Hospital Mergers and Service Repositioning*

Yu Ding† Chenyuan Liu‡

February 15, 2022

Abstract

Horizontal mergers are often associated with product reshuffling, which may have important anti-trust consequences. This article shows that hospitals merging with local competitors reposition service lines after the merger. We use hospital-level service lists data from American Hospital Association 2002 - 2012. To avoid endogenous selection into mergers, we estimate difference-in-differences models comparing hospitals merged later to those merged earlier. We find that merging hospitals eliminate duplicate services without reducing patient volumes. Hospitals within a system become more differentiated in service positioning after the merger. However, there is limited evidence that repositioning leads to significant cost reductions. *JEL Codes:* I11, L40.

*Special thanks to Zack Cooper, Stuart Craig, Martin Gaynor and John Van Reenen for generously providing the merger and acquisition data, and Peter Newcomer for insights about hospital organization and management. We are also grateful to Naoki Aizawa, Ken Hendricks, John Mullahy, Alan Sorensen, Justin Sydnor, Chris Taber, and seminar participants in IIOC, UW Madison, Bates White for helpful comments. All errors are our own.

†yu.ding@wisc.edu. Department of Economics, University of Wisconsin – Madison

‡Corresponding author. Email: liuchy3@sem.tsinghua.edu.cn. Address: School of Economics and Management, Tsinghua University, Beijing, China 100084.

1 Introduction

Analysis of horizontal mergers has been concentrated on price effects, an important dimension that mergers may affect consumer surplus. This is true for many industries, including the hospital sector, an industry that experienced increasing concentration over the last decades (Kaufman Hall, 2019). There is a growing literature documenting both the merger effects on the price charged by hospitals for their services provided (Dafny, 2009; Haas-Wilson and Garmon, 2009; Garmon, 2017; Lewis and Pflum, 2017; Cooper et al., 2018), as well as merger effects on input price, including wages of hospital employees and medical supplies and devices (Prager and Schmitt, 2021; Craig, Grennan and Swanson, 2021).

In contrast, there is less analysis on mergers' impacts on hospital service offering, another important channel through which mergers have potential large welfare consequences. The literature illustrates that multi-product firms often face competitive incentives to reposition product offerings after merger (Gandhi et al., 2008). Such behaviors may soften price competition and have different welfare implications than if only price effects are considered. We extend the analysis to the hospital industry, which can be naturally viewed as multi-product firms. General acute hospitals usually have dozens of service lines and provide different procedures to patients. More importantly, when confronted with antitrust challenges, hospitals seeking mergers frequently claim that they can generate substantial efficiency gains through service consolidation, specifically through removing duplicate services.[1] The potential benefits can come from savings in capital investment and payroll expenditure (economy of scale) and potential efficiency gains through care coordination. However, removing duplicate services can also reduce patients' choices, increase travel distance, and lower consumer surplus, which has potential adverse effects beyond higher prices.

[1]For instance, when the Federal Trade Commission (FTC) challenged the horizontal merger between OSF HealthCare and Rockford Health System, the hospitals stated that the proposed merger could generate efficiencies by "consolidations of several services" and "combining patient volume [...] to meet or exceeds (the generally-accepted minimum patient volume) thresholds associated with improved outcomes"(The Federal Trade Commission, Doc. 9349, 2012).

This article examines hospital mergers in the United States between 2002 and 2012 and documents how the merging health care systems reorganize their services. We investigate whether merging hospitals consolidate duplicate services and quantify the magnitude of service repositioning. Our baseline analysis uses a staggering difference-in-differences (DID) design to compare the service provision of merging hospitals before and after mergers. Analysis of the raw data indicates that non-merging hospitals are different from merging hospitals on a range of pre-merger characteristics, and merging hospitals are similar. To avoid bias due to the direct comparison of merging and non-merging hospitals, we exclude non-merging hospitals from our baseline analysis. We use hospitals that merge later as the control group for hospitals that merge earlier. This strategy takes advantage of the variation in the timing of mergers, and it relies on the assumption of parallel pre-trend across early-merging and later-merging hospitals. As hospitals typically have little control over the exact timing of when a merger is approved, the selection of merging time is not a primary concern. We also refer to several recent articles dealing with potential bias in the staggering DID design and show the robustness of our results using alternative estimators and internal validity tests (Goodman-Bacon, 2021; de Chaisemartin and D'Haultfœuille, 2020; De Janvry et al., 2015).

Our data on hospital service offerings come from the American Hospital Association Annual Survey, and the data on mergers and acquisitions are from Cooper et al. (2018). We restrict our sample to general hospitals which merged between 2002 and 2012. For each hospital and year, we observe whether it offers a list of more than 70 different services, among other hospital characteristics, including the total number of inpatient admissions and outpatient visits. We calculate the number of services offered as the dependent variable.

We find that hospitals reduce one service after the merger, mainly driven by nearby mergers. We define the merging counterpart of a target (acquirer) hospital as the closest acquirer (target) in terms of driving time. We find the effects only exist for hospitals whose merging counterpart is within 30-minute driving time. The effects are roughly the same for targets and acquirers. We also find that the reduction in service lines provided is not driven by hospital downsizing; there is no change in patient volumes after the merger.

Second, we measure service differentiation within a hospital system. We find that service offering is more differentiated after the merger within a system among hospitals located near each other (within 30-minute driving distance), measured by the number of services offered by multiple hospitals in the system or the fraction of hospitals offering a service, averaged across all services. There is no change in the unique service lines offered within the system. Such effects die away once we expand the market definition to broader geographic regions, confirming that the merger effects on repositioning are restricted to local mergers.

Finally, we find that service repositioning is associated with a change in the hospital cost structure. We show that hospitals merged with local competitors slightly increased the capital inputs (measured by the number of beds) but reduced the labor inputs (measured by the number of full-time equivalent employees) after the merger. This pattern is consistent with a reduction in the per-patient salary costs and no change in the per-patient capital costs after the merger. Overall, hospitals experience a small and insignificant reduction in the average costs.

This article adds new insights to the emerging literature exploring the efficiency improvement mechanisms after the merger in the hospital industry. Craig, Grennan and Swanson (2021) examines whether hospitals can reduce costs by bargaining lower prices when purchasing medical supplies. We explore another mechanism for merging hospitals to reduce costs and improve efficiency: service consolidation. We highlight that service repositioning exists only for local mergers with insignificant cost savings. Prior literature shows that these mergers also lead to greater price increases (Dafny, 2009). Our results suggest that a critical question for policymakers is how to pass on to consumers the cost reductions that result from health care system mergers, especially geographically close mergers.[2] In contrast, the lack of service consolidation

[2]One potential choice for policymakers could be a price cap similar to the one implemented in the merger of

and cost savings for distant mergers in our data questions the value of such mergers, especially given that recent literature finds a price increase for these mergers (Dafny, Ho and Lee, 2019).

Our work also contributes to the literature on post-merger endogenous product choices of multi-product firms. Theoretical work by Gandhi et al. (2008) and Mazzeo, Seim and Varela (2013) explains that a merging firm may choose to reposition its products to differentiate from its merging partners. This repositioning might mitigate price increases after a merger. Product choice by merging firms has been investigated empirically in various industries and markets, including music radio (Sweeting, 2010, 2013; Berry, Eizenberg and Waldfogel, 2016), smartphones (Fan and Yang, 2016), the airlines (Ciliberto, Murry and Tamer, 2016), and shampoo (Mao, 2019). We contribute to this line of literature by documenting endogenous product choices in the hospital industry.

The rest of the article is organized as follows: Section 2 illustrates a conceptual framework on hospital mergers and service repositioning. Section 3 outlines the data. Section 4 presents the empirical strategy, and Section 5 shows the results. Section 6 offers a discussion and conclusion.

2 Conceptual Framework

This section shows an illustrative example where hospitals have incentives to remove duplicate services. We use a spatial differentiation model similar to Salop (1971)'s circular city model.

