25	1.16
South	2.46	0.45	0.48	0.37	0.35	0.60	0.68	0.59	0.73
Midwest	2.29	0.80	0.54	0.32	0.28	1.01	1.03	0.83	0.66
Northeast	1.09	0.33	1.33	1.60	1.33	1.81	1.54	1.29	1.11
West	0.86	0.38	1.91	2.06	2.34	0.89	0.98	1.50	1.63

Table 3: Summary statistics

This table presents summary statistics of the variables for analysis at the state-year level (Panel A), the VC fund level (Panel B), and the VC-backed startup level (Panel C). In Panel A, "# VC Funds" is the number of VC funds raised in a given state-year; "# Small/Medium/Large Funds" are the count of VC funds with size in the bottom, middle and top tercile distribution in each state; "Top VC Capital (B)" is the aggregate amount of venture capital raised in billions of 2019 dollars; "Bank Exposure" is the continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. In Panel B, "VC Fund Size (B)" is the size of a fund in billions of 2019 dollars; "VC Fund Sequence" is the sequence number among all funds raised by a VC firm. In Panel C, "Capital Raised" is the amount of venture capital raised in a startup's first VC financing; "Pre-money Valuation (M)" is the pre-money valuation of a startup at the time of its first VC funding in millions of 2019 dollars.

Panel A: At the state-year level

	N	Mean	Std. Dev.	5-%ile	25-%ile	50-%ile	75-%ile	95-%ile
# VC Funds	315	5.20	15.16	0.00	0.00	1.00	4.00	21.00
# Small Funds	315	2.19	6.98	0.00	0.00	0.00	2.00	9.00
# Medium Funds	315	1.41	3.91	0.00	0.00	0.00	1.00	6.00
# Large Funds	315	1.60	4.62	0.00	0.00	0.00	1.00	8.00
Total VC Capital (B)	315	0.65	2.08	0.00	0.00	0.04	0.25	3.48
Bank Exposure	315	1.81	3.02	0.00	0.27	0.50	2.29	10.33

Panel B: At the VC fund level

	N	Mean	Std. Dev.	5-%ile	25-%ile	50-%ile	75-%ile	95-%ile
VC Fund Size (B)	1617	0.14	0.33	0.00	0.01	0.03	0.13	0.56
VC Fund Sequence	1617	7.41	17.64	1.00	1.00	2.00	5.00	38.00
Located in CA	1617	0.45	0.50	0.00	0.00	0.00	1.00	1.00
Bank Exposure	1617	0.37	0.86	0.04	0.04	0.16	0.32	0.81

Panel C: At the startup level

	N	Mean	Std. Dev.	5-%ile	25-%ile	50-%ile	75-%ile	95-%ile
Capital Raised	11048	5.26	9.09	0.11	1.08	2.27	5.39	20.36
Pre-money Valuation (M)	5903	15.32	30.16	1.81	4.71	7.99	14.88	46.28
Equity Sold	5903	0.29	0.15	0.08	0.19	0.27	0.35	0.59
Syndication Size	12788	2.72	2.11	1.00	1.00	2.00	4.00	7.00
Has Pre-VC	12788	0.24	0.43	0.00	0.00	0.00	0.00	1.00
Age at Financing	12788	1.88	1.78	0.00	1.00	1.00	3.00	5.00
Series A Round	12788	0.66	0.47	0.00	0.00	1.00	1.00	1.00
Located in CA	12788	0.46	0.50	0.00	0.00	0.00	1.00	1.00
Information Technology	12788	0.33	0.47	0.00	0.00	0.00	1.00	1.00
Bank Exposure	12788	0.35	0.95	0.04	0.04	0.16	0.32	0.77

Table 4: Changes in the aggregate of VC fundraising activity

This table presents diff-in-diff analyses examining the impact of the Volcker Rule on the aggregate of VC fundraising activity at the state-year level. Panel A reports the OLS regression results of estimating Eq. (1). The sample period is over 2010–2018 for all columns except columns (4) and (8) in which it is over 2011–2017. In columns (3) and (7), the state of California is excluded from the sample. The dependent variables are the natural log of one plus the number of VC funds raised in columns (1) - (4), and the natural log of one plus the aggregate amount of venture capital raised in columns (5) - (8). "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if the observation is after 2014, and 0 otherwise. All regressions include state fixed effects and fund closing year fixed effects. Panel B presents results from additional specifications. Specifically, we use the inverse hyperbolic sine function to transform the count of VC funds in column (1), and run a Poisson regression in column (2). In columns (3) - (4), we replace our main treatment variable with the natural log of one plus the bank exposure variable. Panel C reports the estimation results of a dynamic version of Eq. (1) in which the lone interaction variable in Eq. (1) is replaced with a set of interaction variables between the bank exposure variable and year dummies; the interaction variable for 2013 is omitted to avoid multi-collinearity. The dependent variables are the same as in Panel A in the first two columns and are the natural log of one plus the count of VC funds in three identical groups that are defined by partitioning VC funds in each state according to their size in columns (3) - (5). ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by state.

Panel A: Number of VC funds and total VC capital raised

	ln(# VC Funds)				ln(Total VC Capital)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All	All	ex. CA	11-17	All	All	ex. CA	11-17
Bank Expo × Post	−0.033***	−0.032**	−0.030**	−0.033***	−0.012**	−0.012**	−0.010**	−0.011**
	(0.012)	(0.013)	(0.011)	(0.012)	(0.005)	(0.006)	(0.005)	(0.005)
State GDP growth		0.005				−0.003		
		(0.012)				(0.006)		
Log of GDP p.c.		0.189				1.015		
		(1.014)				(0.725)		
Constant	1.080***	−0.982	0.981***	1.102***	0.268***	−10.754	0.202***	0.272***
	(0.012)	(11.019)	(0.012)	(0.012)	(0.005)	(7.867)	(0.005)	(0.005)
Observations	315	315	306	245	315	315	306	245
Adj. R^2	0.783	0.781	0.684	0.791	0.819	0.820	0.644	0.828
State FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y

Panel B: Additional regression specifications

	Non-linear Models		Log Treatment	
	(1) Inverse Hyperbolic Sine Transformation	(2) Poisson Model	(3) ln(# VC Funds)	(4) ln(Total VC Capital)
Bank Expo × Post	−0.039**	−0.149**		
	(0.014)	(0.072)		
Log of Bank Expo × Post			−0.155**	−0.056**
			(0.066)	(0.027)
Constant	1.363***	3.036***	1.107***	0.277***
	(0.014)	(0.017)	(0.026)	(0.010)
Observations	315	315	315	315
Adj./Pseudo R^2	0.760	0.815	0.783	0.819
State FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Panel C: Dynamic estimation

	ln(# VC Funds)	ln(Total VC Capital)	ln(# VC Funds)		
	(1) All	(2) All	(3) small	(4) medium	(5) large
Bank Expo × 2010	−0.001	0.007	0.002	0.016	0.003
	(0.023)	(0.007)	(0.025)	(0.023)	(0.017)
Bank Expo × 2011	0.005	0.005	0.004	0.015	0.019
	(0.037)	(0.009)	(0.025)	(0.021)	(0.026)
Bank Expo × 2012	−0.016	−0.001	0.005	0.001	−0.006
	(0.025)	(0.007)	(0.027)	(0.023)	(0.019)
Bank Expo × 2014	−0.046**	−0.000	−0.040*	−0.012	−0.001
	(0.022)	(0.006)	(0.023)	(0.022)	(0.017)
Bank Expo × 2015	−0.030	−0.013	−0.014	−0.011	−0.022
	(0.035)	(0.009)	(0.034)	(0.021)	(0.019)
Bank Expo × 2016	−0.024	−0.015*	−0.017	0.008	−0.027
	(0.034)	(0.008)	(0.026)	(0.029)	(0.022)
Bank Expo × 2017	−0.048**	−0.008	−0.038	−0.021	−0.000
	(0.023)	(0.008)	(0.024)	(0.023)	(0.012)
Bank Expo × 2018	−0.032	−0.010	−0.033	−0.004	−0.012
	(0.025)	(0.008)	(0.023)	(0.035)	(0.019)
Observations	315	315	315	315	315
Adj. R^2	0.778	0.815	0.689	0.671	0.737
State FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y

