Concentration and Geographic Proximity in Antitrust Policy: Evidence from Bank Mergers

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Abstract

We present evidence that market concentration (HHI) based antitrust policy in the banking industry misses anticompetitive effects of mergers that are empirically predictable using an observable determinant of bank substitutability: the proximity of their branch networks. Our difference-in-differences estimates reveal that mergers of close-proximity banks lead to more branch closures. These closures have heterogeneous, adverse impacts on consumer distances to banks. Moreover, close-proximity mergers caused rival banks to offer worse interest rates, and caused a decline in the merging banks' deposit growth. We argue that bank antitrust could be improved by complementing the HHI-dependent policy with criteria on bank proximity.

Keywords: Antitrust, Banking, Mergers & Acquisitions, Heterogeneous effects, Non-price effects, Difference-in-Differences.

JEL Codes: L1, L4, G21.

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1 Introduction

Banking is an important industry with an unusually high merger volume. There were more than 10,000 bank mergers over the past four decades in the U.S., about 250 every year, affecting financial assets and deposits worth trillions of dollars. The impact of bank mergers on financial market structure has significant implications for the broader economy as well, affecting monetary policy transmission (Drechsler et al., 2017), economic growth (Jayaratne and Strahan, 1996), firm entry and exit (Fraisse et al., 2018), asset prices (Favara and Imbs, 2015), bankruptcy (Dick and Lehnert, 2010), and crime (Garmaise and Moskowitz, 2006). The executive order on promoting competition encourages the relevant agencies to "review current practices and adopt a plan ... for the revitalization of merger oversight under the Bank Merger Act and the Bank Holding Company Act" (Biden, 2021).

Every proposed bank merger is reviewed by antitrust authorities, the Department of Justice (DOJ) and the Federal Reserve (Fed). Bank merger review differs from antitrust policy for other industries in a few important ways, described in Section 2, and relies heavily on predefined banking markets and on thresholds of market concentration as measured by the Herfindahl Hirschman Index (HHI). This paper examines whether this HHI-based policy overlooks merger harm that could be identified with information about the proximity of merging banks.

A merger's effects depend not only on market shares but also on the similarity of merging firms, on how closely they substitute for and thus compete with each other. Because the HHI primarily conveys information on size within a market definition, HHI-based policy is potentially vulnerable to mismeasurement of substitutability.[1] An important and easily measurable determinant of subsitutability is distance between two banks. In the Survey of Consumer Finances, 40% of respondents cited location as the most important reason they chose their bank, while only 12% of respondents chose their bank based on prices (Benson et al., 2020).[2] Consumers

[1]The 2010 Horizontal Merger Guidelines recognize the importance of substitutability. Although there is theoretical basis for the use of HHIs in differentiated product settings, antitrust enforcement can be vulnerable to reliance on size and HHI thresholds (Wollmann, 2019; Nocke and Whinston, 2020) and market definitions (Carlton and Israel, 2021).

[2]Strong preferences for branch network convenience are also evident in structural demand models, see e.g. Ho and Ishii (2011); Kuehn (2018); Honka, Hortaçsu and Vitorino (2017).

are therefore more likely to view banks with branches near each other as close substitutes. This reasoning suggests that the proximity of merging branch networks might convey information on the anticompetitive effects bank mergers beyond what is captured by the HHI.

We use a difference-in-differences strategy to test this hypothesis, and find that HHI-based policy neglects important non-price effects and effects on competitors of the merging parties that are empirically determined by the proximity of merging branch networks. Close-proximity bank mergers lead to more branch closures and also cause rival banks to offer worse interest rates, and a decline in the merging banks' deposit growth. These harms of close-proximity mergers are evident after conditioning on the HHI, in particular after accounting for HHI-based enforcement actions, and likely have significant effects on welfare. Structural estimates of demand from the literature (Ho and Ishii, 2011), for example, suggest that our estimates of effects of branch closures are equivalent to a 35% price increase for the 15% of consumers who must travel farther to branch locations after close-proximity mergers. Bank antitrust might be improved by complementing the HHI-dependent policy with criteria on branch proximity to mitigate the HHI's vulnerability to mismeasurement of substitutability.

We present the formal empirical strategy in Section 4. The outcomes we study are in part determined by market structure. A merger results in a discrete change in the structure of overlap markets, where both merging banks operate before the merger, but does not directly change the structure of non-overlap markets. This naturally leads to a within-merger difference-in-differences (DID) estimator. Our regression specification allows for 4 binned DIDs, defined by whether the local proximity of the merging banks is less than 4 miles, median proximity, and by whether the HHI increases more than 200 points, the regulatory threshold for enforcement in the banking industry.[3] Estimating heterogeneous effects in this way enables us to test whether close proximity determines adverse effects for one of two reasons. Either the close-proximity merger did not trigger antitrust enforcement because the

[3]The change in HHI, ΔHHI, measures the counterfactual increase in HHI that results from consolidating the control of the merging parties' products with all else fixed. Throughout this paper, HHI ranges from 0 to 10,000 and is calculated as the sum of squared deposit market shares.

increase in HHI was below 200. Or, the close-proximity merger was subject to enforcement action aimed primarily at mitigating the increase in HHI. We estimate the heterogeneous effects of mergers on three product attributes—the number of branches, consumer distances to branches, and deposit interest rates (prices)— as well as estimate effects on deposits growth (quantities) to provide suggestive evidence on how price effects and non-price effects impacted consumer welfare on net.

We present the main results in Section 5. Close-proximity mergers cause significantly more branch closures than far-proximity mergers, and this effect does not vary much with the HHI. After close-proximity mergers, merging banks are 40 percentage points more likely to close branches compared to non-overlap markets where they operate, and market total branches are 17 percentage points more likely to decline. We also find that close- and far-proximity mergers have different effects on the distances between consumers and branch networks. Every bank merger leads to a larger branch network by combining two separate smaller networks, and this "convenience" synergy reduces many consumers' distances to the merged bank. The convenience synergy of close-proximity mergers is less than half that of far-proximity mergers, on average. Close-proximity mergers also increase the distance to branches for at least 15 percent of consumers, whereas far-proximity mergers do not.

Section 5 then turns to the effects of bank mergers on prices and quantities. We find that effects on the deposit interest rates of the acquirer bank do not significantly depend on proximity or on the HHI, in fact, market overlap altogether has no significant effect on an acquirer's prices relative to its non-overlap markets. In stark contrast, we find that close-proximity mergers cause rival banks to offer worse (lower) deposit rates. The effects of mergers on competitors' prices is especially pronounced for close-proximity mergers subjected to HHI-based enforcement. This suggests that even if mergers are closely investigated, enforcement aimed primarily at mitigating the HHI potentially neglects anticompetitive effects that could be identified with information on bank proximity. Finally, we find that close-proximity mergers cause adverse quantity outcomes. Within two years of the merger, the merged banks' deposit growth falls over 20 percent relative to growth of the same bank in its non-overlap markets. Based on revealed preference, we interpret our results for deposits quantity as evidence that the price effects and non-price effects of close-proximity mergers decreased consumer surplus on net, whether or not the merger was subject to HHI-based enforcement.

We conduct a number of robustness checks to show that our results are not driven by a particular sample selection, institutional factor, or regression specification. For example one might argue that lowering the HHI thresholds is sufficient to identify mergers with adverse outcomes that our methodology classified as close-proximity, e.g. to identify more anticompetitive price effects (Nocke and Whinston, 2020) or e.g. if one believed that current bank antitrust markets are too broadly defined to capture substitutability at current HHI thresholds. However, our results are very similar when we consider a lower benchmark of 100 instead of 200 for the change in HHI. Moreover, we find that mergers cause more branch closures in census tracts where both the acquirer and the target have branches, relative to tracts in the same banking market where only one party operated a branch. This result suggests that proximity conveys novel information for any plausible market definition, because census tracts are a very small geographic unit. Therefore, it is unlikely that defining narrower markets or lowering HHI thresholds alone could effectively address competitive effects that are empirical determined by close-proximity.

Section 6 discusses implications of our results for antitrust policy. We find that current HHI-based policy effectively gave safe harbor to 61% of close-proximity banking acquisitions. We tabulate several alternative policies that incorporate information on acquirer-target proximity. For example, complementing the HHI policy with a half-mile proximity threshold would increase the number of mergers closely investigated for enforcement by 69%, and raise extra scrutiny on 35% of mergers that trigger current HHI thresholds. We therefore argue that incorporating criteria on geographic proximity would improve bank antitrust policy.

The usefulness of criteria on determinants of substitutability to mitigate vulnerabilities of HHI-based policy may apply more broadly to other differentiated product industries.[4] The horizontal merger guidelines recognize the importance of

[4]The proximity of firms' establishments is known to be an important determinant of the substitutability of hospitals (Dafny, 2009), gasoline retailers (Houde, 2012), chain restaurants (Thomadsen, 2005), movie theaters (Davis, 2006), and grocery stores (Ellickson et al., 2020), among others.

incorporating substitutability independently of market definitions and concentration. However, direct measures of substitutability such as the value of diverted sales are typically unobservable without costly investigation. For industries with easily observable determinants of substitutability and non-price outcomes, regulators have indicators of harm that are naturally free of market definitions and errors in market shares, which might also predict competitive effects missed by HHIs. Authorities could solicit such information from the merging parties during pre-merger reporting at low cost. In particular, mergers of firms below certain size thresholds are rarely considered for premerger review. Criteria on determinants like proximity could be used to identify potentially anticompetitive mergers below the transaction size thresholds.

Our primary contribution is to the literature on antitrust policy based on size and the HHI, including Nocke and Whinston (2020), Wollmann (2019, 2020), Nocke and Schutz (2018), and Froeb and Werden (1998). Although this literature has examined the limitations of size- or HHI-based merger review, there is little merger retrospectives evidence on the predictive merit of current HHI thresholds. We contribute empirical evidence on the usefulness of the HHI for diagnosing both price and non-price effects, as well as evidence that information reflecting substitutability between firms can improve current antitrust policy. Our results suggest that the non-price effects of bank mergers are primarily determined by proximity, and not by the HHI. Moreover, structural demand estimates from the literature would suggest that non-price effects have bigger impacts on consumer welfare than price effects in the banking industry.[5]

Our paper is also related to several papers that study the effects of bank mergers on prices. Focarelli and Panetta (2003) and Prager and Hannan (1998) estimate the effects of bank mergers on deposit rates. Liebersohn (2021) studies effects of antitrust interventions like divestitures on deposit rates. Erel (2011) and Joaquim et al. (2020) estimate effects on loan prices and spreads, and Allen et al. (2014) study effects on the dispersion of mortgage interest rates. Our contributions rela-

[5]See e.g. willingness-to-pay for branches and distance to branch networks in the models of Ho and Ishii (2011); Honka et al. (2017); Dick (2007); Adams et al. (2007); Kuehn (2018, 2020); Egan et al. (2021); Xiao et al. (2021)

tive to these papers are estimates of heterogeneous effects that depend on merger characteristics like proximity, separate results for merging parties as well as their rivals, and evidence on how mergers affect price and non-price outcomes in concert.

Another group of related papers study mergers and bank branch networks. Nguyen (2019) examines how post-merger branch closures affect local small-business loan originations. Akkus et al. (2015) study the effect of geographic overlap on the probability that two banks merge, and Levine et al. (2019) study how banks' post-merger financial performance depends on geographic overlap of pre-merger branch networks. To this literature we contribute new evidence on the effects of mergers on branch accessibility or convenience, and estimates of heterogeneous effects that depend on pre-merger characteristics of branch networks.

Finally, our results contribute to the broader empirical merger retrospectives literature. Our work is most closesly related to retrospective studies that examine the effects of mergers on firms' positions in the product space, notably Berry and Waldfogel (2001) and Sweeting (2010).

2 Institutional Detail

Although antitrust for banking is overall similar to other industries, banking is unique in a few important ways. To begin, the Federal Reserve (Fed) and the Department of Justice (DOJ) review every bank merger for potential anticompetitive effects, typically 200-300 annual transactions. The banking industry annually accounts for about 10% of all transactions reported to the DOJ or Federal Trade Commission for premerger review via the Hart-Scott-Rodino Antitrust Improvements Act. However, unlike most industries, premerger review of bank acquisitions does not depend on Hart-Scott-Rodino size thresholds. Instead, each bank transaction is reviewed. The review involves antitrust market definitions and at least rudimentary estimates of competitive effects.

Due to judicial standards, as in most other industries, the bank merger review process puts considerable emphasis on market definition and the HHI. However, bank antitrust is unique because judicial precedent also puts considerable emphasis on a particular product market.[6] Litigation has focused on the "cluster" of banking products and services typically supplied at branch locations. Consumers of products in the cluster are households and small businesses, as opposed to larger corporations or wealthy individuals, so the cluster is thought to have narrower geographic markets than most other relevant product markets. Thus, compared to other potential antitrust markets impacted by a bank merger, the transaction is more likely to have competitive effects in antitrust markets defined for the cluster.

Geographic markets for the banking cluster do not change very often, even though they are regularly reviewed. Therefore, to accommodate the large number of annual transactions the Fed predefines geographic banking markets ("Fed markets") for the cluster based on any available data on consumers' bank substitution patterns and the local integration of economic activity, including commuting flows.[7] The DOJ in practice often uses very similar, if not the very same, geographic banking markets in their initial competition screen. Within these geographic markets there are detailed public data on bank deposits, and deposits measure a bank's ability to engage in the full range of the cluster.[8]

For these reasons, the Fed and DOJ prioritize bank mergers for enforcement based on local deposits market shares and HHIs. If the deposits HHI increases less than 200 points or if the HHI level is below 1800, and if the market share is less than 35 percent, a merger is almost always approved by the Fed without being subject to enforcement action like divestitures. Although the DOJ has no safe harbor for bank mergers, and will sometimes decompose the "cluster" by local small business lending and deposits when data are available, its bank merger investigations still place considerable emphasis on HHI thresholds. Transactions that exceed the

[6]Three supreme court cases primarily establish these standards: United States v. Philadelphia National Bank, 374 U.S. 321, 356 (1963); United States v. Connecticut National Bank, 418 U.S. 656 (1974); and United States v. Phillipsburg National Bank Trust Co., 399 U.S. 350 (1970).

[7]The Fed views the available data through the lens of the hypothetical monopolist. There were 1,518 Fed markets in 2014, ranging in geographic scope from larger markets comparable to MSAs to smaller markets comparable to counties. An important factor for Fed market definitions are commuting flows and geographic barriers such as mountains and bodies of water, which signal how easily clients can switch to alternative banks to obtain products and services in the cluster.

[8]Local deposits volume is an aggregate measure over the bank's many deposits products and is also a bank's primary and most important source of funds, determining the scale of its supply of loans and other banking services.

agencies' (Fed and DOJ) thresholds are investigated closely, including analysis of market definitions and scrutiny for competitive effects across the merging banks' lines of business. Bank mergers exceeding the thresholds after initial review are much more likely to be subject to enforcement actions like divestitures. The HHI factors heavily into enforcement actions, as in other industries, because the "courts have regularly relied on the thresholds articulated in the 2010 HMG in finding a presumption that a merger is anticompetitive" (Peters and Wilder, 2021).