Model Setting On the supply side, we assume a market with four hospitals $\{A, B, C, D\}$ evenly distributed on a circle with unit length, as in Figure 1. Each hospital offers a range of services $i = 1, 2, ...$ We assume these hospitals are identical to consumers except for their locations for simplicity. For each service s_i, all hospitals have the same marginal cost $mc_i = c_i$ of treating each unit of patients and fixed cost of entry f_i. Additionally, we assume no other

Beth Israel Deaconess Medical Center and Lahey Health System.

hospitals could enter this market.

On the demand side, consumers are distributed uniformly on a circle with unit length, and they can only travel on the circle. There are equal amounts of consumers seeking each service i, and we assume each type is mass one. Consumers seeking service i have unit demands and enjoy utility $V_i - \alpha_i x - P_i$ if they decide to go to a hospital with a travel distance of x and a price P_i. α_i reflects the marginal utility to patients seeking service i if the travel distance is reduced by one. Because the demand for each service is independent, hospitals decide on service offering independently for each service. For simplicity of exposition, we omit subscript i henceforth.

Model Prediction We summarize the prediction of the model in Table 1. Before the merger, four hospitals are competitors and do not share common ownership. Consider a scenario where the fixed entry costs are small enough, such that all hospitals offer the service. Then the four hospitals simultaneously set prices. In equilibrium, all hospitals set the same price $\frac{\alpha}{4} + c$, attain the same market share $\frac{1}{4}$ and earn the same profit $\frac{1}{16}\alpha - f$.

We assume two adjacent hospitals, A and B, merge into the same system. The newly merging hospital can either decide to have both hospitals offering service i or have only one offering it. For simplicity, we assume c and f are unchanged, so as consumers value receiving care, V (the same for all hospitals).

Consider the case when both hospitals offer the service. The merging system now maximizes the joint profits and set prices at $\frac{2}{5}a + c$ for both hospitals. Hospital C and D also adjust their prices to $\frac{3}{10}a + c$. The profits of the merging system are $\frac{4}{25}\alpha - 2f$. Both consumer surplus and total surplus are lower than with no merger.

If only one hospital offers the service, say hospital A, while hospital B removes it, then the equilibrium prices are $\frac{7}{20}a + c$, $\frac{7}{20}a + c$ and $\frac{3}{10}a + c$ for A, C and D respectively. The profit for the merging system is $\frac{49}{400}\alpha - f$. The condition of repositioning for the merging system A and

B is thus:

$$f > \frac{3}{80}\alpha.$$

The condition shows that all else equal, services with smaller elasticity with regard to distance (α) and higher fixed costs (f), are more likely to be removed.

We also want to highlight that if the system removes duplicate service from B, and there is no price cap regulation restricting pricing behavior, consumers are worse off because they now face longer travel distances and higher prices. The reduction in consumer welfare is smaller if there is no repositioning. Besides, the total surplus will change by $f - \frac{13}{400}a$ relative to no merger. If f is high enough or α is low enough, the merger will increase the total surplus. This illustrates the point that in merger analysis, ignoring the possibility of service repositioning might overestimate the welfare loss from the merger.

Merger Distance In the above illustration, we fixed the distance between the adjacent hospitals. In this section, we want to derive comparative statics for the change in profits and consumer surplus after repositioning when the two merging hospitals have different distances. Fix the location of A, C, D as in Figure 1, but let the distance between A and B be a variable, denoted by d. Without loss of generality, assume $d \in (0, \frac{1}{4}]$. We consider the merger between A and B.

The merging system will reposition the service if

$$f > \frac{27}{13456}a + \frac{2606a}{21025}d + \frac{1516a}{21025}d^2.$$

The right-hand-side is an increasing function when $d \geq 0$. In other words, repositioning is more likely to happen when the distance between A and B is smaller.

Another insight from the model is that if A and B have a shorter distance before the merger, then all else equal, the profits gain from repositioning is larger, the consumer surplus reduction is smaller, and the total surplus increase is more. Figure 2 illustrates a numeric case where $\alpha = 1$ and $f = 0.025$. The figure shows that when the distance between A and B increases, the profits from repositioning (relative to no repositioning) decreases, the consumer surplus and the total surplus also decrease. In this numeric example, merger and the subsequent service repositioning increase the total surplus because the savings in fixed costs exceed travel costs.

Service Repositioning and Quality Change For the merger and repositioning to generate positive consumer surplus, the repositioning has to improve the quality of care. We illustrate this point by extending our model, allowing both endogenous service offering and potential technology change following repositioning (in the form of larger $V - c$). We assume the technology change only happens if the system removes service i from one of its facilities. This assumption captures the fact that pooling labor and capital in both facilities into the same locations improves coordination of care and lowers production costs.

Assume adjacent hospitals A and B merge. Suppose if hospital B removes service i, the system experience an increase in V (now labeled V_A), a decrease in c (now labeled c_A), and a decrease in f (now labeled f_A). For all other hospitals, V, c, and f are unchanged. Assume all hospitals simultaneously choose price and quantity. In equilibrium, we find that the profits for the merging system is $\frac{49}{200}\alpha - f_A + \frac{7}{20}D + \frac{D^2}{\alpha}$, where $D = \frac{2}{5}(c - c_A) + \frac{2}{5}(V_A - V) > 0$. It's straightforward to see that the merging system earns even higher profits if repositioning also leads to quality improvement than without such improvement. All else equal, the increase in quality makes the system more likely to reposition its services.

With quality improvement, the consumer surplus under repositioning is $\frac{33}{50}(V - c) + \frac{34}{100}(V_A - c_A) + \frac{2}{25}((V_A - c_A) - (V - c)) - \frac{43}{100}\alpha$. The difference between the consumer surplus and the surplus without repositioning is $-\frac{47}{200}\alpha + \frac{17}{50}((V_A - c_A) - (V - c)) + \frac{4}{5\alpha}((V_A - c_A) - (V - c))^2$. As long as the quality improvement $((V_A - c_A) - (V - c))$ is large enough relative to consumers' willingness to pay for distance (α), then repositioning could bring in positive consumer surplus.

In other words, service repositioning following a merger can increase consumer welfare if there is enough quality improvement.

3 Data

We use three data sources to study the service repositioning of merged hospitals: (1) Hospital Merger Activity Dataset (Cooper et al., 2018), (2) American Hospital Association Annual Survey, and (3) Healthcare Cost Reports.

Hospital Merger Activity Dataset The Hospital Merger Activity Dataset built by Cooper et al. (2018) provides information about horizontal hospital mergers. The data set contains a panel of hospitals from 2000 to 2012. It includes the following variables: the system identifier of hospitals, an indicator for whether the hospital is a target or acquirer every year, and the longitude and latitude of hospitals.

We categorize the mergers in the Hospital Merger Activity Dataset based on distances between merging entities. Let S_1 and S_2 denote the two systems involved in a merger. Let L and K stand for the number of hospitals belonging to each system, where $L \geq 1$ and $K \geq 1$. We denote these two systems $S_1 = \{H_1^1, H_2^1, .., H_L^1\}$ and $S_2 = \{H_1^2, H_2^2, .., H_K^2\}$, where H_i^s stands for a hospital i belonging to System $s \in \{1, 2\}$, with $i \leq L$ for S_1 and $i \leq K$ for S_2. For a hospital H_l^1 belonging to S_1, we call $H_1^2, H_2^2, .., H_K^2$ its merging counterparts because they are from the other system involved in the merger transaction. We calculate the travel time between a hospital and its counterparts using Google API. This merging hospital H_l^1 is said to have a merging counterpart within x-minute driving time if there exists a hospital H_k^2 from S_2 whose driving time from H_l^1 is no longer than x minutes. This hospital pair (H_l^1, H_k^1) is called a within-x-minute merging pair. We define a merger transaction as within x minutes as long as there exists a hospital pair (H_l^1, H_k^2) whose driving distance is within x minutes driving time.

In our baseline analysis, we define local mergers as having a driving time within 30 minutes.

Figure 3 summarizes horizontal hospital mergers in the United States from 2001 to 2014. The dashed line represents all transactions. The solid line is the number of mergers whose closest merging entities are less than 100 miles away. The dotted line represents mergers of hospitals within 10 miles of each other. As shown in the figure, horizontal hospital mergers often involve hospitals geographically close to each other.