Table 5: Changes in VC fundraising at the fund level

This table examines the impact of the Volcker Rule on VC fundraising activity at the VC fund level. Panel A reports the diff-in-diff estimation results of Eq. (1) where the dependent variable is the natural log of VC fund size. The sample period is over 2010–2018 for all columns except column (5) in which it is over 2011–2017. In column (4), VC funds based in California are excluded from the sample. In column (6), only VC firms that have raised at least one VC fund both before and after the Volcker Rule are included. "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if the fund is raised after 2014, and 0 otherwise. "VC Firm FE" are VC firm fixed effects, "Vintage Year FE" indicate dummies for fund closing year, and "Fund Seq FE" are within-VC-firm fund sequence fixed effects. Panel B reports OLS estimation results of a single-difference regression at the VC firm level. The sample includes VC firms that have raised at least one VC fund over the pre-Volcker period (2010–2013). The dependent variables are dummy variables indicating whether a VC firm has raised a follow-on fund by a certain year between 2014 and 2018 over the post-Volcker period. "Year of Pre-Volcker Fund FE" indicate dummies for the last year the VC firm raised a fund over the pre-Volcker period 2010–2013. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by VC firm in Panel A and by state in Panel B.

Panel A: VC fund size

	ln(VC Fund Size)					
	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	All	ex. CA	11-17	Active VC
Bank Expo × Post	−0.198*	−0.216**	−0.241***	−0.262***	−0.237**	−0.204*
	(0.107)	(0.107)	(0.084)	(0.093)	(0.101)	(0.115)
State GDP growth			−0.047**			
			(0.023)			
Log of GDP p.c.			1.487			
			(2.469)			
Constant	−3.747***	−3.340***	−19.559	−3.607***	−3.400***	−3.037***
	(0.024)	(0.026)	(27.112)	(0.038)	(0.026)	(0.022)
Observations	1,617	1,617	1,617	884	1,265	740
Adj. R^2	0.833	0.783	0.783	0.789	0.795	0.775
VC Firm FE	Y	Y	Y	Y	Y	Y
Vintage Year FE	Y	Y	Y	Y	Y	Y
Fund Seq FE	N	Y	Y	Y	Y	Y

Panel B: Probability of raising a new fund after the Volcker Rule

	Raising Fund after the Volcker Rule				
	(1) (By 2014)	(2) (By 2015)	(3) (By 2016)	(4) (By 2017)	(5) (By 2018)
Bank Expo	−0.027***	−0.035	−0.045*	−0.038	−0.044
	(0.009)	(0.022)	(0.025)	(0.026)	(0.026)
Observations	395	395	395	395	395
Adj. R^2	0.032	0.020	0.036	0.047	0.049
Year of Pre-Volcker Fund FE	Y	Y	Y	Y	Y
Mean of Dep. Var.	0.137	0.284	0.392	0.478	0.519

Table 6: LP home bias and availability of alternative LPs

Panel A of this table computes LP home bias by LP type following Hochberg and Rauh (2013). Specifically, we calculate LP's in-state overweighting for each type of LP as the share of LP's in-state investments against two benchmarks: 1, the share of all investments that are in the state of the given LP in the preceding five years (i.e., BM1); 2, the share of all non-in-state investments that are in the state of the given LP in the preceding five years (i.e., BM2). The calculation is done at the investment level in the first three columns, and at the LP-year level in the last three columns, and the mean of LP's in-state overweighting is reported. Panel B of this table conducts a split sample analysis of the aggregate of VC fundraising for the sample of states with alternative LP assets above the sample median (*Large LP Assets*) and below the median (*Small LP Assets*). The sample period is over 2010–2018 for all columns. The dependent variables are the natural log of one plus the number of VC funds raised in columns (1) - (2), and the natural log of one plus the aggregate amount of venture capital raised in columns (3) - (4). "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if the observation is after 2014, and 0 otherwise. All regressions include state fixed effects and year fixed effects. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by state.

Panel A: LP home bias

	At investment level			At LP-vintage level		
By LP type	In-state Share	Home Bias (BM 1)	Home Bias (BM 2)	In-state Share	Home Bias (BM 1)	Home Bias (BM 2)
Bank	0.232	0.115	0.119	0.293	0.160	0.164
Public Sector Pension	0.208	0.110	0.113	0.226	0.147	0.148
Private Sector Pension	0.112	0.048	0.048	0.135	0.070	0.070
Endowment Plan	0.126	0.067	0.067	0.130	0.068	0.069
Foundation	0.168	0.071	0.073	0.190	0.098	0.099
Insurance Company	0.205	0.093	0.093	0.191	0.110	0.110

Panel B: Availability of alternative LPs

	ln(# VC Funds)		ln(Total VC Capital)	
	(1) Large LP Assets)	(2) Small LP Assets)	(3) Large LP Assets)	(4) Small LP Assets)
Bank Expo × Post	−0.002	−0.035**	−0.003	−0.008**
	(0.012)	(0.015)	(0.007)	(0.004)
State GDP growth	0.009	0.001	−0.021	0.002
	(0.030)	(0.011)	(0.014)	(0.003)
Log of GDP p.c.	1.458	−0.408	2.883**	0.120
	(1.839)	(1.253)	(1.208)	(0.385)
Constant	−14.713	5.250	−31.205**	−1.153
	(20.161)	(13.484)	(13.233)	(4.148)
Observations	153	162	153	162
Adj. R^2	0.866	0.487	0.872	0.370
State FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Table 7: Impacts on startup financing

This table presents diff-in-diff analyses examining the impact of the Volcker Rule on startup financing at the startup level. Specifically, Panel A reports the OLS regression results of estimating Eq. (1) with the natural log of capital raised in the startup's first VC funding as the dependent variable. The sample period is over 2010–2018 for all columns except column (5) in which the sample period is over 2011–2017. In column (4), startups headquartered in California are excluded from the sample. Panel B reports the OLS regression results of estimating Eq. (1) over 2010–2018 with additional financing characteristics as the dependent variables: the natural log of pre-money valuation in column (1), the fraction of equities sold to VC investors in column (2), the log of the number of investors (syndication size) in column (3), and a dummy variable indicating whether the startup has received financing from other non-VC investors (e.g., angels or crowdfunding) before its first VC funding in column (4). "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if the startup raised its first VC financing after 2014, and 0 otherwise. "State FE", "Financing Year FE", "Industry FE", "Series A or Seed FE", and "Startup Age FE" indicate dummies for a startup's headquarter state, year receiving their first VC financing, industry group, a Series A or Seed round in its first VC financing, and age at its first VC financing, respectively. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by startup headquarter state.