Clearly, bank antitrust policy depends crucially on HHIs, and the policy-relevant HHIs depend on lines drawn for geographic market definitions and bank size as measured by local deposits. One might question whether antitrust markets based on geographic competition still reflect consumer demand today. For example, internet banking could make local banking competition less important. However, survey evidence suggests that many consumers still choose their main banking institution based on branch location (Benson, Grundl and Windle, 2020; Anenberg, Chang, Grundl, Moore and Windle, 2018; Honka, Hortaçsu and Vitorino, 2017). In the Survey of Consumer Finances, consumer preferences for geographically close banks have persisted, and remain a much more important determinant of choice than other product attributes (Benson et al., 2020). The share of respondents using online banking increased from about 30% in 2004 to 60% in 2016 . Over the same period, the share of respondents who cite branch location as the primary determinant of their bank choice was stable at around 40% and the share of respondents who made bank choices primarily based on prices (e.g. interest rates and fees) was much lower at around 12%. Several studies that estimate structural models of demand for banking corroborate the survey evidence, suggesting strong willingness-to-pay either for branches or for reduced distance to branch networks (Ho and Ishii, 2011; Honka et al., 2017; Dick, 2007; Adams et al., 2007; Kuehn, 2018, 2020; Egan et al., 2021; Xiao et al., 2021). Because of consumer preferences for convenience, geographic competition remains important in the banking industry despite the evolution of competition over the time window we study.

These institutional features have several advantages for studying vulnerabilities of HHI-based policy. The policy-relevant market definitions and market shares are observed for all banks over the entire sample period. Every bank merger over the sample period is observed and, because the agencies' review criteria are nearly algorithmic, we can reliably identify mergers that evaded enforcement based on the HHI. The importance of geographic competition suggests that the proximity of branch networks is likely a determinant of competitive effects of bank mergers, whether or not the policy-relevant HHI triggers antitrust enforcement. The same dataset measuring local deposits provides the exact location of every bank branch, so we can measure the evolution of each bank's proximity to rival banks as well as convenience for consumers. Finally, local markets and the vast number of bank mergers provides a rich source of variation (across markets and merger events) in the determinants of policy action (HHI) as well as the policy's vulnerability (proximity).

3 Data and Descriptive Statistics

We use the FDIC's Summary of Deposits (SOD) and the Federal Reserve's National Information Center (NIC) database to identify mergers and to take measurements of banks' branch networks and deposits. The SOD is an annual survey of all U.S. branches of depository institutions. The SOD reports the amount of deposits, ownership, street address, and exact latitude/longitude coordinates for each branch. The ownership information in the SOD does not in general identify the highest level of the organization. We use the NIC data to track ownership to the highest level. Appendix B contains more details on identification of mergers based on these data. Population and location data are from the 2000 U.S. Census. Prices for deposit products come from RateWatch (S&P Global, 2021), are only available from 2000-2014, and are not available for all branches in the SOD. Our resulting panel spans 1980-2014, in which we study mergers occurring from 1984-2010.

3.1 Measuring Bank Proximity

Given our focus on how merger effects vary with the geographic proximity of the merging banks, we construct a measure of bank proximity based on information from the SOD on exact latitude/longitude coordinates for each branch. Our measure captures geographic substitutability by featuring the distance between a given branch and a rival's closest branch. To formally define a distance between two branch networks, let I and J be two branch networks. The number of branches in network I is denoted by N_I. For each branch $i \in I$, we compute the distance δ_{iJ} from i to the closest branch of J. The average of δ_{iJ} across I's branches measures the average distance from I's branches to network J. We calculate the analogous distances and average for network J in relation to network I. We call the minimum of these average distances the network distance between I and J. Formally, the network distance is

$$d(I,J) = \min\left\{\frac{1}{N_I}\sum_{i\in I}\delta_{iJ}, \frac{1}{N_J}\sum_{j\in J}\delta_{jI}\right\}. \tag{1}$$

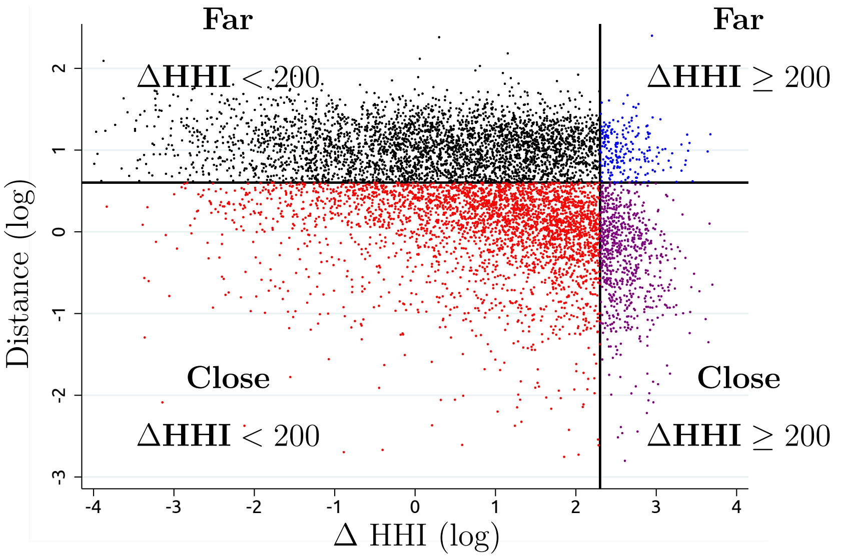
Taking the minimum of the averages ensures that our proximity measure is symmetric, $d(I,J) = d(J,I)$, is robust to outlier distances, but still considers two networks with significant spatial intersection to have close-proximity.

In our main analysis, we use this network distance variable to classify merger-market observations as being either "close" or "far" based on the network distance between the acquirer and the target the year before the merger. Close mergers occur in overlap markets where the acquirer-target network distance is below the median acquirer-target network distance (approximately 4 miles) across all merger-market pairs the year before the merger.

3.2 Summary statistics

Figure 1 displays the joint distribution between ΔHHI and acquirer-target proximity across merger×markets in the year before the merger. The figure shows that there is substantial variation in proximity between the acquirer and target even among mergers with similar changes in HHI. In particular, many close-proximity mergers have $\Delta\text{HHI} < 200$. These mergers involve banks that are potentially close substitutes, but have have safe-harbor under the HHI-based policy.

Figure 1: Joint Distribution of ΔHHI and Acquirer-Target Distance



Note: Log (base-10) distance between acquirer and target plotted against log (base-10) change in HHI, both measured the year before the merger. The sample is merger×markets from 1980-2014 in which both the acquirer and the target had at least one branch in the year before the merger. Reference lines are for median acquirer-target proximity (about 4 miles) and ΔHHI= 200.

Table 1 compares sample means of market×merger-level characteristics across our treatment and control groups. Our treatment groups are comprised of overlap markets, defined as Fed markets where both the acquirer and the target had at least one branch in the year before the merger. We classify overlap markets into four groups depending on acquirer-target proximity and ΔHHI. Our control group is comprised of the merging parties' non-overlap markets, defined as markets where either the acquirer or the target, but not both, had at least one branch in the year before the merger.

The top two rows of Table 1 are the variables by which we group markets, which explains the sharp divergence between their means. The distance between acquirer and target branch networks for far-proximity mergers is over ten times larger than for close-proximity mergers. Similarly, high ΔHHI mergers have an average ΔHHI nearly ten times larger than that of low ΔHHI mergers.

There are systematic differences in averages of market characteristics across groups, as well. For example, because high ΔHHI mergers are more likely to occur

Table 1: Comparison of Treatment and Control Groups

	(1) Close & ΔHHI $\geq$ 200	(2) Close & ΔHHI < 200	(3) Far & ΔHHI $\geq$ 200	(4) Far & ΔHHI < 200	(5) Non-overlap markets
Acq-Tar Distance (miles)	0.7	1.2	13.3	14.9	N/A
ΔHHI	594.3	65.0	603.2	48.9	0.0
HHI	1,970.1	1,533.8	2,042.9	1,376.9	2,013.7
Market Bank Count	10.5	17.8	9.0	18.3	11.4
Market Branch Count	34.0	77.7	18.7	66.0	33.3
Merged Entity Branches	8.8	9.7	4.9	5.3	6.8
Distance to Merged Entity	4.9	5.5	5.6	9.2	7.7
Merged Entity Share (%)	36.1	14.4	37.0	11.2	31.8
Observations	405	651	154	731	32,076

Note: Group means across merger×markets taken the year before the merger. Overlap markets are where both the acquirer and target operate. Non-overlap markets are markets where either the target or the acquirer, but not both, operate. ΔHHI is the change in HHI, and close (far) is defined as below (above) the median distance between merging branch networks.

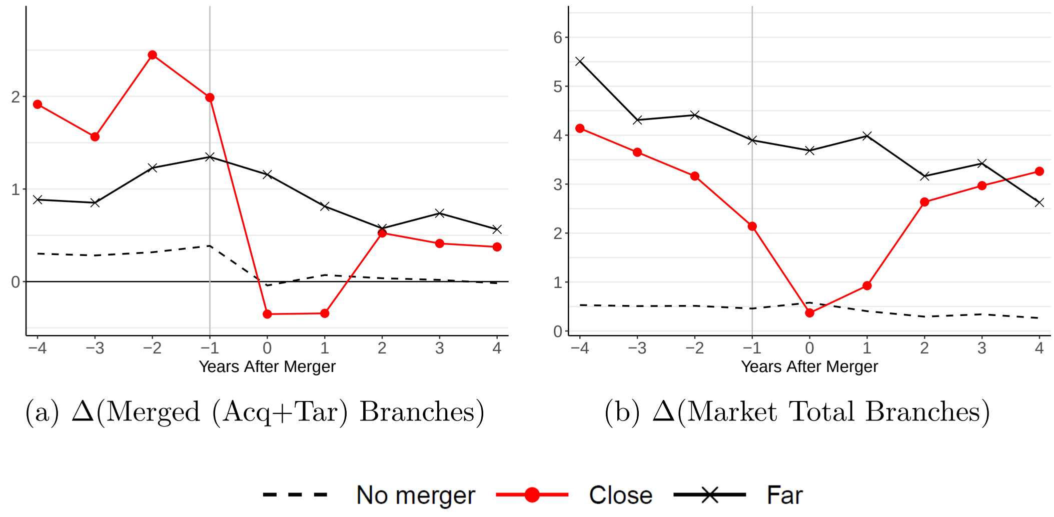
in smaller and more concentrated banking markets, we find on average that markets treated by low ΔHHI mergers have nearly twice as many banks as markets treated by high ΔHHI mergers. We also see systematic differences means between close and far-proximity groups, particularly for measures of the bank. Throughout this paper, measures of the bank are defined by the counterfactual combination of the acquirer and target before the merger and defined by the actual merged entity after consummation of the acquisition. We find that the average number of branches in close mergers is about twice as large as the average in far mergers, in part because large networks are more likely to have branches located near other banks.

In our main analysis, explained in detail in Section 4, we use DID regressions to control for persistent differences across markets. In all of our regressions, we examine whether pre-trends are parallel across these five different market groups. Moreover, we often measure outcome variables in terms of year-over-year changes, for example the growth rate of market-total branches, to make sure that the level differences in the outcome variables do not affect our regression results.

Among the various merger outcomes, branch creation and destruction is perhaps most naturally impacted by the proximity of merging branch networks. Figure 2 plots raw means for close and far mergers for the year-over-year change in branches.

Figure 2(a) shows raw means for the change in number of branches in the merged

Figure 2: "Raw DID" for Branch Openings and Closures



(a) Δ(Merged (Acq+Tar) Branches) (b) Δ(Market Total Branches)

Note: These graphs show raw means for markets where the acquirer and target overlapped in close-proximity (red - solid line), markets where the acquirer and target overlapped but at far-proximity (black - solid line), and markets where the acquirer and target operated branches but did not overlap (black dashed line). Close/far-proximity is defined by below/above the median distance across all merging parties the year before their merger.

network. For close-proximity markets, the merging banks add about two branches per year before the merger, but actually destroy branches soon after the merger. Raw means for far-proximity markets also decline after the merger, but by a smaller magnitude and are never negative. The average far-proximity overlap market sees slightly more than one branch added per year to the network before the merger, and sees slightly less than one branch added per year after the merger.

Figure 2(b) shows raw means for the year-over-year change in the total number of branches in the market. There is no visible effect on the number of branches in the market for far-proximity overlap markets or for non-overlap markets. In contrast, there is sizeable dip in total branches after close mergers. Raw average market total branch creation remains below the pre-merger level for two years after close-proximity mergers, but in later years reverts back to its pre-merger level. Since the reduction in total branches is more muted than branch destruction by the merging banks, there is evidence in the raw means that rival banks respond to mergers by creating branches.

These raw means suggest that bank merger effects depend on geographic proximity between branch networks. We examine this more precisely with regressions.

4 Empirical Strategy

We use a difference-in-differences (DID) strategy to identify how the effects of mergers vary with proximity and ΔHHI, measuring outcomes, treatment status, and acquirer-target proximity by geographic market and year. Because of the vast number of bank mergers in our dataset, we can estimate conditional treatment effects using observables like acquirer-target proximity and ΔHHI. Because our outcomes are measured at the geographic banking market (Fed market) level, we study DIDs that identify the effects of mergers from variation between overlap markets and non-overlap markets. Overlap markets (treatment group) are Fed markets where both the acquirer and the target operated at least one branch in the year immediately prior to the merger. Non-overlap markets (control group) are Fed markets where only one of the merging banks operated a branch. We cannot use markets where neither the acquirer nor the target operated a branch, because many of our outcomes are only measurable in markets where either the acquirer or target exists.

To implement the above identification strategy we adopt a stacked event panel design. For each merger event and outcome variable, we build separate balanced panel datasets and append or "stack" them together to use variation across events.[9] The formal regression specification is

$$\begin{aligned} y_{emt} = \sum_{\tau=\tau_{min}}^{\tau_{\max}} \mathbf{1}[t = t_e^* + \tau] \times \Big(& \beta_\tau^{fl} \times Far_{em} \times \mathbf{1}\{\Delta\text{HHI}_{em} < 200\} \\ & + \beta_\tau^{fh} \times Far_{em} \times \mathbf{1}\{\Delta\text{HHI}_{em} \geq 200\} \\ & + \beta_\tau^{cl} \times Close_{em} \times \mathbf{1}\{\Delta\text{HHI}_{em} < 200\} \\ & + \beta_\tau^{ch} \times Close_{em} \times \mathbf{1}\{\Delta\text{HHI}_{em} \geq 200\} \Big) \\ & + \xi_{em} + \xi_{et} + \epsilon_{emt} \end{aligned} \tag{2}$$

[9]A stacked design allows us to study merger-specific outcome variables, such as the combined market share of the merging parties. Event-stacked designs have been implemented by other papers that had similar data structure, such as Cengiz et al. (2019), Lafortune et al. (2018), Deshpande and Li (2019), and Joaquim et al. (2020). The stacked design also helps us address bias arising from treatment effect heterogeneity and the presence of repeated and staggered treatments, see e.g. (Goodman-Bacon, 2018; de Chaisemartin and D'Haultfoeuille, 2020; Sun and Abraham, 2020) and Appendix D for further discussion.

Indices (e, m, t, τ) denote merger events e, banking markets m, calendar year t, and τ time relative to the merger year t_e^*. Event-specific two-way fixed effects, ξ_{em} and ξ_{et}, control for time invariant effects that are specific to every merger-market combination and control for time varying effects that are specific to every merger.