American Hospital Association Annual Survey We use the AHA Annual Survey to study the services provided by the hospitals. The AHA data set covers over 80% of all hospitals in the United States and contains general information such as ownership type, the total number of beds, and total discharges. Moreover, it contains the service provision status for more than 70 services. We focus on the services that are reported throughout 2001 to 2012. New services are added to the survey over time, but they are usually not up to date, resulting in measurement errors in reporting. We choose to leave them out in the baseline analysis and consider all services in the robustness checks in Appendix A.1. AHA reports a dummy variable indicating whether the hospital offers that service for each service. The service list covers a wide range of services, for example, emergency departments, neonatal intensive care units, ct scans, etc. The complete service list is reported in Appendix Table A.1.

We concentrate on general hospitals and exclude children's hospitals and hospitals specializing in psychiatric, chemical dependency, or long-term care. After data trimming, our sample contains 3,408 hospitals. The summary statistics of all hospitals in the beginning year of the sample period (2002) are presented in Table 2. The first column shows the mean and standard deviation for non-merging hospitals, and the last three columns show the summary statistics of merging hospitals based on the merger year. The characteristics of hospitals that merge are similar across all merging year groups. However, the non-merging hospitals are different from the merging entities in terms of many characteristics. The merging hospitals offer more services than the non-merging hospitals, belong to larger systems, and have a larger patient volume. The merging hospitals also treat more complicated patients with a higher case-mix index.[3]

The summary statistics suggest two features of our data: first, merging hospitals are different from the non-merging hospitals on many dimensions, which suggests that there is selection into mergers. Second, hospitals merged in different years are similar. Both facts motivate our empirical design, which we detail in Section 4.

Healthcare Cost Reports To analyze the welfare impacts of service repositioning, we collect hospital annual cost information from the Centers for Medicare and Medicaid Services (CMS) Healthcare Cost Report Information System (HCRIS), 2001 to 2012. Almost all US hospitals submit annual financial reports to CMS. We merge the data with the AHA sample - 70% of the AHA sample is matched with the cost report.

We construct four measures on hospital costs: the total costs, the capital costs, the salary costs, and the rest.[4] We convert all cost measures into per patient levels by dividing the cost measures by the adjusted total number of discharges (Schmitt, 2017). Let c denote any of the cost measures above. The average cost, $\bar{c}$ is calculated as:

$$\bar{c} = \frac{c}{(\text{outpatient revenue}/\text{inpatient revenue} + 1) \times \text{inpatient discharges}}.$$

This approach assumes that the profit margin for inpatient and outpatient services is the same.

[3]The case-mix index is the average relative diagnosis-related group weight of a hospital's inpatient discharges, calculated by summing the Medicare Severity-Diagnosis Related Group (MS-DRG) weight for each discharge and dividing the total by the number of discharges. The case-mix index reflects the diversity, clinical complexity, and resource needs of all the patients in the hospital. A higher case-mix index indicates more complex and resource-intensive patients.

[4]The capital costs include "depreciation, leases and rentals for the use of facilities and/or equipment, and interest incurred in acquiring land or depreciable assets used for patient care"(CMS, 2022). The salary costs include hospital expenditure in direct salaries and wages, paid vacations, etc.(CMS, 2022).

4 Empirical Strategy

Hospital service repositioning, specifically, duplicate service removal, will show along two dimensions. At the individual hospital level, removing duplicate services leads to a decrease in the number of services offered; at the system level, it leads to lower service overlapping and higher differentiation of service list among individual facilities within the system. We thus conduct two levels of analysis: first at the individual hospital level; second at the system level.

Hospital-Level Analysis We construct the number of services offered by hospital i in year t using service list information from the AHA data. Let n_{it} denote this variable. We then examine the change of n_{it} before and after the merger using a staggering difference-in-differences model:

$$n_{it} = \alpha_i + \gamma_t + \sum_{k=-5}^{4} \lambda_k \cdot \mathbb{1}[t = \tau_i + k] + \epsilon_{it}, \tag{1}$$

where α_i denotes hospital fixed effects, γ_t is the year fixed effect to absorb any time trend. We group observations five or more years before the merger into $k = -5$, and $k = 4$ indicates four or more years after the merger. λ_k represents the effect on service repositioning of being k years post-merger. This specification fully shows how the effects may evolve over time. For ease of presentation, in the table, we also show a version where we group the above coefficients into four categories: two and more years before the merger; year of merger; one and two years after the merger; and three and more years after the merger. The baseline year is one year before the merger. We separate the effects at the merging year because hospitals may merge in the middle of the year.

The baseline analysis includes only merging hospitals with counterparts within 30-minute driving time and excludes all non-merging hospitals. This method avoids the potential bias in comparing merging and non-merging hospitals since there is likely selection into merger activity. We also exclude mergers of hospitals beyond 30-minute driving time from each other. As shown in Section 2, travel distance among merging hospitals plays an essential role in determining the decision to consolidate similar services after the merger. We thus estimate equation (1) separately for mergers with different travel times and examine how the effects change from 30-minute driving time to longer driving time.

We also add different control variables to the baseline specification for robustness checks. First, we add HRR-specific year trends to capture potential geographic differences in time trends that may drive the results. Second, we add other time-varying variables as controls, including the share of revenues from Medicare, the share of revenues from outpatient care, and the patient case mix index. These variables represent other strategies a hospital may take after a merger. These strategies could happen along with service repositioning, or service repositioning is a byproduct of these other goals. We add them as controls to single out their impacts on the number of services offered.

One concern is that the change in patient volumes may drive the change in the number of services offered - for example, hospitals may expand or shrink after mergers instead of relocating services. Such a pattern will also lead to a change in the number of services offered but does not represent the removal of duplicate services and concentration of service offerings within a system. To eliminate such concern, we also estimate equation (1) using the adjusted patient days and number of inpatient admissions as the dependent variables.[5] Besides, we separately estimate equation (1) for targets and acquirers. If the change in the number of services represents shrinking or expanding hospital services scope, it will likely lead to differential effects for targets and acquirers.

System-Level Analysis Removing duplicate services will lead to less overlapping in service offerings within a system without reducing the unique number of services offered. We construct three different measures on service offering pattern:

[5]The adjusted patient days are calculated as $(\frac{\text{outpatient revenue}}{\text{inpatient revenue}} + 1) \times$ inpatient days.

1. The number of unique services offered by a system, *uni*
2. The number of services offered by more than one hospital, *dup*
3. The fraction of hospitals offering a service within a system averaged across all services, *frac*

If a system removes duplicate services without changing the size, then *uni* should stay constant before and after the merger, while both *dup* and *frac* will decrease after the merger.

A key component of this analysis is the definition of a system. We group merged hospitals based on their system ID at the end of our sample period, so hospitals eventually in the same system are grouped in the same system. We then assign them to different geographic markets. To illustrate how distance matters for the results, we pick two market definitions based on geographic regions. First, we use systems formed by merging hospitals in the same system and within a 30-minute driving distance. This system definition captures the change in service offering within a system among only hospitals located close to each other. Second, we define hospitals from the same system and market as hospitals with the same system ID and are in the same hospital referral regions (HRRs). HRRs are regional health care markets for tertiary medical care and represent a much larger geographic region. This system definition captures the change in service offering within a system among hospitals located farther away from each other. In the following presentation, we use s to denote either the system defined by short driving distance or the system defined by HRR.

We estimate a similar staggering difference-in-difference model using only merging systems:

$$y_{st} = \alpha_s + \gamma_t + \sum_{k=-5}^{4} \lambda_k \cdot \mathbb{1}[t = \tau_s + k] + \epsilon_{st}, \tag{2}$$

where y_{st} denotes either uni_s, dup_s or $frac_s$. α_s indicate the system fixed effects, and γ_t indicates the year fixed effects. We group observations that are five or more years before the merger into $k = -5$, and $k = 4$ indicates four or more years after the merger. λ_k represents the effect on service repositioning of being k years post-merger.

In estimation, we exclude systems with only one hospital. These systems do not offer effective information about service differentiation beyond what's already been captured in the hospital-level analysis because there is only one facility. We expect the effects to be more significant with shorter distance systems than HRR because repositioning is more relevant for local markets.