Panel A: First venture capital raised

	ln(Capital Raised)				
	(1) All	(2) All	(3) All	(4) ex. CA	(5) 11-17
Bank Expo × Post	–0.074***	–0.071***	–0.086***	–0.090***	–0.074***
	(0.025)	(0.023)	(0.022)	(0.024)	(0.021)
State GDP growth			0.020**		
			(0.009)		
Log of GDP p.c.			–1.781**		
			(0.792)		
Constant	0.769***	0.768***	20.293**	0.649***	0.728***
	(0.005)	(0.005)	(8.694)	(0.009)	(0.004)
Observations	11,048	11,048	11,048	6,056	8,999
Adj. R^2	0.079	0.275	0.276	0.290	0.279
State FE	Y	Y	Y	Y	Y
Financing Year FE	Y	Y	Y	Y	Y
Industry FE	N	Y	Y	Y	Y
Series A or Seed FE	N	Y	Y	Y	Y
Startup Age FE	N	Y	Y	Y	Y

Panel B: Additional financing characteristics

	(1) ln(Pre-money Valuation)	(2) Equity Sold	(3) ln(Syndication Size)	(4) Has Pre-VC Financing
Bank Expo × Post	−0.106***	−0.003	−0.028**	0.011**
	(0.029)	(0.005)	(0.011)	(0.004)
State GDP growth	−0.003	0.002*	0.004	−0.001
	(0.006)	(0.001)	(0.004)	(0.002)
Log of GDP p.c.	−1.611**	−0.086	−0.329	−0.088
	(0.643)	(0.109)	(0.226)	(0.188)
Constant	19.876***	1.230	4.366*	1.216
	(7.065)	(1.194)	(2.476)	(2.067)
Observations	5,903	5,903	12,788	12,788
Adj. R^2	0.203	0.166	0.054	0.123
State FE	Y	Y	Y	Y
Financing Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Series A or Seed FE	Y	Y	Y	Y
Startup Age FE	Y	Y	Y	Y

Table 8: Distance of out-of-state VCs and having in-state VCs

This table examines the relation between the distance of out-of-state VC investors to a startup and having an in-state VC syndicate at the startup level. The sample consists of startups' first VC funding and is conditional on having an out-of-state VC investor in the funding. The sample period is over 2010–2018 for all columns except column (4) in which it is over 2011–2017. In column (3), startups headquartered in California are excluded from the sample. The dependent variable is a dummy variable indicating whether the startup has raised capital in its first VC funding from an investor locating in the same state as the startup. "Log Dist of Out-of-state VC" is the natural log of the average geodesic distance between the out-of-state VC investors and the focal startup. "State FE" and "Financing Year FE" indicate dummies for a startup's headquarter state and year receiving their first VC financing. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by startup headquarter state.

	Has In-state VC			
	(1)	(2)	(3)	(4)
	All	All	ex. CA	11-17
Log Dist of Out-of-state VC	0.032***	0.032***	0.031***	0.032***
	(0.008)	(0.008)	(0.009)	(0.009)
State GDP growth		−0.001		
		(0.003)		
Log of GDP p.c.		0.293*		
		(0.165)		
Constant	0.479***	−2.734	0.425***	0.497***
	(0.058)	(1.814)	(0.062)	(0.065)
Observations	7,769	7,709	5,308	6,105
Adj. R^2	0.109	0.109	0.080	0.106
State FE	Y	Y	Y	Y
Financing Year FE	Y	Y	Y	Y

Table 9: Having in-state vs. out-of-state VC investors

This table presents diff-in-diff analyses examining the impact of the Volcker Rule on the composition of in-state vs. out-of-state VC investors at the startup level. The dependent variables are: a dummy variable indicating whether the startup has raised capital in its first VC funding from an investor locating in the same state as the startup in columns (1) - (3), and from an investor locating in a different state in columns (4) - (6). The sample period is over 2010–2018 for all columns except columns (3) and (6) in which the sample period is over 2011–2017. In columns (2) and (5), startups headquartered in California are excluded from the sample. "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if the startup raised its first VC financing after 2014, and 0 otherwise. "State FE" and "Financing Year FE" indicate dummies for a startup's headquarter state and year receiving their first VC financing. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by startup headquarter state.

	Has In-state VC			Has Out-of-state VC		
	(1) All	(2) ex. CA	(3) 11-17	(4) All	(5) ex. CA	(6) 11-17
Bank Expo × Post	−0.021***	−0.020**	−0.020**	−0.010	−0.008	−0.011
	(0.007)	(0.007)	(0.010)	(0.008)	(0.009)	(0.009)
State GDP growth	−0.003	−0.003	−0.008**	0.006*	0.001	0.005
	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)
Log of GDP p.c.	0.568***	0.417	0.475**	−0.074	−0.038	−0.042
	(0.149)	(0.307)	(0.224)	(0.227)	(0.389)	(0.302)
Constant	−5.397***	−3.807	−4.344*	1.374	1.089	1.018
	(1.635)	(3.371)	(2.449)	(2.489)	(4.271)	(3.317)
Observations	15,503	8,400	12,373	15,503	8,400	12,373
Adj. R^2	0.093	0.065	0.084	0.088	0.076	0.079
State FE	Y	Y	Y	Y	Y	Y
Financing Year FE	Y	Y	Y	Y	Y	Y

Table 10: Startup migration to VC hubs

This table presents diff-in-diff analyses examining the impact of the Volcker Rule on startups' migration to VC hubs using samples derived from Form D filings at the startup-year level (Panel A) and from the VentureSource database at the startup-quarter level (Panel B). The sample in Panel A includes startups that are at most five years old in 2014 when the treatment starts, i.e. those incorporated during 2009–2013, and track them over the period of 2010–2018. The sample in Panel B includes startups that raised their first VC financing over the 2011–2013 period, and track them over the quarters of 2013Q2–2018Q4. In columns (2), (4) and (6) of both panels, only startups that have ever moved to another state are included. The dependent variables in this table are dummy variables indicating whether a startup has moved its headquarter to: CA in columns (1) - (2), one of the VC hubs including CA, MA and NY in columns (3) - (4), and any other state in columns (5) - (6). "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if the observation is after 2014, and 0 otherwise. In Panel A, "Year FE", "Industry FE", "Incorporation State FE", and "Incorporation Year FE" indicate dummies for the tracking year, a startup's industry group, incorporation state, and incorporation year. In Panel B, "Quarter FE", "Financing Year FE" and "Industry FE" indicate dummies for the tracking quarter, year receiving the first VC financing, and a startup's industry group. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by the initial headquarter state of startups.

Panel A: Startup migration based on Form D filings

	Moved to CA		Moved to VC hubs		Moved to Another State (Placebo)	
	(1) All	(2) cond. on moving	(3) All	(4) cond. on moving	(5) All	(6) cond. on moving
Bank Expo × Post	0.010**	0.088***	0.014**	0.098***	0.011	0.046
	(0.004)	(0.032)	(0.006)	(0.033)	(0.010)	(0.031)
Bank Expo	0.002***	0.003	0.002**	−0.001	0.004***	0.000
	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.004)
Constant	0.002	0.036***	0.005*	0.089***	0.014***	0.225***
	(0.001)	(0.011)	(0.003)	(0.016)	(0.004)	(0.006)
Observations	24,061	1,860	24,061	1,860	24,061	1,860
Adj. R^2	0.002	0.013	0.002	0.003	0.002	-0.014
Year FE	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y
Incorporation State FE	Y	Y	Y	Y	Y	Y
Incorporation Year FE	Y	Y	Y	Y	Y	Y
Mean of Dep. Var.	0.004	0.055	0.008	0.107	0.018	0.234