The regression allows the effect of mergers to depend on proximity and the change in HHI (ΔHHI_{em}). It estimates four different binned treatment effects (β_τ^{fl}, β_τ^{fh}, β_τ^{cl}, and β_τ^{ch}) for each outcome y_{emt}. The four sets of parameters are identified by variation in the DIDs in y_{emt} between overlap markets having different proximity and ΔHHI_{em}. $Close_{em}$ and Far_{em} proximity are dummy variables for whether the distance measure between the acquirer and the target is below and above its median (about 4 miles), respectively. $\mathbf{1}\{\Delta\text{HHI}_{em} \geq 200\}$ is a dummy variable that is equal to one if $\Delta\text{HHI}_{em} \geq 200$, the level that triggers review for antitrust enforcement action under the current screen used by the Fed.[10]

Omitted coefficients are the year before the merger, $\tau = -1$. The window for analysis begins four years prior to the merger, $\tau_{min} = -4$, and ends four years after the merger, $\tau_{max} = 4$. All standard errors for equation (2) are clustered at the unit of treatment exposure: the merger-market level.

Sample Selection: We refine the main regression sample in two ways. From the treatment and control groups of a given merger event e, (i) we drop markets that the merging parties entered or exited within the 9-year study window, and (ii) we drop markets that were treated by any other merger e' at the same time or the year prior (t_e^* or $t_e^* - 1$). These criteria hold the composition of markets fixed between measures of the extensive and intensive margins of an outcome, and ensures that the main sample draws on variation from "switching" treatment status.

5 Results

We estimate of equation (2) for four sets of outcomes: branch closures, branch network convenience, deposit interest rates (prices), and deposits (quantities). Among many attributes of banks, we focus on the size and convenience of branch networks

[10] Although there are also HHI-level and market share criteria, ΔHHI often determines whether whether enforcement is pursued.

as well as prices because these are important determinants of consumer utility in banking. By revealed preference, deposits quantity is an indicator of the value a bank provides consumers. We examine deposits quantities to infer how consumers react on net to the different price and non-price effects of mergers. For many outcomes, we measure growth rates instead of levels to ensure parallel trends between treated and controlled groups.

Among the four binned coefficients in the main regression, we focus on comparing mergers that did not increase the HHI enough to trigger enforcement by the antitrust authorities: β^{fl}_{τ} and β^{cl}_{τ}. This comparison provides a baseline effect of a close-proximity merger. Then we determine the importance of the increase in HHI by comparing effects of close-proximity mergers with different changes in HHI: β^{cl}_{τ} and β^{ch}_{τ}.[11] It is important to note that the effects close-proximity high-HHI mergers, estimated by β^{ch}_{τ}, account for HHI-based enforcement.

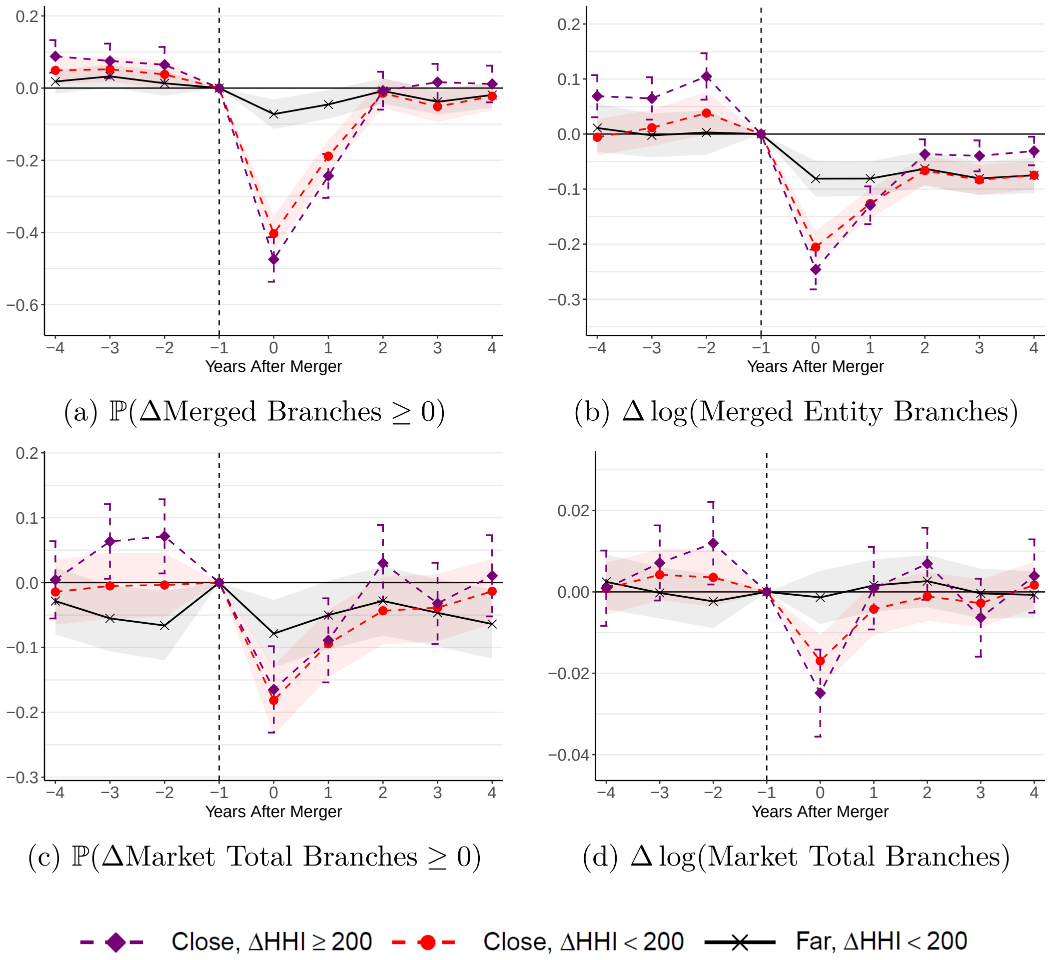
5.1 Post-Merger Branch Closures

We find that close-proximity mergers are more likely to cause branch closures than far-proximity mergers. Close mergers also cause a decline in growth of the number of branches operated by merging banks, and a decline in growth in the total number of branches in the market. These effects of bank mergers on branches apparently do not depend very much on whether $\Delta\text{HHI} \geq 200$.

Figure 3 panels (a) and (b) examine the branch network of the merging banks, defined before the merger as the counterfactual combination of acquirer and target branches. The outcome in panel (a) is an indicator variable for whether the merged bank does not reduce the size of its branch network. Compared to non-overlap markets, after close-proximity acquisitions the merging banks are about 40 percentage points more likely to reduce the size of their branch network in the year the merger is consummated, and are about 20 percentage points more likely to close additional

[11] We leave effects of far-proximity mergers with high $\Delta\text{HHI} \geq 200$, β^{fh}_{τ}, out of the figures. These coefficients are often less precisely estimated, because far-proximity mergers with high ΔHHI comprise a smaller number of observations, only 8% of all treated markets and only 0.5% of all markets. In addition, these estimates are less important for our main empirical question, because these mergers are more likely to be scrutinized by antitrust authorities regardless of proximity.

Figure 3: Branch Closures



(a) $\mathbb{P}(\Delta\text{Merged Branches} \geq 0)$ (b) $\Delta\log(\text{Merged Entity Branches})$

(c) $\mathbb{P}(\Delta\text{Market Total Branches} \geq 0)$ (d) $\Delta\log(\text{Market Total Branches})$

Note: Difference-in-differences estimates and 95 percent confidence intervals from equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

branches the year thereafter. The differential impact of close-proximity on the probability of branch closures in the first two years of the merger is economically large and statistically significant.

The outcome in panel (b) is the year-over-year change in the log-number of branches operated by the merged entity, studying the intensive margin of branch closures. Compared to non-overlap markets in the year of the merger, growth in the number of branches operated by the merged bank drops by about 20 percent in close-proximity markets regardless of the change in HHI, and growth drops by about 10 percent in far-proximity markets. The differential impact of close-proximity – about 10 percent more branch closures – is economically and statistically significant.

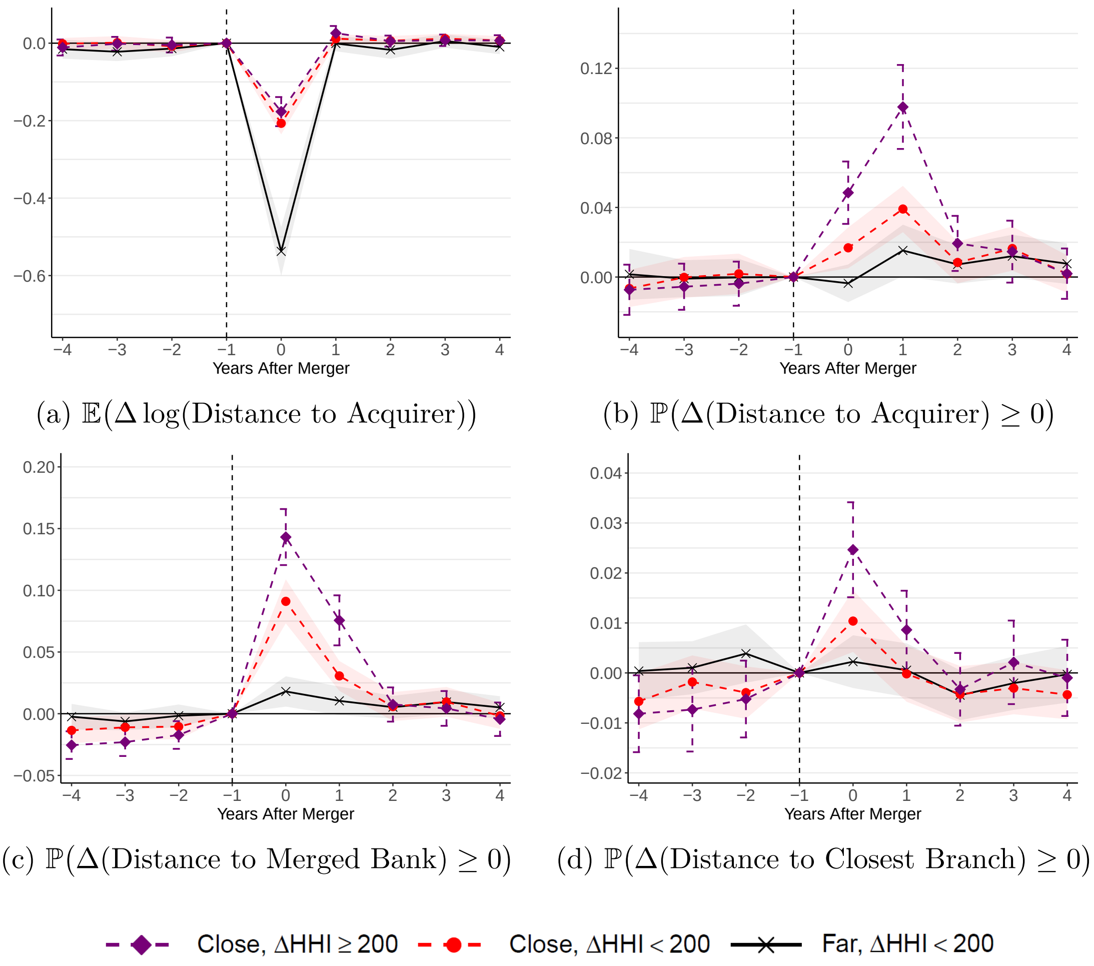
Panels (c) and (d) look at analogous measures for the total number of branches in the market. The change in market-total branches reflects branch closures as well as any branch repositioning by merging banks or their competitors' in response to the merger. Close-proximity mergers are about 15 percentage points more likely to reduce the total number of branches in the market, compared to non-overlap areas, and result in about 2 percent lower growth in aggregate branches. These estimates for close mergers are economically and statistically similar whether ΔHHI is large or small. Comparing the estimates for aggregate branches, panels (c) and (d), with estimates for the merged bank's branches, panels (a) and (b), suggests that rival banks react to the merger by creating branches, and that rivals' reactions only partially offset branch closures by merging banks.

Current HHI-based merger review appears to overlook close-proximity mergers that might adversely impact depositors' welfare through branch closures. Structural models of demand from the literature provide estimates of consumer willingness-to-pay for the size of a banks' branch network. Viewing our results in light of Xiao et al. (2021), for example, suggests that a 20% decrease in the size of the merged branch network is worth about an 8% price increase (lower deposit rate). However, the welfare impact of these branch closures likely depends on distances between branches that are closed and other branches in a merged branch network. In an extreme case where an acquirer's branch and a target's branch happen to be right next to each other, closing down one of them should not significantly effect welfare apart from other changes caused by a merger. At the other extreme, if closed branches are strong geographic complements, then the welfare of consumers who have to travel farther to visit their closest branch might be significantly impacted. We examine this in more detail in the next analysis on convenience.

5.2 Branch Network Accessibility

The distance between a bank's branch network and its customers, "convenience," is an important determinant of consumer utility. Bank mergers might affect branch network convenience in several ways. On the one hand, the synergy from combining the acquirer and target branch networks is an important potential benefit of mergers, one most likely to impact consumers who are located relatively far from one of the merging banks but close to the other bank. On the other hand, mergers could reduce convenience for some consumers through branch closures. Reduced convenience is an important potential harm, one most likely to disadvantage consumers located relatively near one of the merging banks. More broadly, branch repositioning of the merging banks or its rivals in response to the merger might affect the distance between consumers and their most convenient branch of any bank. Accordingly, our network convenience outcomes measure the average or overall impact of a merger as well as how mergers advantage some consumers while disadvantaging others.[12]

Figure 4: Distance Between Consumers and Branches



(a) $\mathbb{E}(\Delta \log(\text{Distance to Acquirer}))$ (b) $\mathbb{P}(\Delta(\text{Distance to Acquirer}) \geq 0)$

(c) $\mathbb{P}(\Delta(\text{Distance to Merged Bank}) \geq 0)$ (d) $\mathbb{P}(\Delta(\text{Distance to Closest Branch}) \geq 0)$

Note: Difference-in-differences estimates and 95 percent confidence intervals from equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

[12]Our analysis of synergies and the disparate impacts of mergers on network outcomes relates to merger retrospectives studies of other industries, e.g. Farronato, Fong and Fradkin (2020).

We begin our analysis on convenience by examining average consumer convenience via the year-over-year percent change in distance to a branch network. To formally describe this measure, let $d(b, I_t)$ denote the distance from census block b to branch network I's nearest branch in time t.[13] The average consumer's percent change in distance to branch network I_t in market m in time t is calculated as $\mathbb{E}\Big(\Delta \log(\text{Distance to } I_t)\Big) = \sum_{b \in m} w_b \log\Big(d(b, I_t)/d(b, I_{t-1})\Big)$, where w_b denotes the share of the m's population living in b.

Figure 4(a) illustrates the effects of mergers on the average percent change in consumer distance to the acquirer's network. After the merger, the acquirer's network is the merged branch network. Thus, effects on this outcome in the year of the merger include the merger's convenience synergy, because consumers' distance to the merged branch network is compared to their distance to the smaller pre-acquisition network. In the year of the merger, we find a large decline in distance to the acquirer's nearest branch for all merger types. This suggests that the potential synergies from merging branch networks outweighs the effects of branch closures, on average. However, far-proximity mergers have significantly larger convenience synergies than close-proximity mergers, on average reducing consumers' distance to the nearest branch in the acquirer's network by about 50 percent. The larger effect of far mergers reflects the fact that far mergers have greater potential to reduce some consumers' distances to the closest branch controlled by the acquiring bank, as well as the result that branch closures are less frequent after far mergers as shown in Section 5.1.[14] This result suggests that proximity is the primary determinant of a merger's convenience benefits. The consumers who benefit the most from these synergies are those located relatively far from one of the merging banks.