Identification Our baseline models exclude non-merging hospitals or non-merging systems from the sample. The merging decision is likely endogenous and is related to many other factors involved in repositioning decisions. This phenomenon can be illustrated by the summary statistics shown in Table 2. As such, the non-merging hospitals may not be comparable to the merging hospitals. By restricting the sample to only merging hospitals and systems, we rule out confounding factors as the driving force of the results. Our specification uses the variation in the timing of mergers: hospitals that merged later serve as the controls for hospitals that merged earlier. All the merging hospitals jointly determine the time trend. Our model assumes a parallel pre-trend across hospitals that merged earlier and those that merged later. The selection of merging time may undermine this assumption. However, due to the complexity of merger activity and the involvement of antitrust authorities, hospitals have little control over when a merger will be approved, which mitigates the concern about selection based on merger time. Besides, Table 2 shows that hospitals merged at different periods have similar characteristics, suggesting that these hospitals are at least comparable for observables.

One concern of the staggering difference-in-difference design is that if there are heterogeneous treatment effects across time and hospitals, a single dummy variable including all post-merger effects may not represent true treatment effects (de Chaisemartin and D'Haultfœuille, 2020). In our case, hospital service repositioning likely takes multiple years to complete, and thus the treatment effects are expected to change over time. That's why in our preferred specification, we present coefficients for multiple post-merger periods and show the full event study graphs, as suggested by Bailey and Goodman-Bacon (2015). In Appendix A.2, we also consider other bias-corrected estimators proposed by Goodman-Bacon (2021) and de Chaisemartin and D'Haultfœuille (2020). We use these alternative estimators to illustrate the robustness of the main results.

Finally, we conduct the validity test as De Janvry et al. (2015) to examine the correlation between merger time and the pre-merger service changes. We find no correlation between the timing of the merger and the change in hospitals' service offerings, providing extra support for the validity of our strategy. We present the details of the analysis in Appendix A.3.

5 Results

In this section, we present our main regression results at the individual hospital level and at the system level.

Hospital-Level Analysis We find that hospitals experience a decrease in the number of services offered after geographically-close mergers. Table 3 column (1) shows the results estimating equation (1) using the number of services as the dependent variable and all hospitals with a merging counterpart within 30-minute driving time as the sample. We find that merging hospitals start to drop about 0.4 more services in the year of merger compared to the control group, and gradually increase the number of services dropped over time. In 3 columns (2) and (3) we add different control variables and the results are robust.

The event study shows no pre-trend, and the effects are increasing over time. Figure 4 shows the event-study results for targets and acquirers separately, estimated based on equation 1. On average, targets drop slightly more services than acquirers, but they are not significantly different. This result suggests that the pattern is not driven by acquirers expanding and targets shrinking. Rather, both entities experience some level of service repositioning.

The reduction in the number of services is not a result of hospital downsizing. Figure 5 panel (a) and (b) using two measures on patient volumes (in log scales) as the dependent variables to estimate equation (1). On average, there is no change in the adjusted number of inpatient days and admissions after the merger. These results show that service repositioning is not a result of patient volume changes. Instead, it represents a change in the service mix.

We then examine whether service repositioning changes the care inputs. We use two measures, the number of beds to capture the capital inputs and the number of full-time equivalent employees as the labor inputs. Figure 5 panel (c) and (d) shows the results. The dependent variables are in log scales. There is an upward trend in the number of beds after the merger, though the magnitude is not large and the estimates are noisy. On the contrary, there is a downward trend in the total number of full-time equivalent employees after the merger. Though the magnitude is small (less than 5%), the estimates are not statistically significant.

We also find that the merger effects fade away for distant mergers. Figure 6 plots the event study graph for two groups: the baseline hospitals, which merged with counterparts within 30-minute driving distance, and the rest. The treatment effects are relatively small once the driving time exceeds 30 minutes (the red hollow circle line). The pattern is consistent with our conceptual framework that service consolidation is only profitable when the two merged parties are close.

System-Level Analysis We find that there is less overlapping in service offering within a system in small geographic markets defined by 30-minute driving distance, but not for larger markets, defined as HRRs. Table 4 shows the estimates of equation (2) when a system is defined based on 30-minute driving distance. Column (2) shows that merging systems drop -0.3 more duplicate services in the year of the merger, drop one more duplicate service one and two years after the merger, and drop more than two duplicate services for later years. Another way to see this measure is by checking the fraction of hospitals offering a service. Column (3) shows the results. The merging system has a lower percent of overlapping offerings after the merger.

We find no change in the unique number of service lines offered within the system after the merger. In Table 4 column (1), the unique number of services offered drops slightly, but the change is much smaller than the number of duplicates, and the coefficients are not significant. These results indicate that service repositioning increases service offering differentiation within a system without reducing the overall service variety. In other words, after the merger, hospitals in the same system and local market become more different from each other.

The merger effects on service repositioning only exist for local markets. Table 5 shows that service overlapping does not change much after the merger for hospitals in the same system and HRR. These results are consistent with the individual-level findings: geographic proximity plays a central role in the decision of service repositioning.

Service Repositioning and Cost Savings A fundamental question of merger analysis is whether the service repositioning leads to welfare gain. Theoretically, the effects on consumer surplus are ambiguous. Merger and service repositioning may lead to a price increase and/or a quality reduction. They may also increase consumer travel distances to hospitals, though such effects are limited given that most of the service repositioning happens for hospitals located near each other.

Service repositioning may also improve care efficiency and consumer welfare. For example, it could increase care coordination by consolidating labor and medical equipment. It can also reduce costs by reducing unnecessary capacity. Some of the costs are fixed in nature: salary-based staff is paid regardless of the number of patients treated; An MRI machine incurs fixed costs for operation regardless of demand. Consolidating services could reduce such costs. Besides, service repositioning may also reduce marginal costs if merged hospitals learn from each other for more efficient care. As suggested by Craig, Grennan and Swanson (2021), distinguishing whether the reduced costs are marginal or fixed is essential for welfare analysis.

In this section, we focus on the welfare implications by analyzing the cost effects of service consolidation. We take the baseline sample — hospitals merge within 30-minute driving distance, and use the staggering difference-in-difference design to estimate the change in average costs after the mergers—our analysis supplements previous literature by focusing on local mergers (Schmitt, 2017).

Figure 7 shows the results. In panel (a), we find a 2% decrease in average total costs after the merger. The magnitude is smaller than what's estimated in previous literature including more distant mergers (Schmitt, 2017) and is not statistically significant. We break down the total costs into three categories. The total cost decrease is mainly driven by salaries (3% decrease) and operations and administrative costs (4%). There is no change in the capital costs. These results are consistent with Figure 5 panel (c) and (d), where we find that there is an increase in the number of beds and a decrease in the number of full-time equivalent employees. Price effects of inputs can also drive these patterns. For example, Prager and Schmitt (2021) find a wage decrease for nurses after the merger, which could also contribute to the decrease in the average costs in salaries.

In summary, we find limited evidence that service repositioning is associated with significant cost changes after the merger. However, there is some suggestive evidence that hospitals change their cost structures after the merger: there is less expenditure on salaries and more expenditure on capital costs.

6 Conclusion

In this article, we find evidence that hospitals remove duplicate services after the merger. Merging hospitals that are geographically close (within 30-minute driving time) eliminate about one duplicate service after the merger. We find that such repositioning does not lead to the reduction of patient volumes. We also find that hospitals become more specialized and differentiated within a system after the merger. Our analysis provides systematic evidence supporting hospitals' claim that mergers can enable reorganizations of services.

Ultimately, antitrust enforcement is based on consumer welfare standards and concerns about whether consumers can enjoy the benefits of the created surplus. We find some suggestive evidence that hospitals change their cost structures after the merger by directing more capital inputs than labor inputs. However, there are only modest savings in the overall costs.

Our analyses highlight the importance of considering service repositioning in antitrust analyses for hospital mergers. We show that such a phenomenon is quite common for mergers in local markets and potentially impacts hospital cost structures. Service repositioning happens primarily among mergers in local markets, which often face large price pressure. We show that service repositioning can further complicate the welfare consequences of such mergers because they may change care quality and lead to potential cost savings on the supply side.