Panel B: Startup migration conditional on VC financing

	Moved to CA		Moved to VC hubs		Moved to Another State (Placebo)	
	(1)	(2)	(3)	(4)	(5)	(6)
	All	cond. on moving	All	cond. on moving	All	cond. on moving
Bank Expo × Post	0.001***	0.008**	0.001**	0.010**	0.001	0.009
	(0.000)	(0.003)	(0.000)	(0.004)	(0.001)	(0.010)
Bank Expo	−0.000	−0.007*	−0.000	−0.010**	0.000	−0.009
	(0.000)	(0.003)	(0.000)	(0.004)	(0.001)	(0.009)
Constant	0.001	0.012***	0.001***	0.022***	0.002***	0.047***
	(0.000)	(0.004)	(0.000)	(0.002)	(0.000)	(0.001)
Observations	159,148	8,181	159,148	8,181	159,148	8,181
Adj. R^2	0.000	0.006	0.001	0.011	0.001	0.025
Quarter FE	Y	Y	Y	Y	Y	Y
Financing Year FE	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y
Mean of Dep. Var.	0.001	0.012	0.001	0.022	0.002	0.046

Internet Appendix A: Venture Capital Revenue

According to the FFIEC instructions on filing Call Reports, bank investments in VC funds with non-controlling stakes should adopt the equity method of accounting. Under this method, the carrying value of a bank's investment in a VC fund is originally recorded at cost but is adjusted periodically to record as income the bank's proportionate share of the fund's earnings or losses and decreased by the amount of cash dividends or similar distributions received from the fund.

Capturing earnings or losses from their VC investments, venture capital revenue is reported by banks on their Call Reports as part of non-interest income since 2001. To better understand the sources of this income, consider an example in which a bank invests as an LP into VC fund X. They invest \$I and receive 20% of the fund (i.e. they are 20% of total committed capital), and the bank's equity position in the fund is 20% of all proceeds up to \$I/0.2, and 80%*20% of all distributions after \$I is paid back (i.e., 20% carry). The fund has a 2% annual fee on committed capital, i.e., \$I*0.02 is paid by the bank every year. For the bank's VC investments in fund X, we can then analyze whether there will be venture capital revenue booked for different types of events.

1. *Capital commitment:* After the bank makes capital commitments to VC fund X and signs the commitment agreement, the bank has a legal liability to pay \$I to the fund over the next 10 years. However, if this commitment does not come with an initial cash transfer, then there will be no accounting entries on the bank's accounting books, and no venture capital revenue booked. On the other hand, if it does come with a cash transfer (as initial investment), it is equivalent to a capital call (analyzed below). Under the equity method of accounting, the bank will record this initial investment in its long-term equity investment account, but will not book any venture capital revenue.
2. *Management fee:* After VC fund X starts operating, the bank pays the fund \$I*0.02

each year for the cost of managing the fund. Paid out of the original capital commitment \$I, the management fee is considered part of the investment cost and will not have venture capital revenue effect. Therefore, it will not be booked as venture capital revenue.

3. *Capital calls (Drawdown):* Suppose fund X makes a capital call of \$Z. After receiving a notice of the capital call from the fund, the bank will transfer the cash of \$Z to the fund within a given time. Then the bank will increase the carrying value of its VC investments by \$Z in its long-term equity investment account. In this case, the bank will not book any venture capital revenue. Note that the sum of all calls will be \$(I - 0.02*10*I) (i.e., invested capital).

4. *VC marks up or down the investment:* Suppose at the end of each quarter, VC fund X marks up or down the bank's investment from \$Z to \$Z+m, where m can be positive or negative. According to the U.S. Financial Accounting Standards Board (FASB) accounting standards (see Topic 946, the AICPA Audit and Accounting Guide, Investment Companies), VC funds are treated as investment companies for accounting purposes and thus will use the fair value method of accounting. Under this method, when the VC fund marks up or down the investment, the VC fund will record the change on its own accounting books either as income or losses. Because the bank uses the equity method of accounting, it will accordingly record the adjustments \$m as venture capital revenue.

5. *Capital distribution:* Suppose VC fund X sells its investments (e.g. after a portfolio company exit) at a price \$Z+m+n (the bank's proportionate share), and the bank receives a capital distribution (cash) in that amount. In this case, the bank will reduce the carrying value of its VC investments from \$Z+m to 0 in its long-term equity investment account. At the same time, the bank will book the extra \$n (it can be either positive or negative) as venture capital revenue. Note that after the capital

distribution, the bank's position in VC fund X is no longer active.

6. *The bank (either partially or fully) sells it position in the fund:* Suppose the bank has a position left in the VC fund at time t with original book value of 4*$Z and current carrying value of $Y, and then the bank sells that position in the VC fund for $V. In this case, after the bank sells its position, the bank reduces the carrying value of its VC investments from $Y to 0 and records the difference between $Y and $V, i.e. $(V-Y) as venture capital revenue in its income statement in the period of sale. Note that the venture capital revenue recorded is the difference between the price sold and the current fair value of the bank's VC investment, not the book value. Under the equity method of accounting, the bank adjusts the value of its VC investments over time according to capital calls, capital distribution, and changes in the fair value of VC funds' investments.

In summary, under the equity method of accounting, a bank investing in VC funds will report venture capital revenue when the VC fund reports earnings or losses, e.g. in the case of writing up or down the fund value or making capital distributions. This is also consistent with the FFIEC's direct instruction on how venture capital revenue should be reported in Call Reports (see instructions for item 5.e of Schedule RI – Income Statement of Call Reports):

> Report as venture capital revenue market value adjustments, interest, dividends, gains, and losses (including impairment losses) on venture capital investments (loans and securities). Include any fee income from venture capital activities that is not reported in one of the preceding items of Schedule RI, Income Statement.
>
> Also include the bank's proportionate share of the income or loss before extraordinary items and other adjustments from its investments in equity method investees that are principally engaged in venture capital activities. Equity method investees include unconsolidated subsidiaries; associated companies; and corporate joint ventures, unincorporated joint ventures, general partnerships, and limited partnerships over which the bank exercises significant influence.

Finally, capturing the earnings/losses from VC investments but not the amount of capital allocated to the asset class, venture capital revenue is more representative of banks' VC investment position only when observed in a relatively long window. First, VCs' investments in startups are illiquid, the VC fund's earnings or losses may not be adjusted frequently. Therefore, banks may not report any venture capital revenue in a short period of time. Second, the venture capital revenue reported could exhibit strong cyclic patterns based on the VC fund's investment life. A VC fund is more likely to have large gains towards the second half of its life during which there will be more startups having exits (either through IPO or acquisition). For these reasons, we construct our measure of VCs' bank exposure using venture capital revenue over a relatively long window, 2001–2013, to more precisely capture banks' involvement in VC.

Internet Appendix B: Additional Figures and Tables

Figure IB.1: Number and fraction of banks with negative VC revenue by year

This figure plots the number and fraction of banks with negative VC revenue by reporting year from 2001 to 2018. The data come from banks' Call Reports. The vertical line represents the year 2013, the last year before the implementation of the Volcker Rule. We determine that a bank has negative VC revenue in a reporting year if it reports negative revenue in any of the 4 quarters in that year.