Although Figure 4(a) shows that mergers improve the acquirer's network convenience on average, mergers could harm consumers located near branches that the acquirer closes as a consequence of the merger. We therefore examine disparate impacts of mergers on consumer convenience by measuring the fraction of

[13] This distance is calculated using the latitude/longitude of each branch location from the SOD data and the latitude/longitude of census block centroids.

[14] Unreported estimates for the average percent change in distance to the target's network are very similar, with far-proximity mergers having the largest synergies and exhibiting little dependence on the change in HHI.

consumers whose distance to their nearest branch in a network increased year-over-year. Formally, this outcome variable with respect to branch network I_t is measured as $\mathbb{P}\Big(\Delta(\text{Distance to } I_t) > 0\Big) = \sum_{b \in m} w_b 1\Big(d(b, I_t) > d(b, I_{t-1})\Big)$.

Figure 4(b) shows that close-proximity mergers increase the distance to the acquirer's network for a significant fraction of consumers despite the synergy from consolidating two networks. In the year of consummation, close-proximity mergers increase distance to the acquirer's network for 2-5 percent of consumers. Note that distance increased for these consumers even in comparison to the acquirer's smaller pre-merger network. In the year immediately following close mergers, distance to the acquirer's (now merged) network increases for another 5 to 10 percent of consumers, with close-proximity mergers with ΔHHI ≥ 200 exhibiting the greatest reduction in convenience. For the first two years after a merger, the differences in our estimates between close mergers with low ΔHHI and far mergers with low ΔHHI are statistically significant at the 5% level.[15] That convenience declines for a larger fraction of consumers in the first two years after close-proximity mergers is consistent with our result that merging banks tend to close branches during the same period.

Panel (c) illustrates how mergers affect convenience of the merged bank's network. The merged bank's convenience measure is based on consumer distances to the counterfactual combined acquirer and target networks in years before the merger and on distances to the actual merged network in years after the merger. Thus, convenience of the merged branch network holds the potential convenience synergy fixed, which allows us to isolate the effects of merger-induced branch openings and closings on consumer distances to the merging banks. We find that in the year of consummation close-proximity mergers increase the distance to the merged network for 10 to 15 percent of consumers, mergers with ΔHHI ≥ 200 reducing convenience the most. Distances to the merged network also increase in the following year, albeit to a smaller degree. In contrast, far-proximity mergers with ΔHHI < 200 affect the merged bank's convenience for a much smaller fraction of consumers.[16]

[15]The p-values for the differences of the estimates for year 0 and 1 between the two types of mergers are 0.013 and 0.018, respectively.

[16]Between far and close mergers with ΔHHI < 200, close-proximity mergers reduce access for about 7 percent more consumers than far-proximity mergers (p-value 1.121e-10) in the year of consummation.

In panel (d), we study the effects of bank mergers on the distance between consumers and their closest branch of any bank, disregarding which banks own which branches. Consumers' distances to the "market network" measures aggregate or overall convenience of the local banking industry, and therefore captures the effects of branch repositioning both by the merging banks and its rivals. We find that after close mergers, 1 to 2.5 percent of consumers experience an increase in distance to their nearest branch, with larger and more persistent adverse effects after mergers that are close-proximity and ΔHHI ≥ 200. Although close-proximity mergers with ΔHHI < 200 have slightly smaller effects in the year of consummation, the estimate is statistically larger than the estimate for far-proximity mergers with ΔHHI < 200.[17] Far-proximity mergers with ΔHHI < 200 do not significantly affect the convenience of consumers' nearest branch location.

We also examine the convenience of branch networks of competitors of the merging banks. In Appendix Figure A.10 we illustrate results for the acquirer and target's biggest, closest, farthest, and average rivals. We find no evidence that mergers improve the branch network convenience of rival banks. These results suggest that adverse effects of mergers on the convenience of consumers' nearest branch of any bank are not only due to the behavior of the merging banks, but also due to branch repositioning by their rivals.

As judged by effects on product characteristics measuring convenience, close-proximity mergers are more likely to harms consumers and are less likely to convey offsetting benefits. Even though a merger's convenience synergy benefits the average consumer, the heterogeneous effects of branch closures and repositioning caused by close-proximity mergers harm 15% of consumers. For the acquirer's consumers whose convenience is negatively affected by close-proximity mergers (Figure 4.b), we find that their distance to the acquirer's branch network increases by 0.7 miles, on average. And for consumers whose convenience to any bank is negatively affected by close-proximity mergers (Figure 4.d), the distance to their nearest branch increases by 0.26 miles, on average. Moreover, a significant fraction of consumers lose access

[17] Between far and close mergers with ΔHHI < 200, close-proximity mergers reduce access for about 0.8 percent more consumers than far-proximity mergers (p-value 0.048)

altogether to a branch less than 1 mile away (Appendix Figure A.9).

To gauge the economic importance of these effects, we use structural demand estimates from the literature to measure the trade-off between distance to branches and deposit interest rates. The estimates from Ho and Ishii (2011) imply that consumers who choose the acquirer bank would be willing to accept a 35% reduction in deposit interest rates to avoid traveling an additional 0.7 miles to their branch network. By the same estimate of willingness-to-pay for convenience, consumers would accept a 13% change in prices to avoid travelling an additional 0.26 miles to access any bank. These significant harms are determined primarily by close-proximity, we find no evidence that far-proximity mergers have such effects. These harms are evident, and in fact most pronounced, for close-proximity transactions subject to HHI-based enforcement. Our results therefore suggests that HHI-based bank antitrust policy not only gave safe harbor to mergers with non-price harm, but also designed enforcement to mitigate the HHI that was ineffective at addressing the non-price harm.

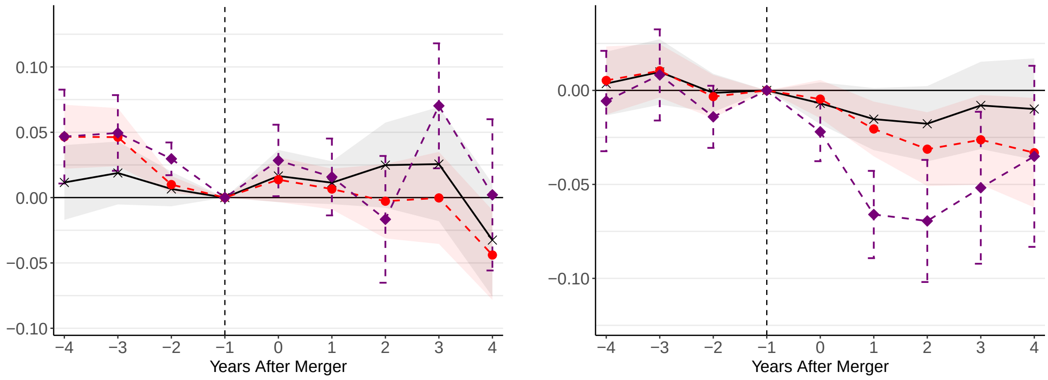
5.3 Deposit Interest Rates

Next we examine the effects of bank mergers on deposit rates. Based on our findings so far, the effects of mergers on the prices of the merging banks and their rivals might vary with acquirer-target proximity in different ways. For the merging banks, proximity impacts the typical trade-off between market power and cost synergies. Whether the merged bank offers worse prices depends on the resolution of these two forces, and on balance proximity might be a mitigating factor.[18] In a differentiated products setting like banking, the proximity of the merging parties can also affect rivals' market power. Thus, even if proximity mitigates the merger's competitive effects on the acquirer's prices, proximity might exacerbate the merger's competitive

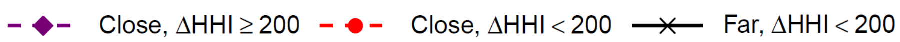
[18]A close-proximity acquisition eliminates competition from a close substitute and therefore increases market power beyond what might be indicated by the HHI. Yet, a merger's cost synergies, like accessibility synergies, may also depend on branch network proximity. The fact that merging banks are more likely to close branches that are very close to another branch of theirs may indicate that competition led to too many branches and thereby duplication of fixed costs, as shown by Mankiw and Whinston (1986). Levine et al. (2019) find that mergers between banks with overlapping branch networks creates greater value in terms of stock returns, which could be passed down to customers in the form of higher deposit rates.

effects on rivals' prices.

Figure 5: Deposit Interest Rates



(a) log(2-year CD Rate of Acquirer) (b) log(2-year CD Rate of Competitors)



Note: Difference-in-differences estimates and 95 percent confidence intervals from equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

Figure 5 presents our estimates for the effects of mergers on 2-year certificate-of-deposit (CD) rates for the merging banks and their average competitor using the Ratewatch data. Because deposit rates determine interest that is paid to depositors, consumers prefer a higher price in this setting. Therefore, a lower deposit rate is an adverse outcome.

Panel (a) shows that the acquirer's deposit rates in overlap markets do not change very much after a merger relative to its rates in non-overlap markets, and do not depend very much on proximity or the HHI. Our estimates for other measures of deposit prices of the merging banks, illustrated in Appendix Figure A.11, are qualitatively the same. As well, note that the negative results in panel (a) are not due to imprecise estimation. This suggests that even if there are cost efficiencies from close mergers, the merging banks do not pass the efficiencies through in the form of better prices.

In contrast, panel (b) shows that, relative to non-overlap markets, rival banks decrease their deposit rates about 3-6 percent after close-proximity mergers. Regardless of ΔHHI, our estimates for the effects of close-proximity mergers on rivals' deposit rates are generally statistically different from zero, including our results for other deposit price outcomes illustrated in Appendix Figure A.11. Our estimates for mergers that are far-proximity and ΔHHI $\geq$ 200 are also similar to estimates for mergers that are close-proximity and ΔHHI $<$ 200, with adverse price effects being largest for mergers that are close-proximity and ΔHHI $\geq$ 200. Although the standard errors of our estimates reject the hypothesis that close mergers have no effect of rivals' prices, it is difficult to statistically distinguish the effects of close and far-proximity mergers. Thus, we cannot precisely conclude that close-proximity itself leads rivals to decrease deposit rates.

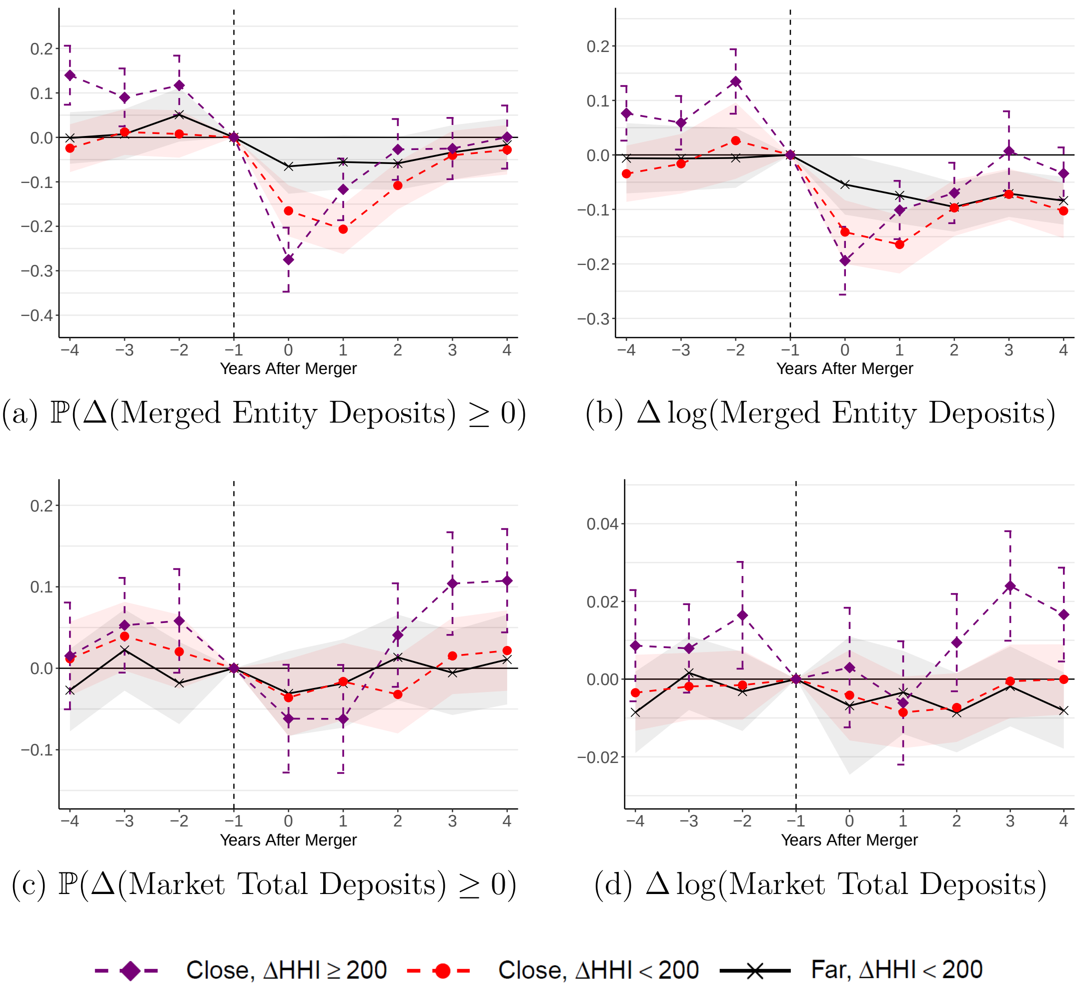
Even so, these results do not suggest that close mergers cause price responses by merging banks or by rivals that would offset the anticompetitive effects of close mergers on branch networks. If anything, close-proximity mergers likely lead to worse deposit rates, especially for consumers who choose rival banks. That proximity predicts these price effects, even after accounting for HHI-based enforcement action, suggests that the HHI does not capture a dimension of substitutability that influences the market power of rival banks.

These findings relate to a literature studying the price effects of bank mergers. For example, Prager and Hannan (1998) found that bank mergers that substantially increase the HHI result in worse deposit prices. Our results suggest that effects on competitor prices might drive their findings, and indicate that close-proximity mergers that do not significantly increase the HHI result in worse prices as well. Also closely related are Focarelli and Panetta (2003), who found that bank deposit rates in Italy increased in the long-run after mergers, arguably due cost synergies. In contrast, our results do not suggest that cost synergies significantly improve prices relative to non-overlap markets where the merging firms operated but did not compete. This may indicate that bank merger cost synergies are primarily firm-level, and not firm-market-level, efficiencies.

5.4 Deposits Growth

Lastly we study deposits quantities in order to examine how the forging price and non-price effects of mergers impact consumer welfare on net. By revealed preference, a bank's deposits should increase if consumers altogether value the effects of the merger on its branches, network convenience, interest rates, and any other product characteristics that we do not explicitly study. Figure 6 illustrates how the effects of bank mergers on deposits growth vary with the ΔHHI and with acquirer-target proximity.

Figure 6: Deposits Run-Off



(a) $\mathbb{P}(\Delta(\text{Merged Entity Deposits}) \geq 0)$ (b) $\Delta \log(\text{Merged Entity Deposits})$

(c) $\mathbb{P}(\Delta(\text{Market Total Deposits}) \geq 0)$ (d) $\Delta \log(\text{Market Total Deposits})$

Note: Difference-in-differences estimates and 95 percent confidence intervals from equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

In panel (a), we measure the effects of mergers on the probability that pro forma quantity of the merged bank does not decline. The pro forma demand counterfactual is constructed before the merger as the combined deposits of the acquirer and the target, which holds fixed the direct effect of merging product lines, and therefore allows us to study how quantity is affected on balance by merger-induced changes in utility without knowing consumer preferences for their banking options. Compared to far-proximity mergers, close-proximity mergers more frequently cause quantity of the merged bank to decline. Relative to non-overlap markets, in the year of consummation the deposits of the merged bank decline 28 percent of the time after mergers that are close-proximity and ΔHHI $\geq$ 200 and decline 17 percent of the time after mergers that are close-proximity and ΔHHI $<$ 200. Mergers that are far-proximity and ΔHHI $<$ 200 only cause demand to decline about 7 percent of the time. Merged quantity persistently declines for two to three years after close-proximity mergers.