Our analyses open up future research opportunities to study the pass-through of cost reductions to consumers. If the cost savings generated by service repositioning are not effectively transformed into price reduction, policy interventions may help achieve this goal. One potential option is to impose a price-cap condition on the merger terms. For instance, in the merger of Beth Israel Deaconess Medical Center and Lahey Health System in Boston, the attorney general imposed a seven-year price-cap condition. Another potential solution to extract the surplus of service repositioning without creating market power is to form operating agreements across close facilities but prohibit them from joint price bargaining. For example, accountable care organizations of geographically close hospitals may improve the service repositioning across facilities by aligning their financial incentives. Meanwhile, accountable care organizations are not likely to experience price increases because hospitals are mainly paid under capitation from the Centers for Medicare and Medicaid Services.

Tables and Figures

Table 1: Summary of Model Predictions: A Numeric Example

	No Merger	Merger A&B Both Offering	Merger A&B Only A Offering
p_A	$\frac{\alpha}{4}+c$	$\frac{2}{5}a+c$	$\frac{7}{20}a+c$
p_B	$\frac{\alpha}{4}+c$	$\frac{2}{5}a+c$	/
p_C	$\frac{\alpha}{4}+c$	$\frac{3}{10}a+c$	$\frac{7}{20}a+c$
p_D	$\frac{\alpha}{4}+c$	$\frac{3}{10}a+c$	$\frac{3}{10}a+c$
π_{AB}	$\frac{1}{8}\alpha-2f$	$\frac{4}{25}\alpha-2f$	$\frac{49}{400}\alpha-f$
Consumer Surplus	0	$-\frac{19}{200}\alpha$	$-\frac{47}{400}\alpha$
Total Surplus	0	$-\frac{1}{200}\alpha$	$f-\frac{13}{400}\alpha$

Note: Author's calculation of equilibrium price (p_i), profits (π) of hospitals A and B, and surplus in a salop circular city model with four hospitals equally distributed along the circle. We calculate consumer and total surplus as the difference from the no merger case. See details in Section 2.

Table 2: Summary Statistics at Start Year

	Non-merged	<05	05-09	>09
Number of services	27.00	32.00	34.44	32.65
	(12.49)	(13.85)	(11.99)	(12.25)
Size of system	25.59	39.47	39.76	45.11
	(33.84)	(36.19)	(24.72)	(30.82)
Casemix index	1.23	1.37	1.41	1.38
	(0.25)	(0.27)	(0.24)	(0.27)
Number of staffed beds	161.66	252.89	261.24	252.24
	(171.91)	(241.32)	(236.98)	(196.14)
Total full-time equivalent staff (K)	0.78	1.31	1.36	1.34
	(1.09)	(1.58)	(1.52)	(1.35)
Total inpatient admissions (K)	6.58	11.07	11.78	11.70
	(8.21)	(11.61)	(9.96)	(11.39)
Adjusted total patient days (K)	63.71	92.69	100.41	101.84
	(70.60)	(91.46)	(90.04)	(80.63)
Fraction of revenue from Medicare	0.51	0.50	0.49	0.50
	(0.14)	(0.13)	(0.14)	(0.13)
Fraction of revenue from outpatient	0.48	0.43	0.42	0.43
	(0.14)	(0.14)	(0.11)	(0.15)
Observations	3093	87	119	109

Note: Data from the AHA Annual Survey and Center for Medicare and Medicaid Services. Mean and standard errors in parenthesis. All variables are measured in 2002. Column 1 indicates non-merged hospitals. Columns 2-4 indicate merged hospitals with different merging times: before 2005, between 2005 and 2009, after 2009.

Table 3: Number of Services Offered: Hospital Merged w/ 30 Min Travel Time

	(1)	(2)	(3)
2 and More Years before Merger	0.371	0.377	0.445
	(0.266)	(0.268)	(0.325)
Year of Merger	-0.376	-0.343	-0.445
	(0.265)	(0.250)	(0.325)
1 and 2 Years after Merger	-0.746**	-0.766**	-0.914**
	(0.351)	(0.361)	(0.401)
3 and more Years after Merger	-1.184**	-1.052*	-1.204*
	(0.515)	(0.543)	(0.622)
Hospital FE	Y	Y	Y
Year FE	Y	Y	Y
HRR-specific year trend	N	Y	N
Time-varying controls	N	N	Y
N	4424	4423	3127
R^2	0.92	0.93	0.91
Dep. Var. Mean	33.66	33.66	36.62
Dep. Var. Std.	12.81	12.81	11.77

Note: All three columns include merged hospitals with a merging counterpart within a 30-minute driving time. Time-varying controls include the fraction of revenue from Medicare, the fraction of revenue from outpatient care, and the patient case-mix. The last two variables are only available for some hospitals, so the sample size is smaller. Standard errors are clustered at the HRR level. $^{*}: p < 0.1, ^{**}: p < 0.05, ^{\dagger}: p < 0.01$.

Table 4: Service Offering: Systems with Mergers within 30-min Travel Time

	(1) # Services	(2) # Duplicates	(3) % Hospitals Offering
2 and More Years before Merger	0.418	-0.566	0.475
	(0.541)	(0.633)	(0.575)
Year of Merger	0.072	-0.461	-0.842*
	(0.397)	(0.379)	(0.431)
1 and 2 Years after Merger	-0.749	-1.052*	-1.124**
	(0.566)	(0.576)	(0.534)
3 and more Years after Merger	-0.909	-2.119**	-2.029**
	(0.761)	(0.811)	(0.775)
N	1112	1112	1112
R^2	0.93	0.91	0.93
Dep. Var. Mean	47.66	26.13	45.24
Dep. Var. Std.	12.65	11.59	12.68

Note: In all columns, each observation is a hospital system formed by merging hospitals in the same systems and within a 30-minute driving distance from each other. The dependent variable in column (1) is the unique number of services the system offers. The dependent variable in column (2) is the number of services offered by more than one hospital in that system. The dependent variable in column (3) is the fraction of hospitals offering a service, averaged across all services. Standard errors are clustered at the HRR level. $^{*}: p < 0.1, ^{**}: p < 0.05, ^{\dagger}: p < 0.01$.

Table 5: Service Offering: System by Hospital Referral Region

	(1) # Services	(2) # Duplicates	(3) % Hospitals Offering
2 and More Years before Merger	-0.082	-0.193	0.045
	(0.397)	(0.427)	(0.477)
Year of Merger	0.614	0.687*	-1.184†
	(0.417)	(0.400)	(0.442)
1 and 2 Years after Merger	0.218	-0.016	-0.422
	(0.528)	(0.475)	(0.590)
3 and more Years after Merger	-0.211	-0.462	-0.417
	(0.683)	(0.719)	(0.775)
N	1700	1700	1700
R^2	0.89	0.91	0.87
Dep. Var. Mean	51.11	30.58	61.75
Dep. Var. Std.	11.86	13.85	11.46

Note: In all columns, each observation is a hospital system formed by merging hospitals in the same systems and HRR. The dependent variable in column (1) is the unique number of services the system offers. The dependent variable in column (2) is the number of services offered by more than one hospital in that system. The dependent variable in column (3) is the fraction of hospitals offering a service, averaged across all services. Standard errors are clustered at the HRR level. $^* : p < 0.1, ^{**} : p < 0.05, ^{\dagger} : p < 0.01$.