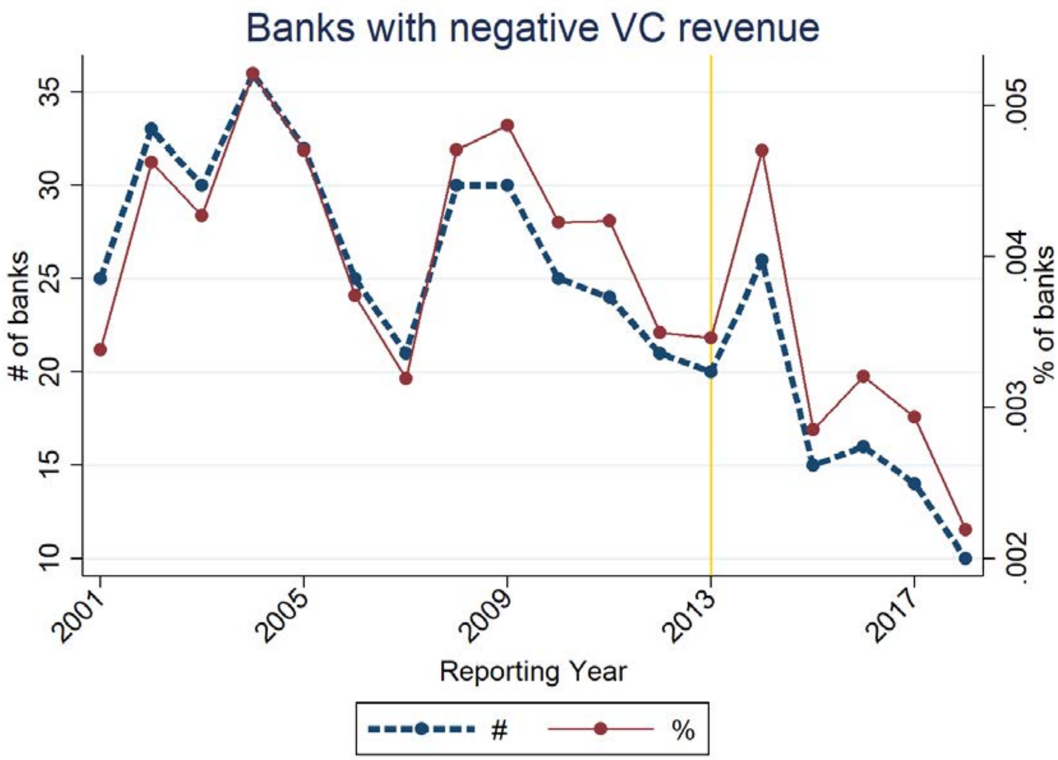
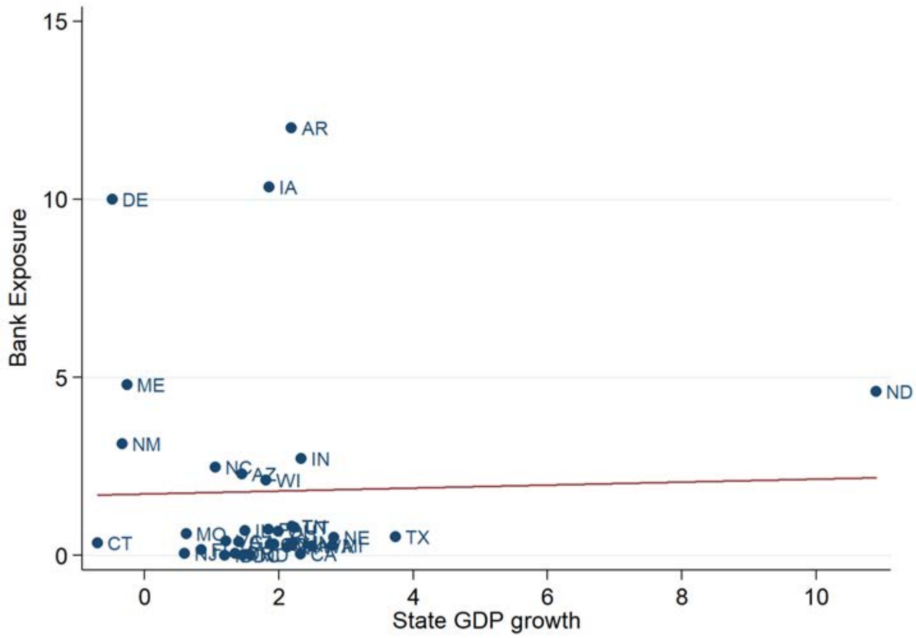


Figure IB.2: Bank exposure and state-level attributes

This figure presents the scatter plots of the bank exposure variable against state attributes: GDP growth in Panel A and log GDP per capita in Panel B. The state attributes are averaged over the pre-Volcker period 2010–2013 to reduce the influence of outliers, while time-varying analogues of these measures are included as state-year level controls in our regressions.

Panel A: State GDP growth



Panel B: State GDP per capita

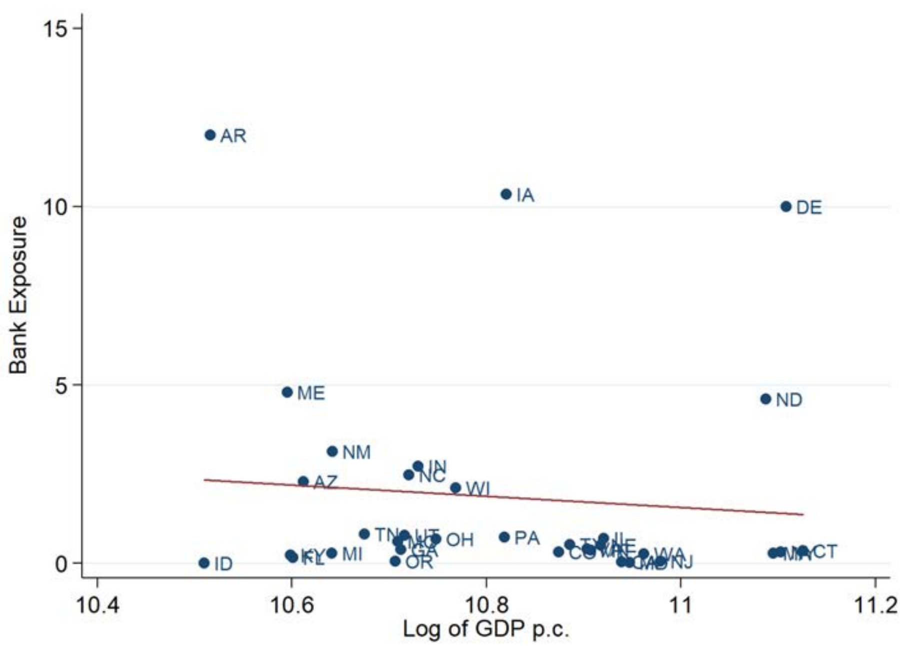
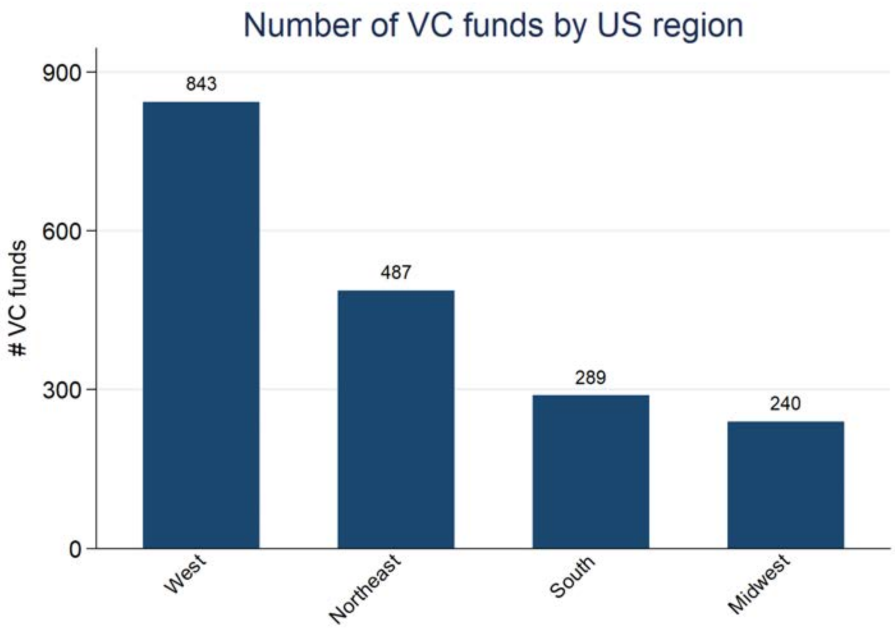


Figure IB.3: VC fundraising by U.S. region

Panel A of this figure plots VC fundraising activity by U.S. region based on VC funds closed over the 2001–2013 period. VC fundraising activity is measured by the number of VC funds. Panel B of this table plots the median size of VC funds closed over the 2001–2013 period by U.S. region. The fund size is expressed in millions of 2019 dollars. The data come from the VentureSource database.