Formally comparing close-proximity acquisitions by ΔHHI in panel (a), we find that the three-year cumulative effects of ΔHHI $<$ 200 versus ΔHHI $\geq$ 200 mergers are not significantly different from each other. In contrast, formally comparing ΔHHI $<$ 200 acquisitions by close and far-proximity, we find that cumulative effects within three years of close versus far-proximity mergers are different by a statistically significant 30 percentage points.

This result suggests that ΔHHI plays a more limited role than proximity in determining deposits run-off from the merged bank. Moreover, this evidence also rules out the hypothesis that factors common in all mergers, such as destruction of the target's brand, are unlikely main drivers for the deposit runoff after close-proximity mergers because far-proximity mergers do not exhibit a similar runoff.

The deposit result may look inconsistent with our finding in Section 5.3 that merging banks do not change their deposit rates, whereas rivals lower deposit rates by up to 6%. However, note that the estimated effects on rivals' deposit rates are very small in size relative to our back-of-envelope calculation of the negative welfare impact of reduced convenience for consumers experiencing traveling distances to the nearest branch (about 40% of the deposit rate). Thus, some consumers of merging banks could run off to rivals although rivals may offer worse deposit rates after mergers. Yet, it is important to note that reduced convenience is not the only reason for the deposit runoff. Other merger-included changes in product attributes that we do not consider might also have contributed to the deposit runoff.

In panel (b) we measure the effects of mergers on the growth of pro forma merged desposits. We find that close-proximity acquisitions cause growth of the merged bank's deposits to decline by a statistically and economically significant 15-20 percent in the year of the merger, and that the difference between close-proximity mergers with ΔHHI < 200 and ΔHHI ≥ 200 is not statistically significant. In contrast, in the year of consummation we find that close mergers cause growth in merged deposits to fall a statistically significant 10 to 15 percent more than far mergers with ΔHHI < 200. Once again, we find evidence not only that proximity is an important determinant of deposits run-off from the merged bank, but also that proximity is a more significant determinant of run-off than ΔHHI.

We complement the analysis of pro forma demand with a study market aggregate deposits. Variation in aggregate quantity captures depositor substitution to outside options as well as substitution to (or from) rival banks in response to the merger. Figure 6 panel (c) examines the effects of mergers on the probability that aggregate quantity does not decline, and panel (d) examines effects on the growth of aggregate deposits. We find no statistically significant evidence that mergers reduce growth in aggregate quantity in overlap markets, relative to non-overlap markets where the merging banks have operations but did not compete before the acquisition. This indicates that reduced demand for the merged bank fully diverts to competitors and not to outside options.

In a wide class of oligopoly models,[19] consumer surplus does not decrease after a merger if and only if the merging firms' pro forma quantity does not decrease (Nocke and Schutz, 2018; Nocke and Whinston, 2020). Our results for deposits growth in panels (a) and (b) therefore suggest that eliminating competition from a close substitute harms consumers even when ΔHHI is small. Moreover, eliminating a close-proximity substitute might harm consumers more than removing competition from a large rival.

For a more complete welfare analysis, the effects of mergers on rivals' demands and aggregate quantity are also needed to infer the effect on consumer welfare. Further, switching to another bank itself might be costly (Kiser, 2002). In light of panels (c) and (d), a bank merger's overall effect on consumer surplus would therefore

[19]Including multinomial logit and constant elasticity of substitution demand frameworks with price competition that are commonly used in antitrust practice.

depend on whether mergers cause rival banks to offer better products, qualities, and prices to consumers. Our analysis does not suggest that rivals substantively improve their product characteristics in response to the merger. On the contrary, if anything, rivals tend to offer worse prices for similar products and services after close-proximity mergers. Therefore, we interpret the results of our revealed preference exercise as evidence that close-proximity bank mergers cause a larger decrease in consumer surplus than far-proximity mergers.

5.5 Robustness Checks

Lower ΔHHI threshold: Our main specification uses a $\Delta\text{HHI} \geq 200$ threshold as a simplification of current antitrust screening criteria. However, because of the correlation between proximity and ΔHHI, one might argue that it is possible to adequately screen close-proximity mergers by lowering the ΔHHI threshold. To investigate this possibility, Figure A.3 in Appendix C illustrates DID regression estimates for main outcomes when we lower the ΔHHI threshold to 100 instead of 200. We find that, even among mergers with $\Delta\text{HHI} < 100$, close-proximity mergers still lead to outcomes associated with a larger decrease in consumer welfare: more branch closures, more consumers experiencing increases in distances to their closest branch, a decrease in rivals' deposit rates, and a decrease in merged bank's deposits growth. These results altogether show that lowering the threshold for ΔHHI would not effectively screen out close-proximity mergers that potentially have anticompetitive effects.

HHI level screening criteria: As discussed in Section 2, the Federal Reserve's merger policy incorporates the HHI level in addition to the change in HHI. Although the change in HHI is the primary screening trigger, close-proximity mergers with anticompetitive effects might be captured by the other dimensions of the screening policy. To investigate this possibility, instead of classifying mergers based on whether a merger's ΔHHI is above or below 200, we redefine our DID bins using both the change and level criteria: $\Delta\text{HHI} \geq 200$ & $\text{HHI} \geq 1800$. The results from this robustness exercise (Appendix Figure A.4) are once again very similar to our main results.

Evolving bank competition: Our main sample covers the period 1980-2014. Some aspects of bank competition clearly evolved over our sample horizon. For example, due to the rise of internet banking, branch network proximity might play a more limited role in modern bank substitution patterns. To study robustness of our results to the evolving nature of bank competition, Appendix Figure A.5 presents our regression estimates over a later time period 2000-2014. We find that these results are very similar to our main estimates, suggesting that geographic competition is still an important determinant of the effects of mergers in the banking industry.

Within-market census tract analysis: If the geographic scope of a market is misspecified, then mergers might be misclassified as high/low ΔHHI. In particular, some of the mergers that are close-proximity and low ΔHHI that we observe might, in actuality, be mergers that are close-proximity and high ΔHHI under a better geographic market definition. This potential misclassification does not change our argument or the interpretation of our results in relation to economic policy, since antitrust authorities use the same geographic market definitions in bank merger screening. However, the interpretation of our results in relation to the economics of mergers in differentiated product markets might be sensitive to misclassification of high/low ΔHHI, since our empirical exercise examines between-market DIDs.

In Appendix A we investigate the role of proximity controlling for potential misclassification of high/low ΔHHI by studying outcome DIDs between census tracts within overlap banking markets. This strategy allows outcomes to evolve arbitrarily at the market-year level, fully controlling for any dependence on market-level determinants like the ΔHHI whether or not such determinants are measured with error. To study proximity in this setting we classify three type of census tracts: tracts where both merging banks had operations (close-proximity), tracts where only one of the banks operated (far-proximity), and tracts where neither bank operated (control group). The within-market census travel-level DID results closely mirror our findings from between-market DIDs. Bank mergers cause more branch destruction in tracts where the merging banks both operated before the merger, even after allowing for arbitrary variation in branches and deposits at the market level. This suggests that the proximity of the merging banks is an important determinant of merger outcomes for any plausible geographic market definition that satisfies the usual hypothetical monopolist test. Therefore, even if the Fed banking markets were more narrowly defined, an HHI-based screen could still be improved by using data on the proximity of the merging banks.

Alternative definition of close-proximity: Our main specification distinguishes above from below-median acquirer-target proximity using the distribution of all overlap markets and merger events, resulting in an overall merger-median proximity cutoff just under 4 miles. We also investigate a more relative notion of proximity using market-specific distribution of bank distances, defining close-proximity when the distance between the merging banks is below the median distance across banks operating within the given overlap market. Figure A.6 in Appendix C shows that mergers that are close in terms of the within-market notion of proximity have similar anti-competitive effects as our main results.

Alternative sample selection: As discussed in Section 4, the main sample excludes merger event - market observations (e, m) that experienced other bank mergers in the year of or in the year prior to the focal merger event (t_e^* and t_e^*-1). In a stacked panel design, these are the weakest necessary criteria to focus on identifying variation from observations that "switch" treatment status. We consider alternative sample criteria for robustness. First, we investigate a stronger counterpart of our main selection criteria, excluding markets that experienced any other bank mergers over the regression horizon from t_e^*-4 to t_e^*+4. Appendix Figure A.7 reports results from this alternative sample, and they are qualitatively unchanged from our main findings. Second, we study robustness to market size by restricting the regression sample to markets that have eight or fewer banks the year before the merger (the median market has eight banks). The incentives brought by mergers likely depend on the number of competitors in the market, which is primarily determined by market size. Appendix Figure A.8 reports results from this alternative sample, and they are also qualitatively unchanged.

6 Policy Implications

Our evidence sheds light on two vulnerabilities of bank antitrust policy: deciding which transactions are unlikely to warrant enforcement and, for mergers that do warrant enforcement, designing remedies sufficient to mitigate anticompetitive effects. There are several ways policy makers might use information on proximity to mitigate its vulnerability to mismeasurement of substitutability. This section concerns two important classes of such policies: reforms that complement the HHI with proximity criteria independent of market definitions and shares, and reforms that rely on the HHI but using more narrowly defined bank antitrust markets. We quantify how many bank mergers in the data would have received safe harbor or additional enforcement under a counterfactual policy.

Table 2 presents tabulations for policies that would complement the current HHI policy with bank proximity criteria. Columns of the table consider several acquirer-target proximity thresholds. The first panel of rows show the number and percent of all mergers in the data that would be "close" under these candidate proximity thresholds. The second panel illustrates how using proximity criteria to trigger more detailed investigation would impact the number of bank mergers in the Fed's safe harbor, cross-tabulating $\Delta\text{HHI} < 200$ with close-proximity. The third panel illustrates how using proximity criteria as a basis for additional enforcement action would impact transactions already subjected to enforcement actions based on the HHI, cross-tabulating $\Delta\text{HHI} \geq 200$ with close-proximity.

Column 1 considers a four mile proximity threshold, as in our main regression analysis. From 1984-2014, there were 3929 mergers where the acquirer and target branch networks were within four miles of each other, just over half of all 7604 merger-market observations in the data. Of mergers within four mile proximity, 3213 increased the HHI less than 200 points and were therefore not captured by the Fed's current thresholds for enforcement action. Put differently, 82 percent of close-proximity mergers (42 percent of all mergers) which may have had adverse effects on consumers received effective safe harbor based on the HHI. Over 1984-2014, 929 mergers were subject to HHI-based enforcement action, of which 716 had ac-

Table 2: Candidate Proximity Thresholds for Close Mergers

Distance (miles):	**4**	**2**	**1**	**0.5**	**0.25**
A. Statistics on Close Mergers					
Number of Close Mergers	3929	2689	1645	961	574
% of All Mergers	52%	35%	22%	13%	8%
B. Safe Harbor:					
Number of Close Mergers with ΔHHI < 200	3213	2058	1147	637	371
% of all Mergers	42%	27%	15%	8%	5%
% of Close Mergers	82%	77%	70%	66%	65%
% of ΔHHI < 200 Mergers	48%	31%	17%	10%	6%
C. Enforcement:					
Number of Close Mergers with ΔHHI $\geq$ 200	716	631	498	324	203
% of ΔHHI $\geq$ 200 Mergers	77%	68%	54%	35%	22%

Note: All (N = 7604) overlap merger-markets for banking acquisitions between 1984-2014, based on Federal Reserve banking market definitions in 2014. Tabulations by proximity thresholds (columns) and by the transaction's effect on the local HHI (row-panels), separately for the Fed's safe harbor ΔHHI < 200 (N = 6675) and for mergers subject to enforcement action ΔHHI $\geq$ 200 (N = 929).

quirer and target branch networks within four mile proximity. That is, 77 percent of mergers that received HHI-based enforcement were not subjected to additional enforcement based on close-proximity which may have mitigated effects on consumers that were missed due to mismeasurement of substitutability.

Although our regression results suggest that acquisitions where the merging parties are within four miles of each other have bad outcomes for consumers, these estimates are interpretable as average treatment effects. The average merger effect might reflect both severe effects of very close-proximity mergers and more benign effects of mergers nearer the 4-mile bin definition. Therefore, a lower proximity threshold might suffice to identify mergers that are most likely to harm consumers in ways that are missed by the HHI. Columns 2–5 of Table 2 explore the implications of relaxing the proximity criteria to 2 miles, 1 mile, 0.5 miles, or even 0.25 miles. At each candidate distance threshold we find that over half of close-proximity mergers have effective safe harbor based on the HHI, and therefore evade antitrust enforcement. Moreover, a significant fraction of mergers subjected to HHI-based enforcement would be considered for additional proximity-based enforcement even at small distance thresholds.

These tabulations strongly suggests that complementing current process with proximity criteria can improve bank antitrust policy. Columns 3 and 4 of Table 2 show that a proximity threshold between 0.5-1 mile would trigger closer investigation, including scrutiny of the relevant market definitions, about as often as $\Delta\text{HHI} \geq 200$. Complementing the current HHI threshold with a half-mile proximity threshold would reduce the safe harbor for antitrust enforcement by 8 percentage points over the status quo, a 69% increase in the volume of transactions heavily investigated for enforcement.[20] As well, a half-mile proximity threshold would levy additional enforcement on 35% of transactions that current policy subjects to HHI-based remedies like divestitures.[21]

Another policy alternative based on close-proximity is to use narrower geographic markets. Would an HHI-based policy applied to a smaller geographic area have a similar effect as adding a proximity-based screen to current bank antitrust markets? To investigate this we consider county level markets, and a policy that triggers enforcement of transactions that increase the county HHI by more than 200 points for any county within a Fed banking market. Such a policy might in particular flag mergers of close-proximity banks in MSA markets, which typically span several counties.

We find that an HHI-based policy with narrower markets differs substantially from the proximity policy considered above. The county-HHI policy misses many likely harmful close-proximity mergers. Of mergers inside the Fed banking market safe harbor ($\Delta\text{HHI} < 200$), county HHI thresholds identify only 12% (373 mergers) of mergers where the acquirer and target branch networks were within four miles of each other. At the same time, the county-HHI flags many likely benign far-proximity mergers for enforcement, affecting 7.4% of far-proximity mergers (256 mergers) in-

[20]637 mergers with $\Delta\text{HHI} < 200$ were within 0.5 mile proximity, and 929 mergers were closely investigated because of $\Delta\text{HHI} \geq 200$, resulting in $0.69 = 637/929$.

[21]It would be desirable to quantify potential costs and benefits of incorporating proximity criteria into bank antitrust policy. Wollmann (2020) finds that the stricter pre-merger screening results in higher total welfare. Because the agencies' costs of bank antitrust are relatively small, for example only five full-time economists analyze merger proposals for the Fed, the benefits to consumers likely far outweigh the costs of increased enforcement. More precise measurement of costs and benefits is beyond the scope of our paper because we do not have a structural model to estimate the change in surplus and because there is no clear way to estimate the cost on the regulatory agency (DOJ and Federal Reserve) as opposed to the case in Wollmann (2020).

side the Fed market safe harbor. Moreover, a policy using a lower county-HHI threshold increases the fraction of close-proximity mergers that are captured, but also increases the fraction of far-proximity mergers likely misclassified as anticompetitive. For instance, if the county HHI threshold were lowered to 100 then 28% of close-proximity mergers (886 mergers) would be identified, but 13% of far-proximity mergers (459 mergers) would be misclassified as anticompetitive.