Figure 1: Ilustration of Hospital Distribution

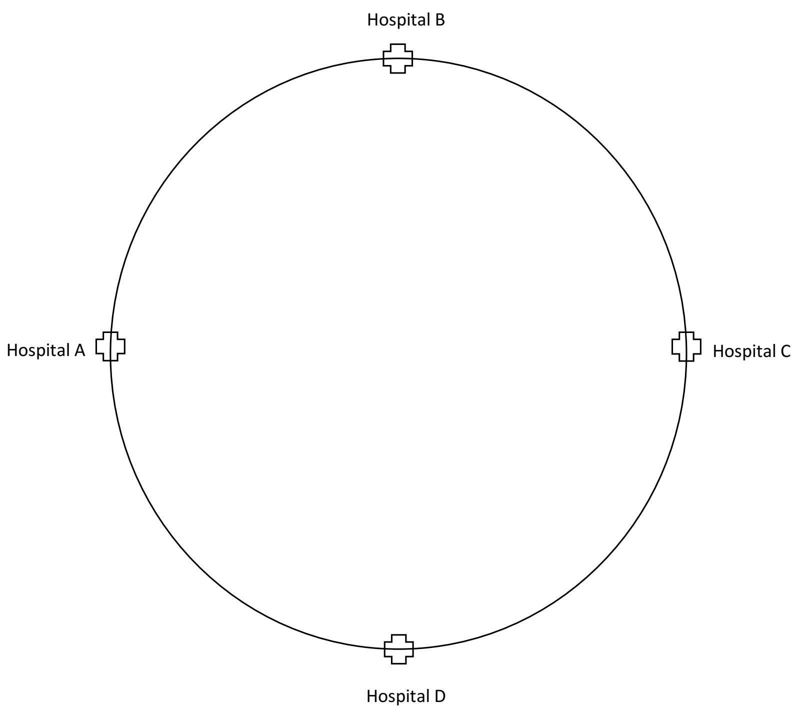
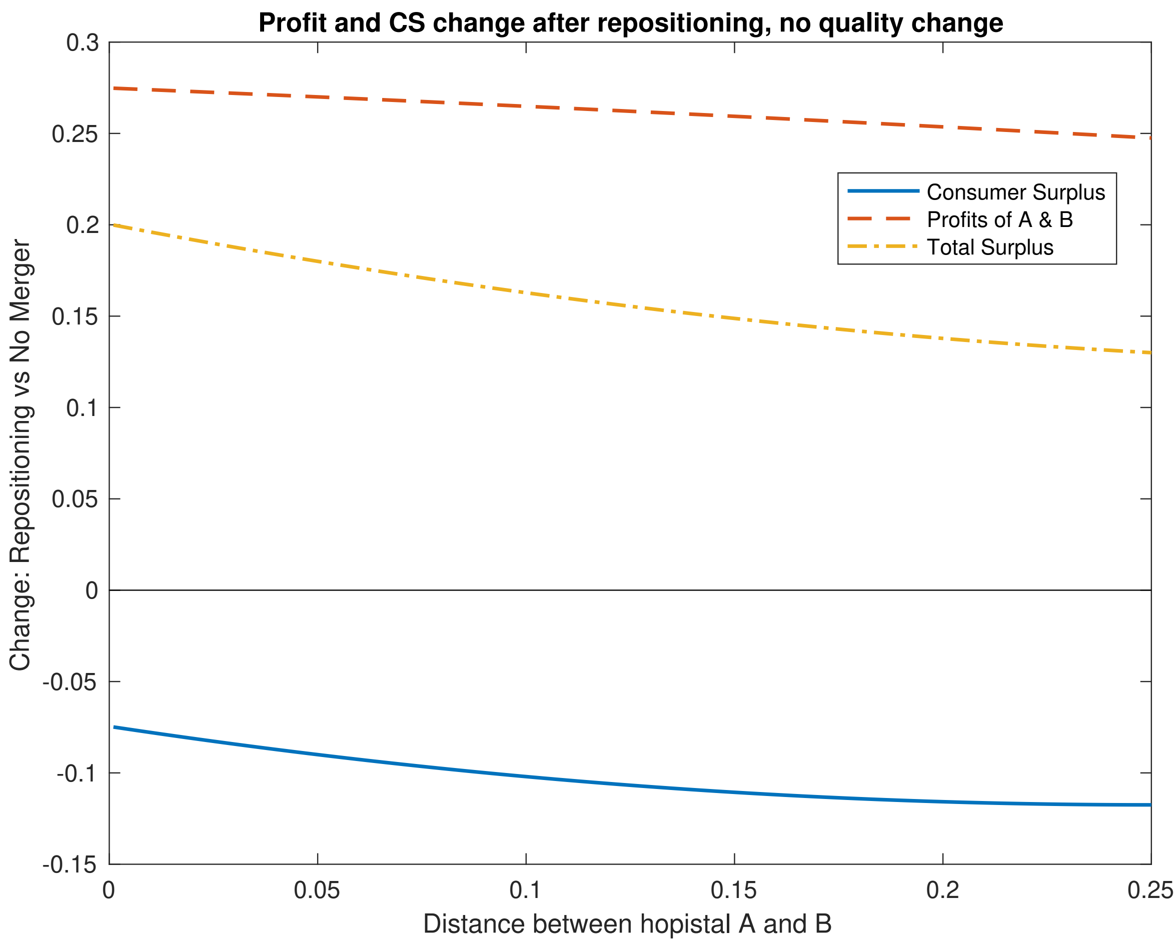
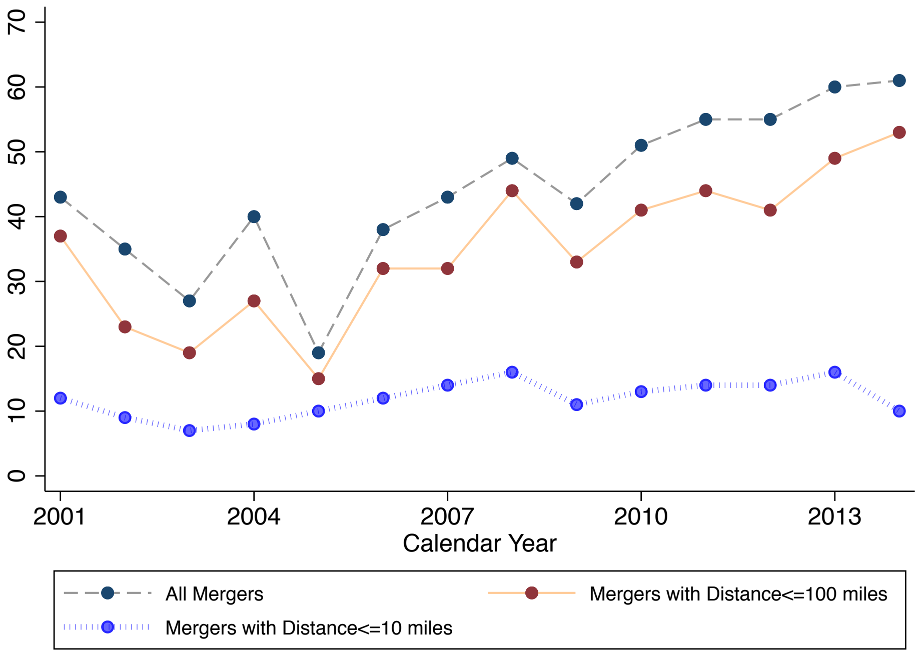


Figure 2: Merging Distance and Welfare



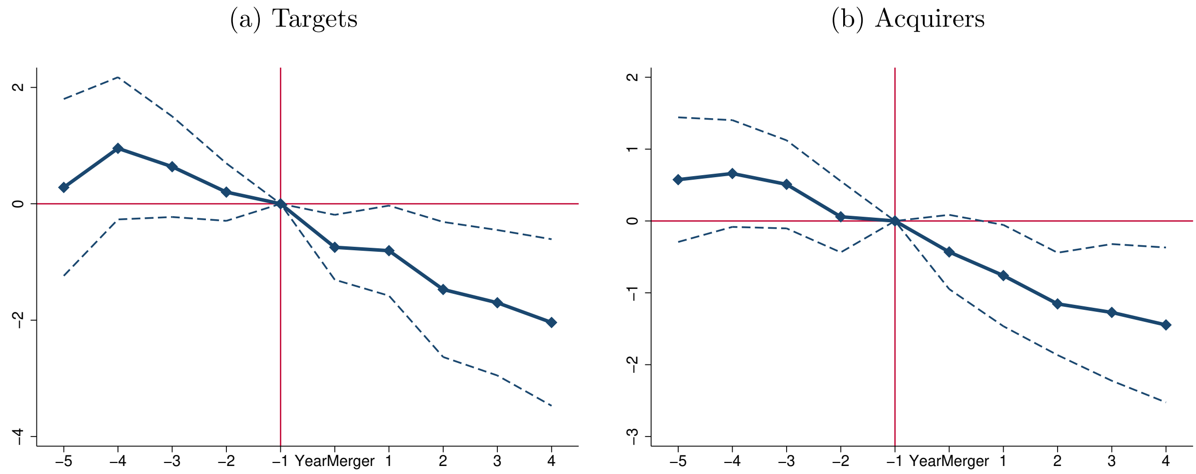
Note: Author calculation using a simplified Bertrand competition model as in Section 2. $\alpha = 1$ and $f = 0.025$. The figure shows the change in the merging system's profits and consumer welfare due to service repositioning, relative to the pre-merger period (on the y-axis), as a function of the distance between the merging entity (on the x-axis).