Panel A: Number of VC funds



Panel B: Total VC capital

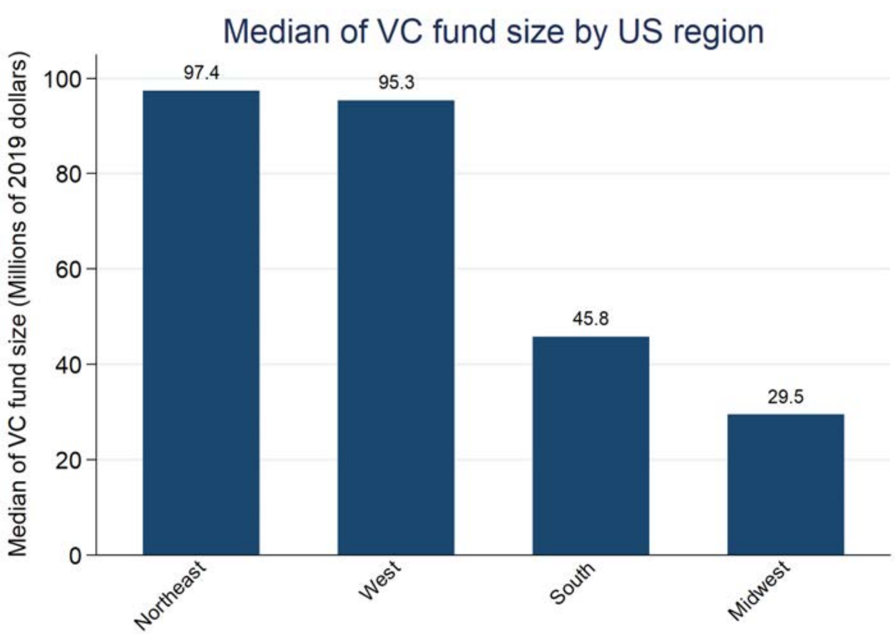
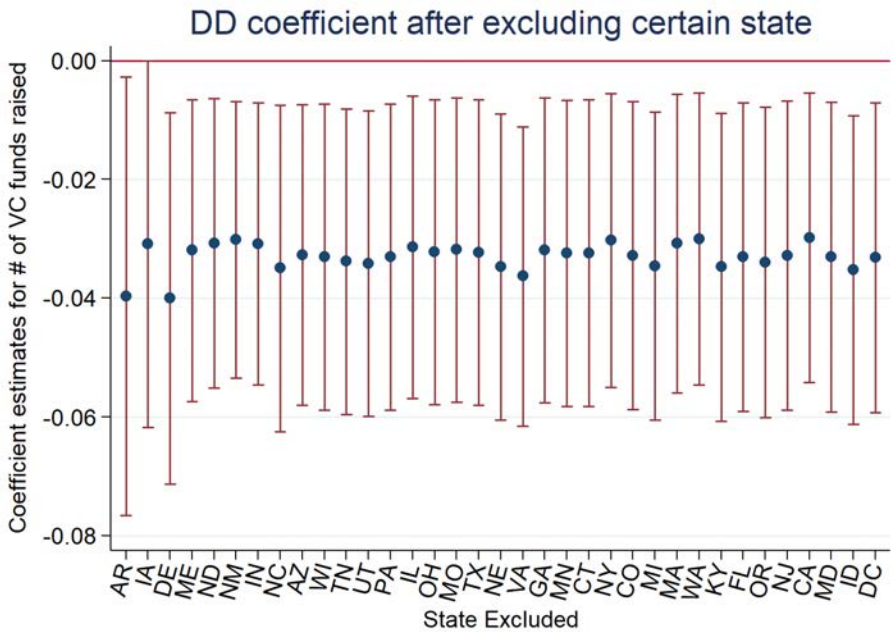


Figure IB.4: Difference-in-difference estimates with one state excluded

This figure provides robustness checks for our main results in Tables 4 and 7 by excluding one state at a time from the main regression samples. We plot the corresponding diff-in-diff coefficient estimates for each state excluded. The estimates are based on the state-year sample with the natural log of one plus the number of VC funds raised as the dependent variable in the upper panel, and the startup sample with the natural log of capital raised in a startup's first VC funding as the dependent variable in the lower panel. The vertical red lines represent the 95% confidence interval for the coefficient estimates with standard errors clustered by state.



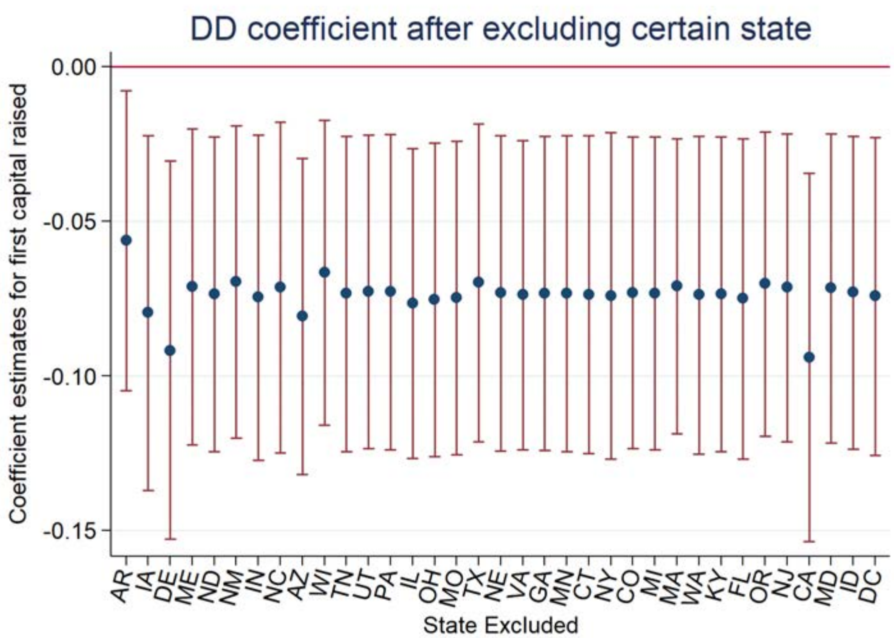


Figure IB.5: Difference-in-difference estimates for first venture capital raised

This figure plots the coefficients for the interaction terms of each financing year and the bank exposure variable estimated from a dynamic version of Eq. (1) where the dependent variable is the log of first venture capital raised and the unit of observation is a VC-backed startup. The 2014 interaction term is the excluded category, reported as zero in the figure. The vertical red lines represent the 95% confidence interval for the coefficient estimates with standard errors clustered by startup headquarter state.