7 Conclusion

This paper studies whether bank antitrust policy is susceptible to mismeasurement of substitutability and could be improved by incorporating information on the geographic proximity of branch networks, an important and observable determinant of the merging banks' substitutability. Our findings altogether suggest that close-proximity mergers in the banking industry lower consumer welfare and, moreover, that even by relaxed definitions for "close-proximity" there are many such mergers missed by the HHI that likely warrant heavier investigation and enforcement. Quantifying the social costs and benefits of counterfactual bank antitrust policies that incorporate proximity criteria is an avenue for future research.

Potential, broader policy implications of our findings also suggest avenues for further research. The literature has found that geographic competition is important in many industries other than banking, and the proximity of establishments of merging firms in these industries is likely observable to regulators. In industries where geographic competition is less important, there may be other determinants of product substitutability that are observable to regulators or otherwise easy to solicit during premerger notification. Such determinants could be used to identify potentially anticompetitive transactions below the current size thresholds that otherwise would not trigger premerger notification. Criteria on industry-specific determinants of substitutability could be more systemically incorporated into the agencies' criteria to initiate investigations, relaxing the dependence on soft information at the earliest stages of review, as well as incorporated into enforcement actions like divestitures, for which the HHI plays a central role. The agencies might form such criteria with evidence from natural experiments and merger retrospectives, as in this paper. Whether such data could improve antitrust review in industries other than banking is a topic for future study. Theory to understand optimal antitrust policy that incorporates multidimensional criteria for differentiated product settings is interesting research direction, as well.

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Appendix

A Census-tract-level analysis

Figure A.1 shows estimates of census tract level difference-in-differences regressions. The sample for this analysis are all census tracts in banking markets where both merging parties have a branch presence, and the banking markets correspond to the markets in the sample for the main analysis. The specification is as follows:

$$y_{emct} = \sum_{\tau=-4}^{4} \mathbf{1}[t = t_e^* + \tau] \times (Both_{emc} \times \beta_{\tau-Both} + One_{emc} \times \beta_{\tau-One}) + \xi_{emc} + \xi_{emt} + \epsilon_{emct}. \tag{3}$$

Here, e denotes a merger, m is a market, c a census tract, and t a year. There are two treatment dummies. $Both_{emc}$ is a dummy for census tracts where both merging banks operate. One_{emc} is a dummy for census tracts where either the acquirer or the target has a branch presence, but not both. The control group consists of tracts in the same overlap market where neither party operates a branch.

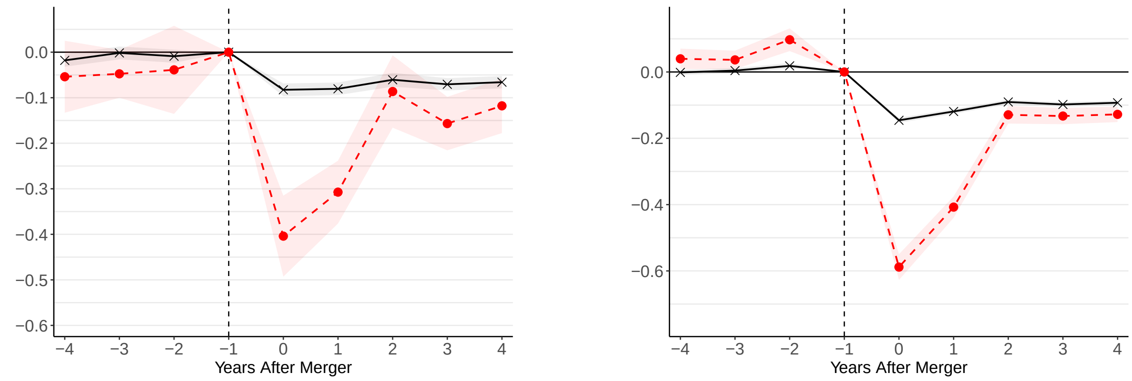
The fixed effects, ξ_{emc} and ξ_{emt} control for time invariant effects that are specific to a combination of merger and a census tract, and for time-varying effects that are specific to a combination of a merger and a market. The standard errors are clustered at the merger-tract level, the unit of exposure.

Figure A.1 plots the estimated coefficient together with the 95% confidence interval. The estimated coefficients for tracts where both merging banks operate ($\beta_{\tau-Both}$) are shown in red, and the coefficients for tracts where only one of them operates are shown in black.

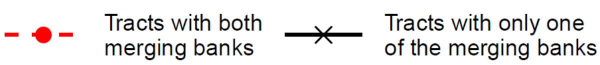
In Panel (a), the outcome variable is the year-over-year change in the total number of branches in a tract. In census tracts where both merging banks had branches, the number of branches decreases by 0.4 in the year of the merger, by 0.3 one year after the merger, and by about 0.1 in subsequent years. This graph shows that branch closings are concentrated in census tracts where both merging banks had branches.

Panel (b) shows the effect on the year-over-year change in the number of branches of the merging banks, which evolves in parallel to the estimates in Panel (a). This result suggests that the reduction in the number of branches is driven by branch closures of the merged bank. Notice, however, that the number of branches of the merging banks decreases more than the total number of branches. The merged bank decreases the number of branch by 0.6 in the year following the merger, and decreases its branches by 0.4 two years after the merger. The differences between panels (a) and (b) suggest that some branch closures of the merging banks are offset by branch openings of rivals that move into the opened territory, which is consistent with the findings in the main estimation specification.

Figure A.1: Branch Closures at the Census Tract Level



(a) ΔTotal Branches in Census Tract (b) ΔMerged Entity Branches in Census Tract



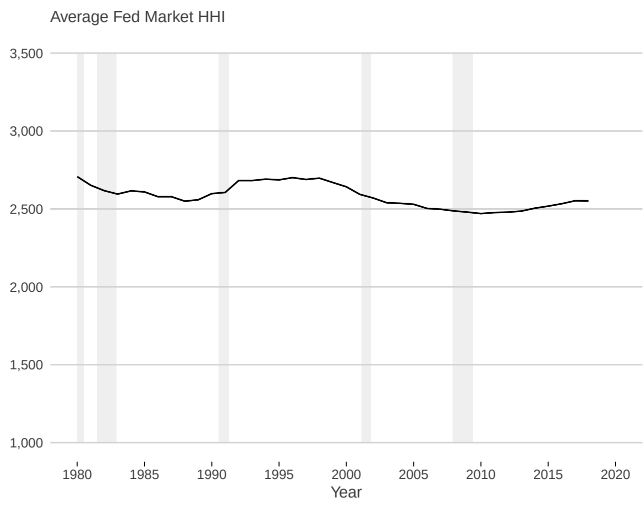
Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (3) as a function of time (τ) relative to the merger year; $\beta_{\tau-Both}$ in red and $\beta_{\tau-one}$ and in black. All standard errors are clustered at the unit of treatment exposure: the merger-tract level.

B Data Appendix: Identifying Mergers

We study mergers that occur between 1984 and 2010. We identify mergers from the SOD dataset. We take advantage of a branch identifier created by the Federal Reserve that identifies branches by their locations. In other words, this identifier is time and ownership invariant, and therefore allows us reliably to track how branches change ownership over time. When a bank disappears from the SOD, it is almost always in the event of a merger. Using the branch identifier in the SOD, we define as the acquirer in such events the bank that acquires the plurality of branches from the disappearing bank, and we define as the target the disappearing bank.

During our sample period, the number of banks in the U.S. declined from 16,729 in 1980 to 6,165 in 2014. We identify 11,513 mergers between 1984 and 2014. Of these mergers, 6,182 involve at least one "overlap" market, that is, a market in which both merging parties operate at the time of the merger. Despite the tremendous number of mergers, the average deposit HHI in Fed markets has remained at a level around 2,500 for the entire sample period, which can be see in Figure A.2.

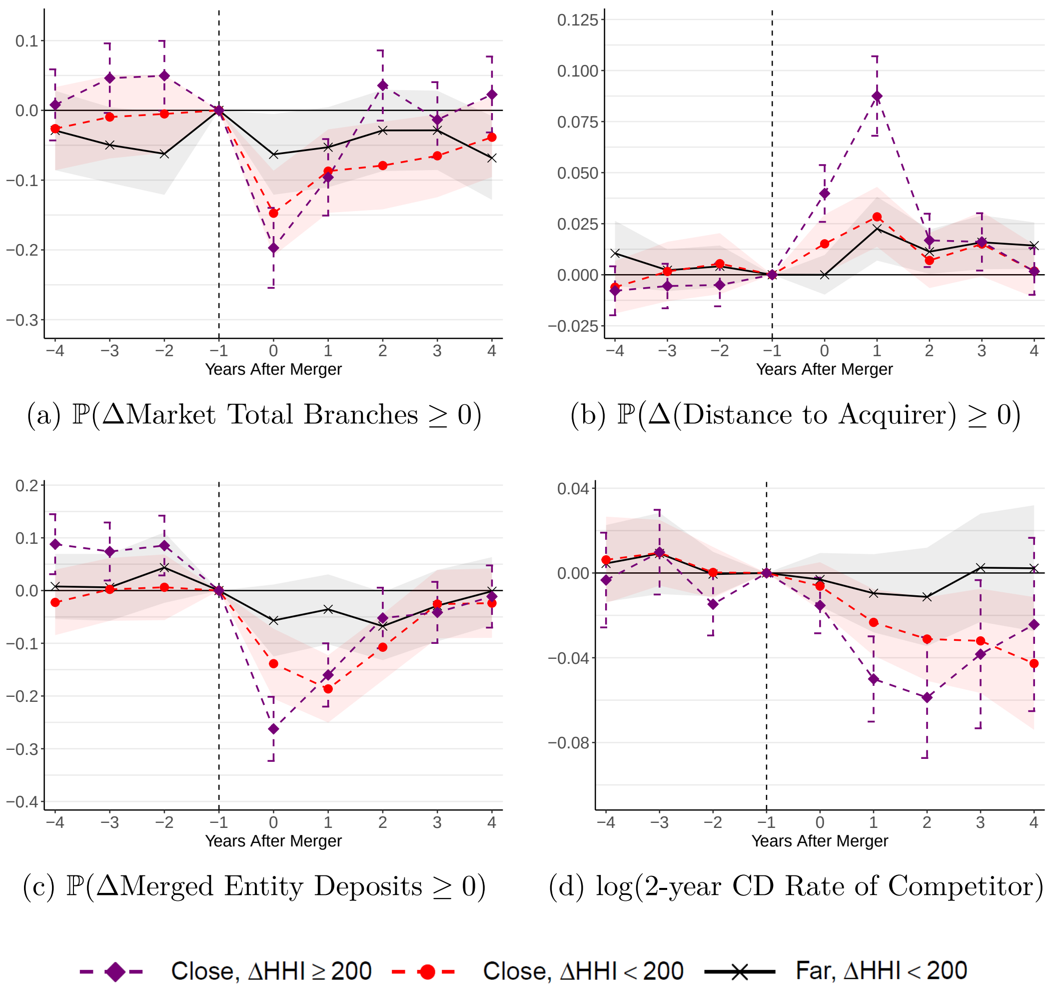
Figure A.2: Market Concentration 1980-2018



Note: The average Herfindahl-Hirschman Index (HHI) in each year across 1,518 Fed markets. The HHI uses deposit market shares derived from the FDIC's annual Summary of Deposits data. Vertical bars represent recessions as defined by the National Bureau of Economic Research.

C Robustness Results Figures

Figure A.3: ΔHHI threshold of 100



(a) $\mathbb{P}(\Delta\text{Market Total Branches} \geq 0)$

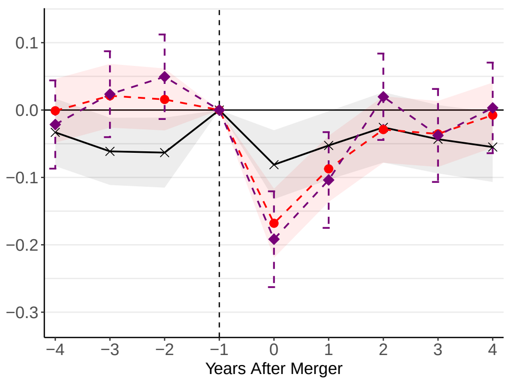
(b) $\mathbb{P}(\Delta(\text{Distance to Acquirer}) \geq 0)$

(c) $\mathbb{P}(\Delta\text{Merged Entity Deposits} \geq 0)$

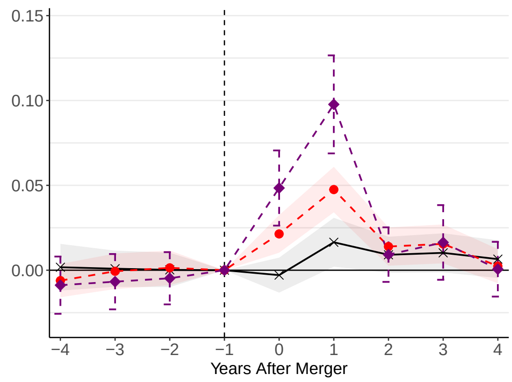
(d) log(2-year CD Rate of Competitor)

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

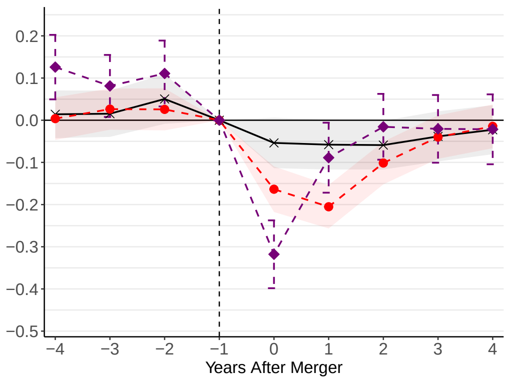
Figure A.4: Federal Reserve Screening Criteria (ΔHHI $\geq$ 200 & HHI $\geq$ 1800)



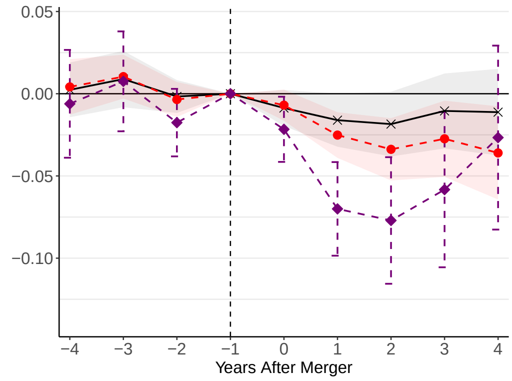
(a) $\mathbb{P}(\Delta$Market Total Branches $\geq 0)$



(b) $\mathbb{P}(\Delta$(Distance to Acquirer) $\geq 0)$



(c) $\mathbb{P}(\Delta$Merged Entity Deposits $\geq 0)$

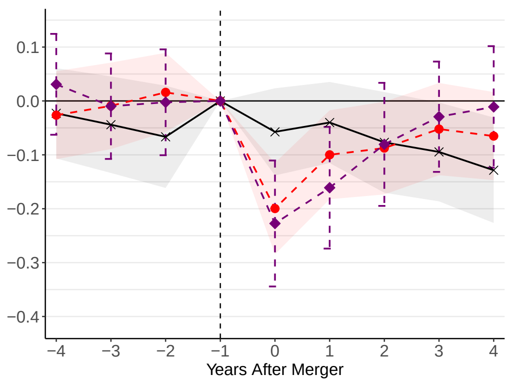


(d) log(2-year CD Rate of Competitor)