Figure 3: Hospital Merger Transactions, 2001-2014



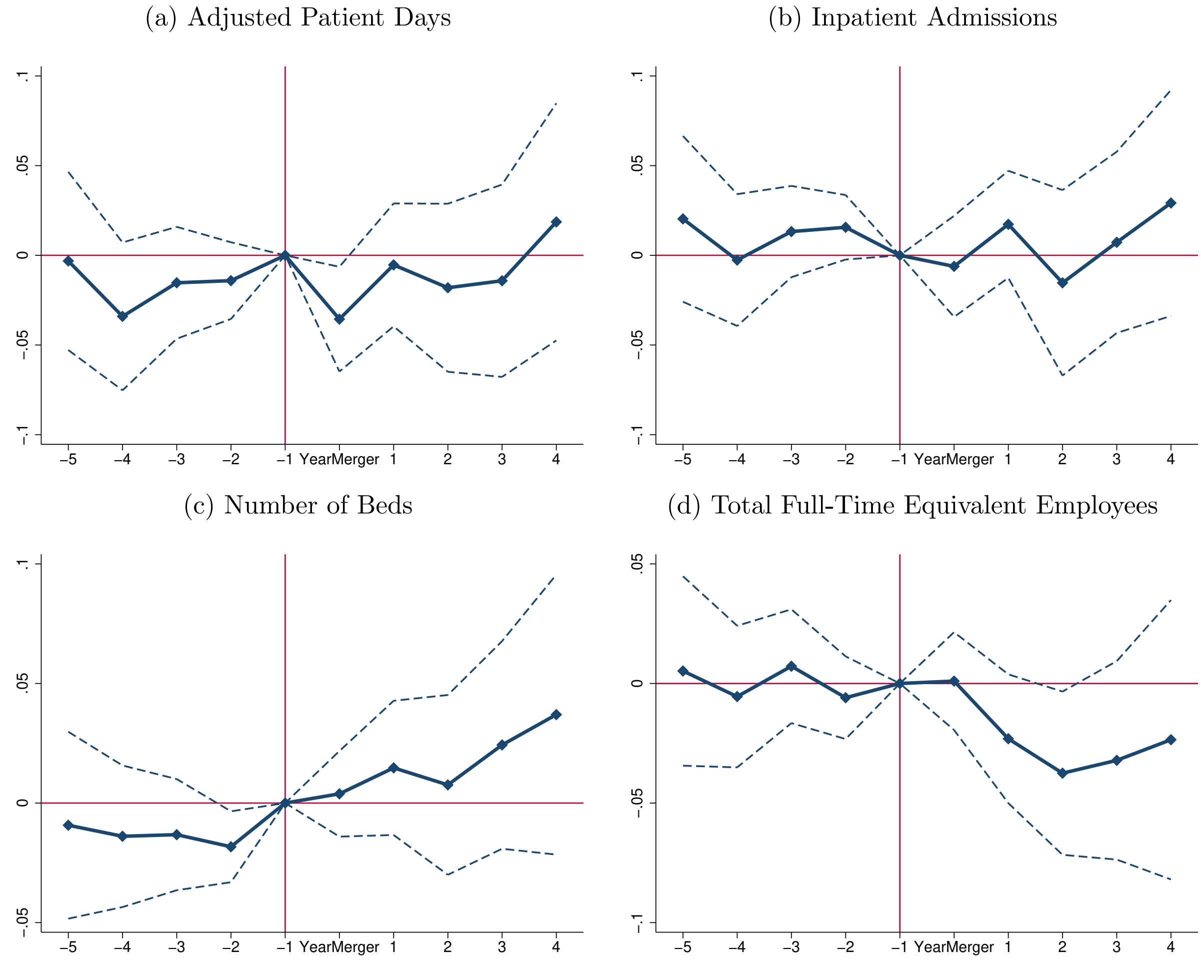
Note: data from Cooper et al. (2018). The y-axis indicates the number of merger transactions in each year.

Figure 4: Merger Effects on Number of Services Offered



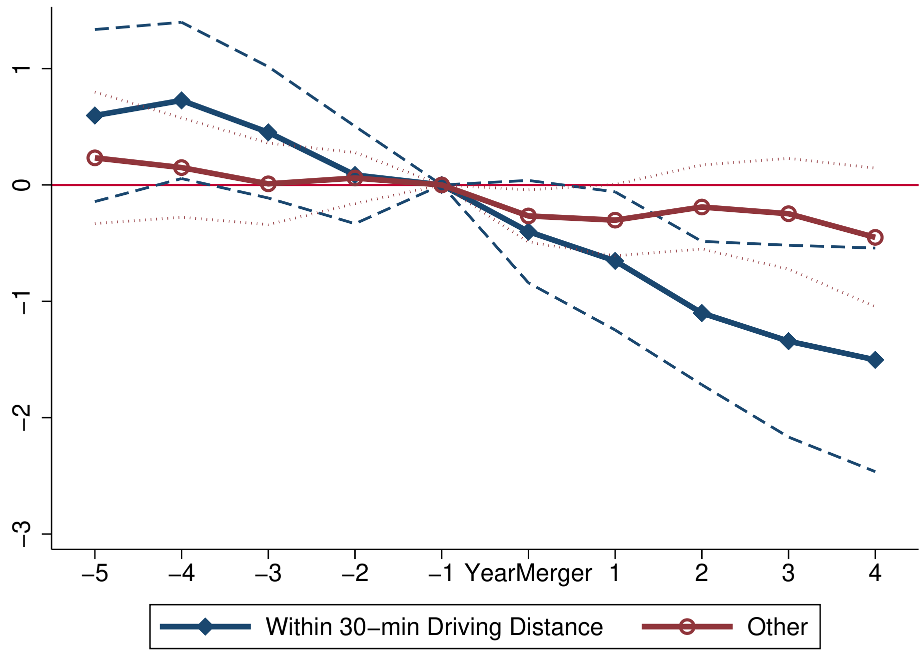
Note: Coefficients and the 95% confidence interval from the estimation of equation (1) using the number of services as the dependent variable. The left panel uses only targets, and the right panel uses only acquirers. Both use only merged hospitals with a merging counterpart within a 30-minute driving distance. Standard errors are clustered at the HRR level.