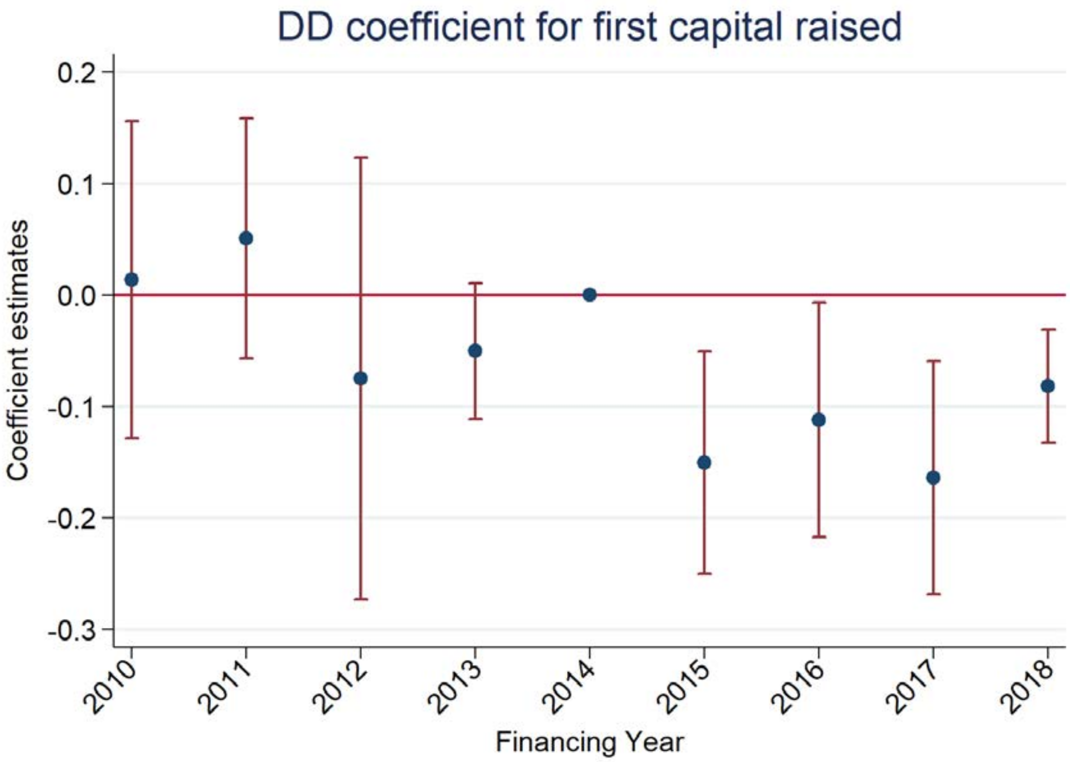


Table IB.1: Summary statistics for banks

The table presents summary statistics of bank characteristics for the sample of banks with and without VC revenue reported over the 2001–2013 period. "Total Assets (B)" is the average of banks' total assets over 2001–2013 in billions of 2019 dollars; "Total Deposits (B)" is the average of banks' total deposits over 2001–2013 in billions of 2019 dollars; "No Foreign Office" is a dummy variable indicating whether the bank only has domestic offices as identified in their Call Reports; "High/Low Exposure States" are dummy variables indicating whether the bank is located in a state with VCs' bank exposure above/below the sample median; "# Year with VC" is the number of years a bank reports VC revenue over 2001–2013.

Panel A: The sample of banks with VC revenue

	N	Mean	Std. Dev.	5-%ile	25-%ile	50-%ile	75-%ile	95-%ile
Total Assets (B)	191	37.35	166.55	0.05	0.18	0.61	4.37	167.11
Total Deposits (B)	191	19.35	79.48	0.05	0.14	0.49	3.38	92.97
No Foreign Office	191	0.83	0.36	0.00	1.00	1.00	1.00	1.00
High Exposure States	191	0.64	0.48	0.00	0.00	1.00	1.00	1.00
Low Exposure States	191	0.36	0.48	0.00	0.00	0.00	1.00	1.00
# Year with VC	191	3.54	3.98	0.00	1.00	2.00	6.00	13.00

Panel B: The sample of banks without VC revenue

	N	Mean	Std. Dev.	5-%ile	25-%ile	50-%ile	75-%ile	95-%ile
Total Assets (B)	8767	0.88	6.54	0.03	0.08	0.16	0.37	1.90
Total Deposits (B)	8767	0.56	3.20	0.02	0.07	0.13	0.30	1.43
No Foreign Office	8767	0.99	0.11	1.00	1.00	1.00	1.00	1.00
High Exposure States	8767	0.57	0.50	0.00	0.00	1.00	1.00	1.00
Low Exposure States	8767	0.43	0.50	0.00	0.00	0.00	1.00	1.00

Table IB.2: Distribution of banks by state

This table reports the mean of state-year level characteristics in banks over the 2001–2013 period for different groups of U.S. states. "# Banks per State" is the total number of banks headquartered in each state; "Avg. Bank Assets (B)" is the average of banks' total assets in a given state in billions of 2019 dollars; "# Banks per Mil Pop" is the total number of banks in a given state scaled by the state population measured in millions; "Bank Deposits p.c. (K)" is the amount of bank deposits per capita in thousands of 2019 dollars in a given state; "GDP p.c. (K)" is the amount of GDP per capita in thousands of 2019 dollars in a given state. "High Exposure States" are states with VCs' bank exposure above the sample median.

	# Banks per State	Avg. Bank Assets (B)	# Banks per Mil Pop	Bank Deposits p.c. (K)	GDP p.c. (K)
US	170	2.53	38.88	46.89	51.07
High Exposure States	214	3.63	48.20	52.88	47.23
Low Exposure States	141	1.80	32.67	42.89	53.64
South	181	3.40	30.03	49.13	54.98
Midwest	279	2.45	78.33	87.86	48.12
Northeast	98	2.06	18.03	18.14	53.99
West	82	1.71	21.51	17.35	46.41

Table IB.3: Changes in the aggregate of VC activity

Using the same specifications as Panel A of Table 4, this table presents diff-in-diff analyses examining the impact of the Volcker Rule on the aggregate of VC activity at the state-year level. Specifically, using the same dependent variables as Panel C of Table 4, Panel A of this table reports the OLS regression results of estimating Eq. (1) with the aggregate of VC fundraising activity as the dependent variables over the two-year period of 2013–2014 around the implementation of the Volcker Rule. Panel B reports the OLS regression results of estimating Eq. (1) with the natural log of one plus the aggregate amount of capital invested in startups' initial VC financings as the dependent variable.