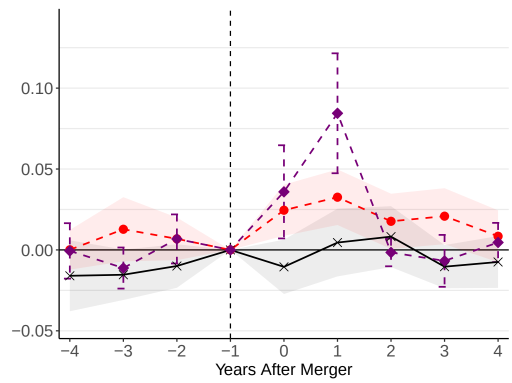
Close, ΔHHI ≥ 200 Close, ΔHHI < 200 Far, ΔHHI < 200

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

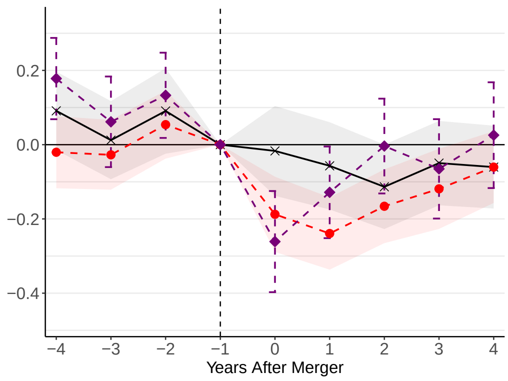
Figure A.5: Sample period 2000-2014



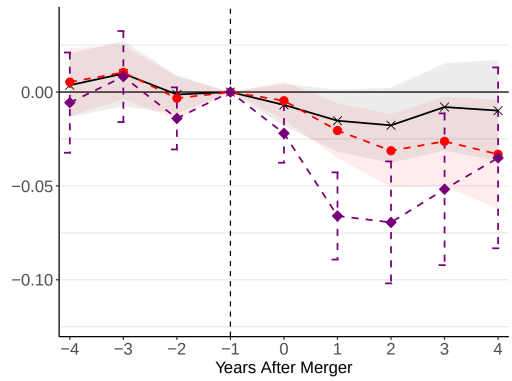
(a) $\mathbb{P}(\Delta$Market Total Branches $\geq 0)$



(b) $\mathbb{P}(\Delta$(Distance to Closest Branch) $\geq 0)$



(c) $\mathbb{P}(\Delta$Merged Entity Deposits $\geq 0)$

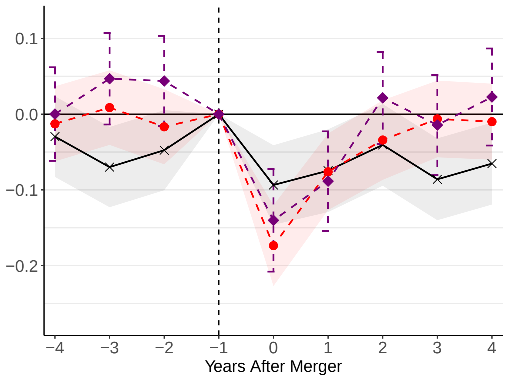


(d) log(2-year CD Rate of Competitor)

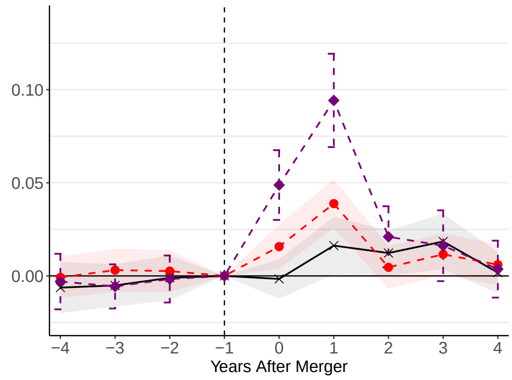
Close, ΔHHI ≥ 200 Close, ΔHHI < 200 Far, ΔHHI < 200

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

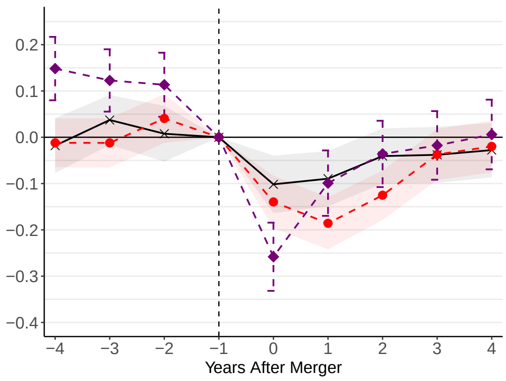
Figure A.6: Within-market proximity measure



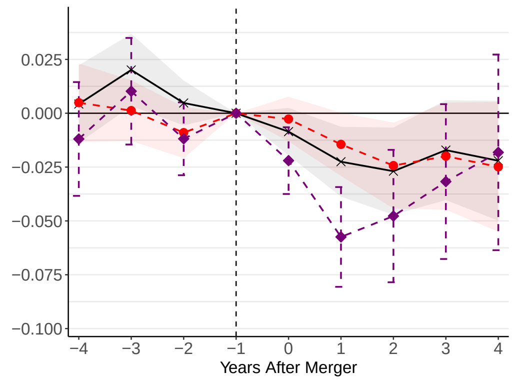
(a) $\mathbb{P}(\Delta\text{Market Total Branches} \geq 0)$



(b) $\mathbb{P}(\Delta(\text{Distance to Acquirer}) \geq 0)$



(c) $\mathbb{P}(\Delta\text{Merged Entity Deposits} \geq 0)$

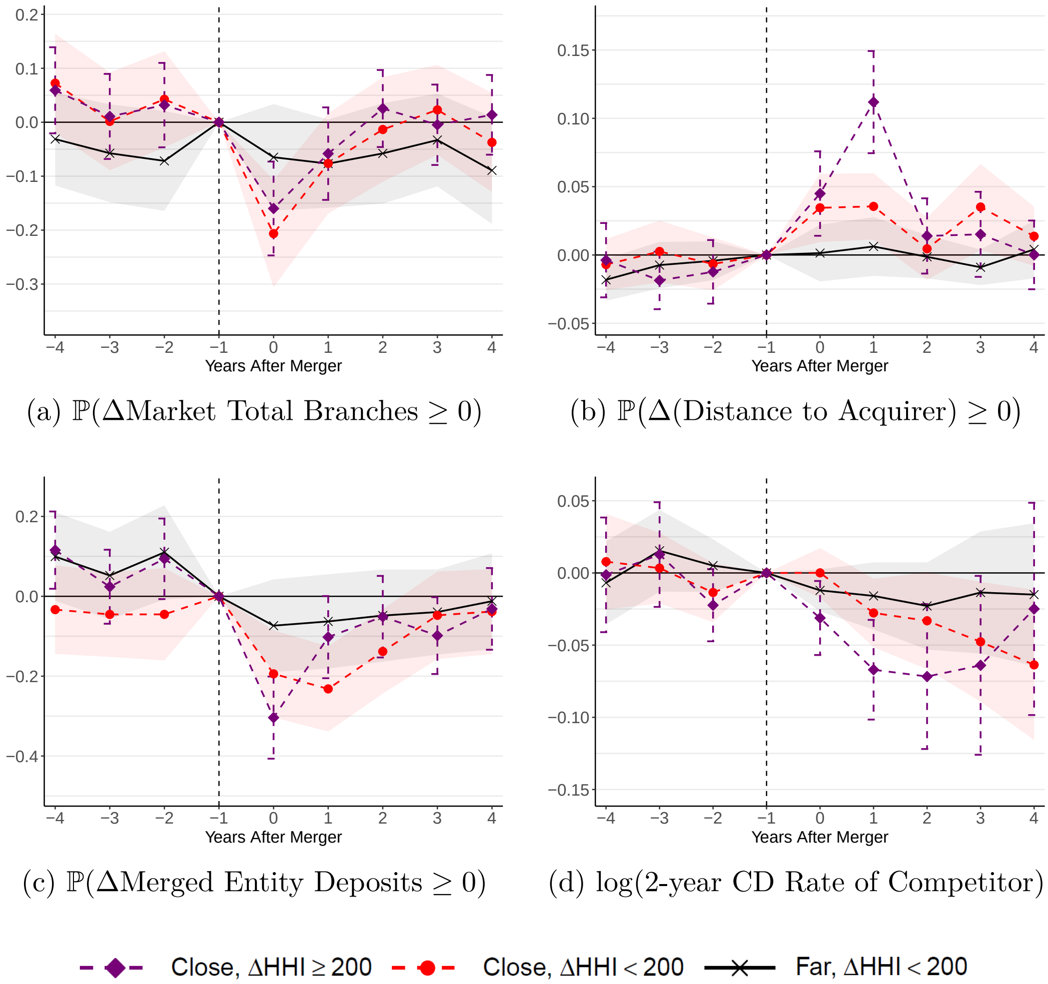


(d) log(2-year CD Rate of Competitor)

Close, ΔHHI ≥ 200   Close, ΔHHI < 200   Far, ΔHHI < 200

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

Figure A.7: No other mergers in the sample window



(a) $\mathbb{P}(\Delta\text{Market Total Branches} \geq 0)$

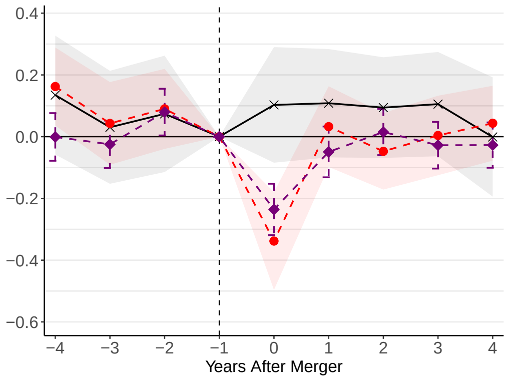
(b) $\mathbb{P}(\Delta(\text{Distance to Acquirer}) \geq 0)$

(c) $\mathbb{P}(\Delta\text{Merged Entity Deposits} \geq 0)$

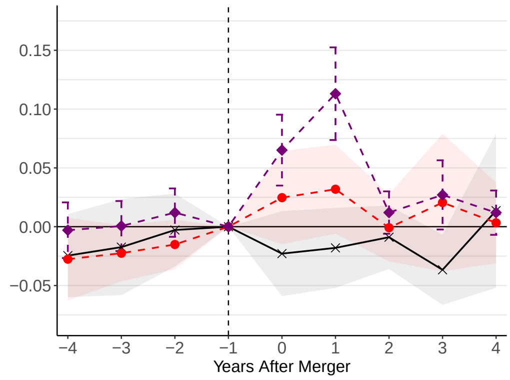
(d) log(2-year CD Rate of Competitor)

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}_{\tau}^{fl}$ in black, $\hat{\beta}_{\tau}^{cl}$ in red, and $\hat{\beta}_{\tau}^{ch}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

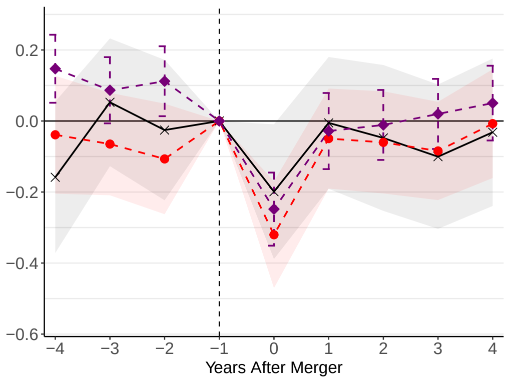
Figure A.8: Markets with 8 or fewer banks



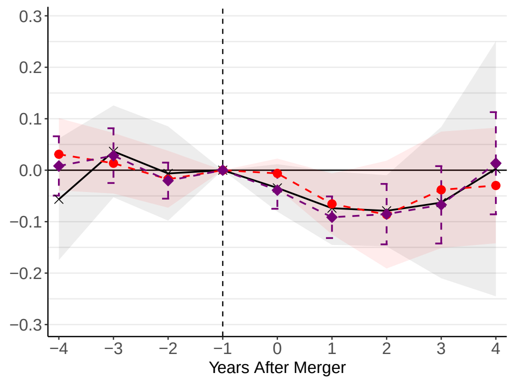
(a) $\mathbb{P}(\Delta\text{Market Total Branches} \geq 0)$



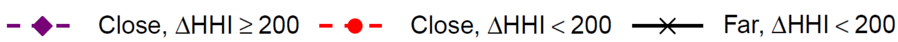
(b) $\mathbb{P}(\Delta(\text{Distance to Acquirer}) \geq 0)$



(c) $\mathbb{P}(\Delta\text{Merged Entity Deposits} \geq 0)$

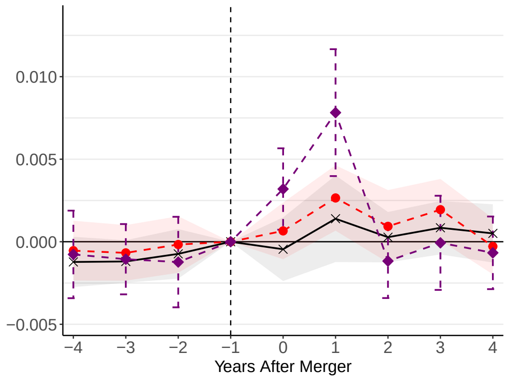


(d) log(2-year CD Rate of Competitor)

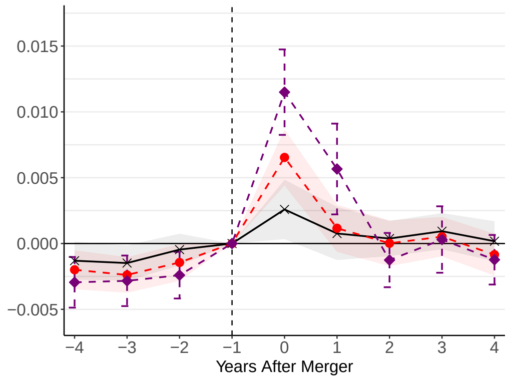


Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}_{\tau}^{fl}$ in black, $\hat{\beta}_{\tau}^{cl}$ in red, and $\hat{\beta}_{\tau}^{ch}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

Figure A.9: Fraction Losing 1-mile Access: $\mathbb{P}\big(\text{Distance}_{t-1} \leq 1 \;\&\; \text{Distance}_t > 1\big)$



(a) Acquirer

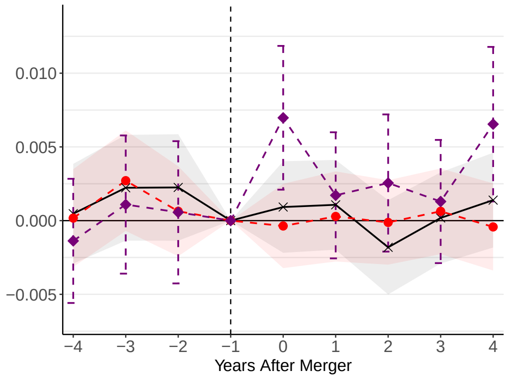


(b) Merged Entity (Pro Forma)