Panel A: VC fundraising over narrow window (2013-2014)

	ln(# VC Funds)	ln(Total VC Capital)	ln(# VC Funds)		
	(1) All	(2) All	(3) small	(4) medium	(5) large
Bank Expo × Post	−0.056***	0.005	−0.051**	−0.023	0.009
	(0.020)	(0.008)	(0.021)	(0.029)	(0.017)
State GDP growth	0.011	0.001	−0.003	−0.010	0.019
	(0.015)	(0.004)	(0.011)	(0.012)	(0.014)
Log of GDP p.c.	−7.018	2.510	−5.187	−4.290	2.189
	(4.705)	(1.914)	(5.742)	(3.945)	(4.397)
Constant	77.356	−27.005	57.025	47.131	−23.264
	(51.086)	(20.777)	(62.344)	(42.842)	(47.739)
Observations	70	70	70	70	70
Adj. R^2	0.846	0.866	0.668	0.689	0.671

Panel B: Total capital invested in initial VC fundings

	ln(Capital Invested in Initial Funding)		
	(1) All	(2) All	(3) 11-17
Bank Expo × Post	−0.007**	−0.007**	−0.006***
	(0.003)	(0.003)	(0.002)
State GDP growth		−0.000	
		(0.002)	
Log of GDP p.c.		0.340	
		(0.278)	
Constant	0.127***	−3.570	0.127***
	(0.003)	(3.023)	(0.002)
Observations	315	315	245
Adj. R^2	0.947	0.948	0.962
State FE	Y	Y	Y
Year FE	Y	Y	Y

Table IB.4: Falsification tests with measures less impacted by the Volcker Rule

This table reports the falsification tests of our diff-in-diff model specified in Eq. (1) at the state-year level using measures of economic activities that are not directly related to VCs and presumably also less impacted by the Volcker Rule. The sample period is over 2010–2018 for all columns. The dependent variables are the natural log of one plus the average market valuation of VC-backed IPOs in column (1), the natural log of one plus the total market valuation of VC-backed IPOs in column (2), the natural log of one plus the number of VC-backed IPOs in column (3), the natural log of one plus the total number of patents filed by VC-backed companies in column (4), state GDP growth in column (5), and the natural log of state GDP per capita in column (6). "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if the observation is after 2014, and 0 otherwise. All regressions include state fixed effects and year fixed effects. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by state.

	IPO			Patents	GDP	
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Avg. MktVal of VC-backed IPO)	ln(Total MktVal of VC-backed IPO)	ln(# of VC-backed IPO)	ln(# of Patents by VC-backed Companies)	State GDP Growth	Log of GDP p.c.
Bank Expo × Post	−0.001	−0.009	−0.008	−0.003	−0.137	−0.002
	(0.037)	(0.039)	(0.007)	(0.016)	(0.125)	(0.002)
Constant	2.407***	2.736***	0.538***	3.631***	2.161***	10.880***
	(0.037)	(0.039)	(0.007)	(0.017)	(0.125)	(0.002)
Observations	315	315	315	315	315	315
Adj. R^2	0.495	0.585	0.789	0.963	0.154	0.991
State FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y

Table IB.5: GP finance and banking background across states

This table compares GPs' prior finance background and work experience for VC firms located in the treated states (we select the top seven states with the highest bank exposure: AR, IA, DE, ME, ND, NM, IN) with those located in the control states (we select the three VC hubs: CA, MA, NY). For all VC firms in these ten selected states that have raised at least one VC fund over the 2010–2013 pre-Volcker period, we manually collect all their GPs' education background and employment information prior to working at the current VC job from LinkedIn. Based on this information, we examine GPs' finance background in the first two columns with the following dependent variables: a dummy variable indicating whether the GP has worked at a financial firm before working at current job in column (1), and the natural log of one plus the number of years working in financial firms. We further break down GPs' finance experience, and examine their background in banking (columns (3) and (4)) and VC industry (columns (5) and (6)). The dependent variables in columns (3) - (6) are defined similarly to those in columns (1) and (2). In the last three columns, we examine GPs' education background with the following dependent variables: a dummy variable indicating whether the GP has received an MBA degree (column (7)), a JD degree (column (8)), or a PhD degree (column (9)). "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "ln(VC Fund Size)" is the natural log of the average size of all VC funds raised by the VC firm over the 2010–2013 pre-Volcker period. "GP Start Year FE" indicate dummies for the year when the GP starts her current VC job. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by state.

	Finance		Bank		VC		Education		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Has Background	ln(Years of Exp)	Has Background	ln(Years of Exp)	Has Background	ln(Years of Exp)	Has MBA	Has JD	Has PhD
Bank Expo	−0.090**	−0.165**	0.003	0.018	−0.078***	−0.154**	−0.064	−0.022	0.068
	(0.028)	(0.055)	(0.032)	(0.064)	(0.020)	(0.050)	(0.044)	(0.012)	(0.067)
ln(VC Fund Size)	0.012	−0.000	0.004	−0.005	0.001	−0.010*	0.001	0.003	0.010
	(0.019)	(0.033)	(0.017)	(0.030)	(0.003)	(0.004)	(0.009)	(0.005)	(0.014)
Constant	0.300**	0.653**	0.105	0.239	0.196***	0.403***	0.409***	0.045	0.020
	(0.115)	(0.201)	(0.094)	(0.186)	(0.014)	(0.026)	(0.048)	(0.023)	(0.074)
Observations	254	254	254	254	254	254	254	254	254
Adj. R^2	-0.035	-0.043	-0.059	-0.046	-0.008	-0.026	-0.041	-0.000	0.041
GP Start Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table IB.6: Impacts on additional startup financing characteristics

Using the same specifications as Table 7, this table presents diff-in-diff analyses examining the impact of the Volcker Rule on additional startup financing characteristics. Specifically, this table reports the OLS regression results of estimating Eq. (1) with the following dependent variables: the natural log of post-money valuation for the startup's first VC funding in column (1), the natural log of capital raised per investor in the startup's first VC funding in column (2), a dummy variable indicating whether the founding team of the startup has a serial entrepreneur in column (3) and the natural log of a startup's age at its first VC funding in column (4).

	(1)	(2)	(3)	(4)
	ln(Post-money Valuation)	ln(Capital Raised per Investor)	Ha Serial Entrepreneur	ln(Startup Age)
Bank Expo × Post	−0.106***	−0.049**	0.004	−0.012*
	(0.027)	(0.018)	(0.004)	(0.006)
State GDP growth	0.001	0.017	0.002	0.000
	(0.006)	(0.011)	(0.002)	(0.003)
Log of GDP p.c.	−1.819***	−1.536**	−0.264***	0.045
	(0.642)	(0.746)	(0.096)	(0.223)
Constant	22.527***	16.782**	3.064***	0.431
	(7.054)	(8.188)	(1.055)	(2.452)
Observations	5,903	11,048	12,788	12,786
Adj. R^2	0.249	0.254	0.028	0.171
State FE	Y	Y	Y	Y
Financing Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Series A or Seed FE	Y	Y	Y	Y
Startup Age FE	Y	Y	Y	N

Table IB.7: Aggregate of SBIC venture fundraising activities

This table presents diff-in-diff analyses examining the impact of the Volcker Rule on the aggregate of SBIC venture fundraising activity at the state-year level over the 2010–2018 period. Specifically, it reports the OLS regression results of estimating Eq. (1) with the following dependent variables: the natural log of one plus the number of SBIC venture funds raised in column (1), a dummy variable indicating whether there is an SBIC venture fund raised in column (2), the natural log of one plus the number of bank-affiliated SBIC venture funds raised in column (3), and a dummy variable indicating whether there is a bank-affiliated SBIC venture fund raised in column (4). The data come from a FOIA request to the SBA and include all VC funds that participate in the SBIC program. "Bank Expo" is a continuous treatment variable measuring VCs' reliance on banks for capital prior to the Volcker Rule. "Post" is set to be 1 if an SBIC venture fund is raised after 2014, and 0 otherwise. All regressions include state fixed effects and fund closing year fixed effects. ***, **, and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses are clustered by state.

	(1)	(2)	(3)	(4)
	ln(# SBIC)	Raised SBIC?	ln(# Bank-owned SBIC)	Raised Bank-owned SBIC?
Bank Expo × Post	0.017	0.012	0.005*	0.006*
	(0.014)	(0.017)	(0.003)	(0.004)
Constant	0.371***	0.379***	0.030***	0.041***
	(0.014)	(0.017)	(0.003)	(0.004)
Observations	315	315	315	315
Adj. R^2	0.471	0.277	0.115	0.135
State FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y