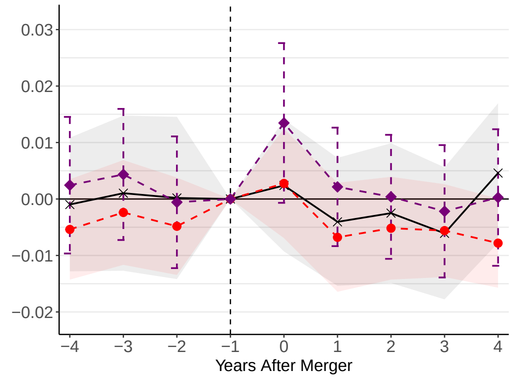
Close, ΔHHI ≥ 200   Close, ΔHHI < 200   Far, ΔHHI < 200

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

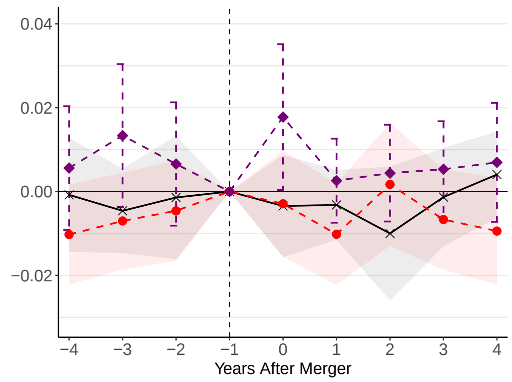
Figure A.10: Increase in Consumer Distance to Competitor Networks: $\mathbb{P}\Big(\Delta(\text{Distance to ...}) \geq 0\Big)$



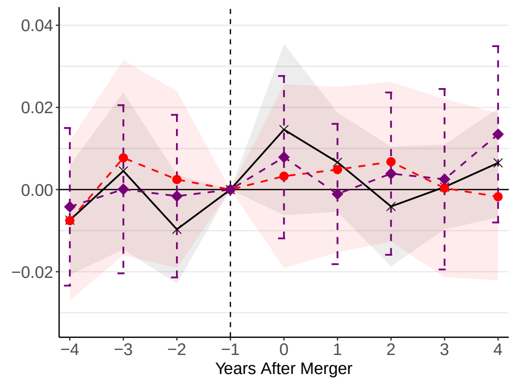
(a) Average Competitor



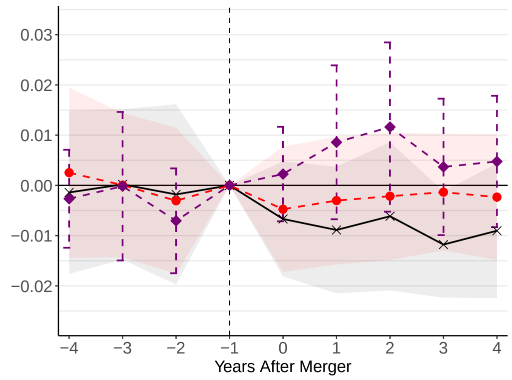
(b) Largest Competitor



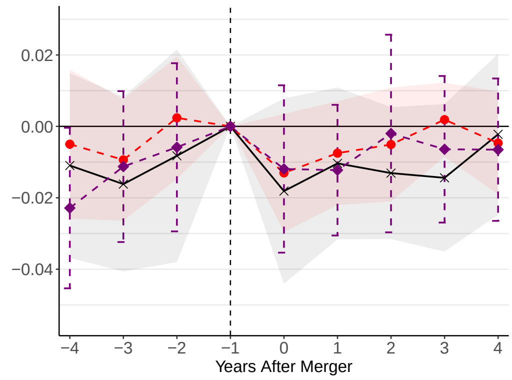
(c) Acquirer's Closest Competitor



(d) Target's Closest Competitor



(e) Acquirer's Farthest Competitor

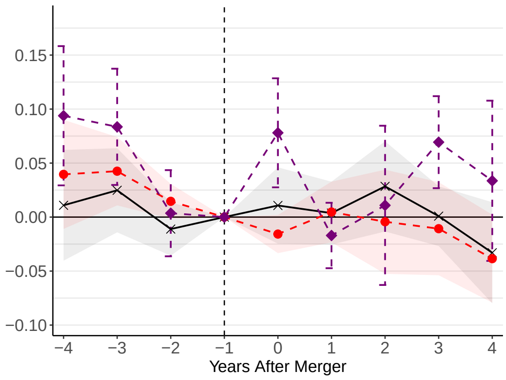


(f) Target's Farthest Competitor

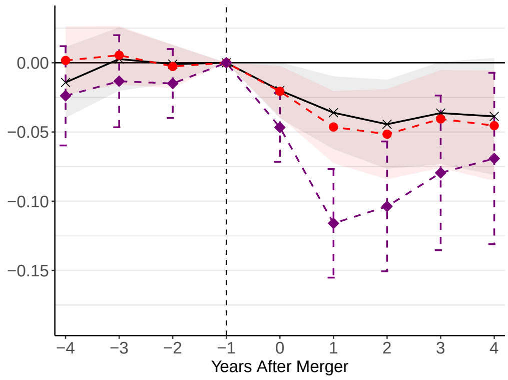
Close, ΔHHI $\geq$ 200 Close, ΔHHI < 200 Far, ΔHHI < 200

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

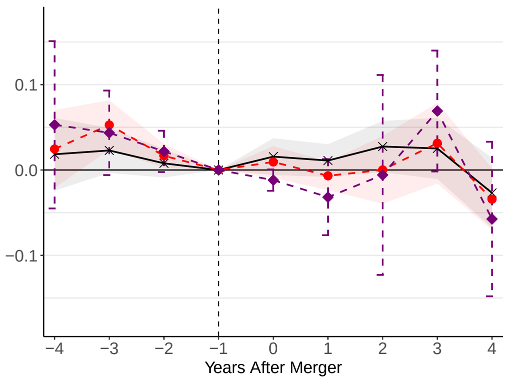
Figure A.11: More Deposit Price Outcomes



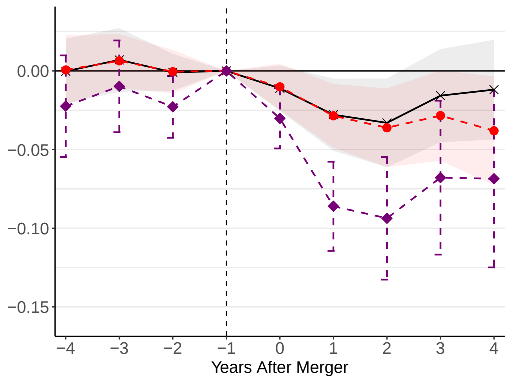
(a) log(Acquirer's 6-month CD Rate)



(b) log(Competitors 6-month CD Rate)



(c) log(Acquirer's 1-year CD Rate)



(d) log(Competitors 1-year CD Rate)

Close, ΔHHI ≥ 200 Close, ΔHHI < 200 Far, ΔHHI < 200

Note: Difference-in-differences estimates and 95 percent confidence intervals from Equation (2) as a function of time (τ) relative to the merger year; $\hat{\beta}^{fl}_{\tau}$ in black, $\hat{\beta}^{cl}_{\tau}$ in red, and $\hat{\beta}^{ch}_{\tau}$ and in purple. All standard errors are clustered at the unit of treatment exposure: the merger-market level.

D Stacked Design & DIDs with Heterogeneity

This appendix discusses the econometric properties of our "stacked" event empirical strategy and regression specification (2). If there is heterogeneity in timing or exposure, a two-way fixed effects regression estimator of the difference-in-difference can produce biased estimates of the average treatment effect on the treated (ATT) in a regular panel design (de Chaisemartin and D'Haultfoeuille, 2020; Goodman-Bacon, 2018). We show that there is observable heterogeneity in merger-specific difference-in-differences of raw means in our data, as well as variation in treatment (merger) timing across events in our sample period. To investigate the performance of the "stacked" design in addressing potential bias from these features of the data, we use results from de Chaisemartin and D'Haultfoeuille (2020) to estimate the weights that a two-way fixed effects regression places on observational-level DIDs.

Weight estimates confirm the potential bias of an empirical strategy that uses an "un-stacked" design. We find that about 20-percent of treated markets receive negative weight in the market-year panel regression. In addition, estimates confirm that all weights are positive (and sum to 1) after "stacking" the market-year panels across merger events and using a regression with event-specific two-way fixed effects.

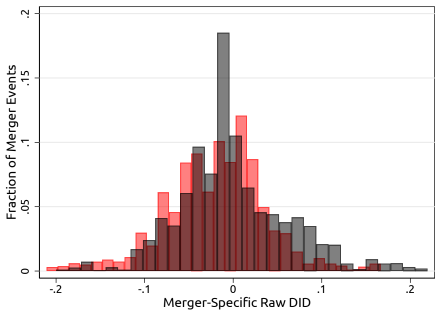
Heterogeneity in Raw DIDs There are several thousand merger events in our data, each with its own treatment and control markets. For a given outcome, a DID exists for each of these events. For example, the estimator

$$DID_{e,\tau} = \left(\bar{y}_{e,\tau} - \bar{y}_{e,-1}\right) - \left(\tilde{y}_{e,\tau} - \tilde{y}_{e,-1}\right)$$

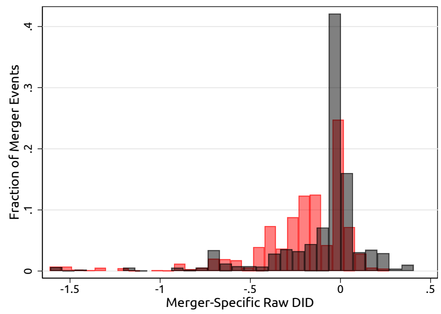
where $\bar{y}_{e,\tau} = \mathbb{E}(y_{emt}|t = t^*_e + \tau, m \in \text{treatment group of } e)$ and $\tilde{y}_{e,\tau} = \mathbb{E}(y_{emt}|t = t^*_e + \tau, m \in \text{control group of } e)$ is a DID of raw means for event e measured τ years after the merger. Sample counterparts of $\bar{y}_{e,\tau}$ and $\tilde{y}_{e,\tau}$ can also be conditioned on covariates like acquirer-target proximity or the merger's effect on the HHI. Hence, one can observe heterogeneity in "raw" event-specific DIDs.

Figure A.12 provides evidence of heterogeneity in DIDs for four outcomes studied in Section 5. We illustrate the empirical densities of merger-year treatment effects

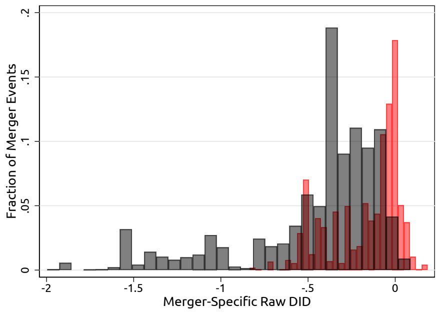
Figure A.12: Observed Heterogeneity in $DID_{e,0}$ Across Merger Events



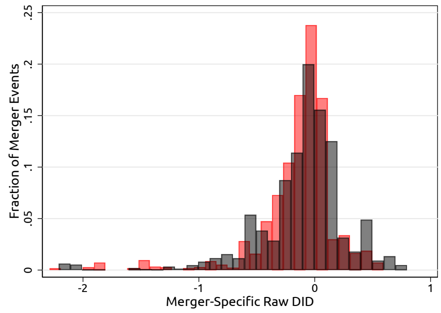
(a) Δ log(Market Total Branches)



(b) Δ log(Merged Entity's Branches)



(c) Δ log(Consumer Distance to Acquirer)



(d) Δ log(Merged Entity's Market Share)

$\widehat{DID}_{e,0}$, computed separately by acquirer-target proximity for: (Panel a) growth in market total branches, (Panel b) growth in the number of branches operated by the merged entity, (Panel c) the percent change in the distance between consumers and the acquirer's branch network, and (Panel d) growth in the merged entity's market share. The density of the DID for each of these outcomes exhibits significant variation across mergers. Also, the densities of $\widehat{DID}_{e,0}$ for close proximity markets (red histograms) are starkly different from the corresponding densities of far proximity markets (grey histograms).

Negative Weights in a Two-way Fixed Effects Regression How does this observable heterogeneity impact an empirical strategy for estimating average treatment effects? A two-way fixed effects regression will yield a weighted average of feasible DID comparisons in the data.[22] Variation in exposure within the effective

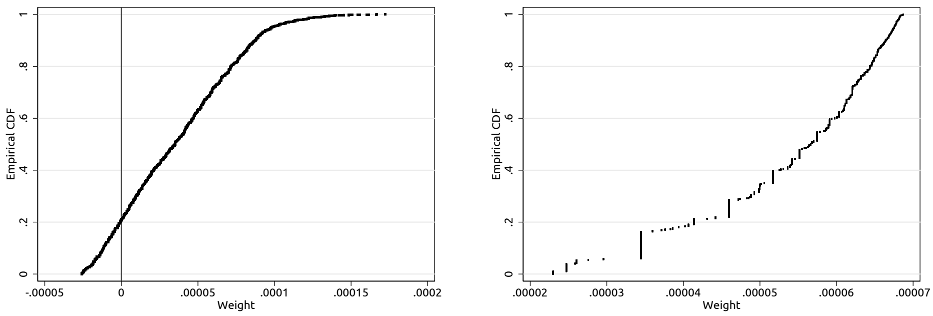
[22]See de Chaisemartin and D'Haultfoeuille (2020), Sun and Abraham (2020), Goodman-Bacon (2018), de Chaisemartin and D'Haultfoeuille (2019), Sandler and Sandler (2014), Athey and Imbens (2018), and the related literature.

treatment/control groups defined by two-way fixed effects can (i) result in negative weighting and (ii) introduce unwanted but feasible DID comparisons such as the DID between observations treated one year before/after each other. With treatment effect heterogeneity, negative weighting might produce a weighted average that has the opposite sign of all of the underlying treatment effects. If there are feasible DID comparisons in the data which are not properly interpretable as treatment effects, then the weighted average produced by a two-way fixed effects estimator is not interpretable as an average treatment effect.

There is no widely accepted estimation strategy to address such concerns, though several alternative estimators have been proposed. Our strategy is in the spirit of de Chaisemartin and D'Haultfoeuille (2020). We construct a panel of treatment and control markets specific to each merger event, stack these event-specific panels across treatment events, and employ regressions with event-specific two-way fixed effects. Negative weighting is eliminated mechanically by event-specific market and year fixed effects, because event-specificity controls for variation in treatment timing (now relative to a single reference merger) and intensity (by stacking across merger events). The event-specific two-way fixed effects regression averages over the underlying merger-specific DIDs, a weighted average across events in the stack that is free of negative weighting.

To examine the effectiveness of our strategy, we bring the weighting formula in de Chaisemartin and D'Haultfoeuille (2020) to our data. Figure A.13 illustrates the empirical cumulative distribution functions for weights placed on treated observations in a market-year panel regression with market and year fixed effects versus weights in our stacked panel regression with event-specific two-way fixed effects. We find that in a market-year panel design, over 20 percent of treated markets have negative weights (Panel a). In contrast, in the stacked panel design no treated observations have negative weights (Panel b). Note that the weights illustrated in Figure A.13 are for the pooled DID regression, i.e. a single coefficient for all post-treatment periods. Estimates of weights for the various τ event-time effect as well as HHI- and proximity-conditioned effects from in the main results in Section 5 are qualitatively similar to the weights for the pooled regressions illustrated here.

Figure A.13: Two-way Fixed Effects Weight Estimates



(a) Market-Year Panel (b) Event-Stacked Panel

Estimates of the weights (de Chaisemartin and D'Haultfoeuille, 2020) that two-way fixed effects regressions place on treated observations.