Figure 5: Merger Effects on Patient Volume and Care Inputs



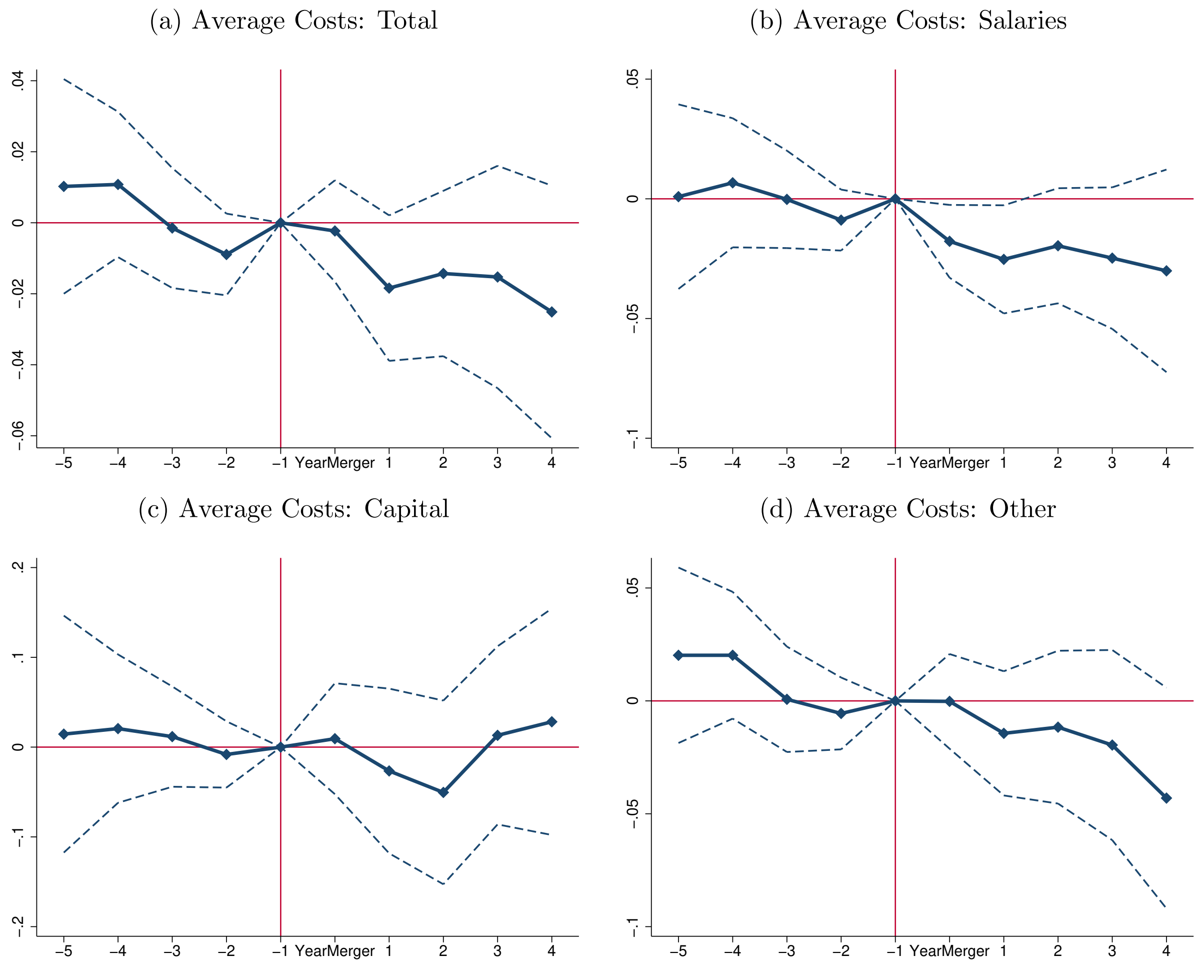
Note: Coefficients and the 95% confidence interval from the estimation of equation (1). The dependent variables are the adjusted patient days in panel (a), the number of inpatient admissions in panel (b), the number of beds in panel (c), and the total full-time equivalent employees in panel (d), all in log scales. All panels use only merged hospitals with a merging counterpart within a 30-minute driving distance. Standard errors are clustered at the HRR level.

Figure 6: Number of Services Offered for Distant Mergers



Note: Coefficients and the 95% confidence interval from the estimation of equation (**??**) using the number of services as the dependent variable. Each line represents a different sample: merged hospitals with a counterpart within a 30-minute driving distance (solid blue line with diamond marker, and dashed blue lines); merged hospitals with more than 30-minute driving distance (solid red line with circle markers, and dotted red lines). Standard errors are clustered at the HRR level.

Figure 7: Merger Effects on Average Costs Per Patients



(a) Average Costs: Total

(b) Average Costs: Salaries

(c) Average Costs: Capital

(d) Average Costs: Other

Note: Coefficients and the 95% confidence interval from the estimation of equation (1). The dependent variables are in log scales. All panels use only merged hospitals with a merging counterpart within a 30-minute driving distance. Standard errors are clustered at the HRR level.

References

Bailey, Martha J., and Andrew Goodman-Bacon. 2015. "The War on Poverty's Experiment in Public Medicine: Community Health Centers and the Mortality of Older Americans." *American Economic Review*, 105(3): 1067–1104.

Berry, Steven, Alon Eizenberg, and Joel Waldfogel. 2016. "Optimal product variety in radio markets." *The RAND Journal of Economics*, 47(3): 463–497.

Ciliberto, Federico, Charles Murry, and Elie T Tamer. 2016. "Market structure and competition in airline markets."

CMS, Centers for Medicare & Medicaid Services. 2022. "Cost Reports."

Cooper, Zack, Stuart V Craig, Martin Gaynor, and John Van Reenen. 2018. "The price ain't right? Hospital prices and health spending on the privately insured." *The Quarterly Journal of Economics*, 134(1): 51–107.

Craig, Stuart V., Matthew Grennan, and Ashley Swanson. 2021. "Mergers and marginal costs: New evidence on hospital buyer power." *The RAND Journal of Economics*, 52(1): 151–178.

Dafny, Leemore. 2009. "Estimation and identification of merger effects: An application to hospital mergers." *The Journal of Law and Economics*, 52(3): 523–550.

Dafny, Leemore, Kate Ho, and Robin S. Lee. 2019. "The price effects of cross-market mergers: theory and evidence from the hospital industry." *The RAND Journal of Economics*, 50(2): 286–325. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/1756-2171.12270.

de Chaisemartin, Clément, and Xavier D'Haultfœuille. 2020. "Difference-in-Differences Estimators of Intertemporal Treatment Effects." Social Science Research Network SSRN Scholarly Paper ID 3731856, Rochester, NY.

de Chaisemartin, Clément, and Xavier D'Haultfœuille. 2020. "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects." *American Economic Review*, 110(9): 2964–2996.

De Janvry, Alain, Kyle Emerick, Marco Gonzalez-Navarro, and Elisabeth Sadoulet. 2015. "Delinking land rights from land use: Certification and migration in Mexico." *American Economic Review*, 105(10): 3125–49.

Fan, Ying, and Chenyu Yang. 2016. "Competition, product proliferation and welfare: A study of the us smartphone market."

Gandhi, Amit, Luke Froeb, Steven Tschantz, and Gregory J Werden. 2008. "Post-Merger Product Repositioning." *The Journal of Industrial Economics*, 56(1): 49–67.

Garmon, Christopher. 2017. "The accuracy of hospital merger screening methods." *The RAND Journal of Economics*, 48(4): 1068–1102.

Goodman-Bacon, Andrew. 2021. "Difference-in-differences with variation in treatment timing." *Journal of Econometrics*, 225(2): 254–277.

Haas-Wilson, Deborah, and Christopher Garmon. 2009. "Two hospital mergers on Chicago's north shore: a retrospective study."

Kaufman Hall, Co. 2019. "2018 M&A in Review: A New Healthcare Landscape Takes Shape." [Online; posted 27-Jan-2018].

Lewis, Matthew S, and Kevin E Pflum. 2017. "Hospital systems and bargaining power: evidence from out-of-market acquisitions." *The RAND Journal of Economics*, 48(3): 579–610.

Mao, Qianyu. 2019. "Merger Simulation with Endogenous Product Portfolios."

Mazzeo, Michael, Katja Seim, and Mauricio Varela. 2013. "The welfare consequences of mergers with product repositioning." working paper.

Prager, Elena, and Matt Schmitt. 2021. "Employer Consolidation and Wages: Evidence from Hospitals." *American Economic Review*, 111(2): 397–427.

Schmitt, Matt. 2017. "Do hospital mergers reduce costs?" *Journal of health economics*, 52: 74–94.

Sweeting, Andrew. 2010. "The effects of mergers on product positioning: evidence from the music radio industry." *The RAND Journal of Economics*, 41(2): 372–397.

Sweeting, Andrew. 2013. "Dynamic product positioning in differentiated product markets: The effect of fees for musical performance rights on the commercial radio industry." *Econometrica*, 81(5): 1763–1803.

Appendix. (For Online Publication)

A.1 AHA Service List

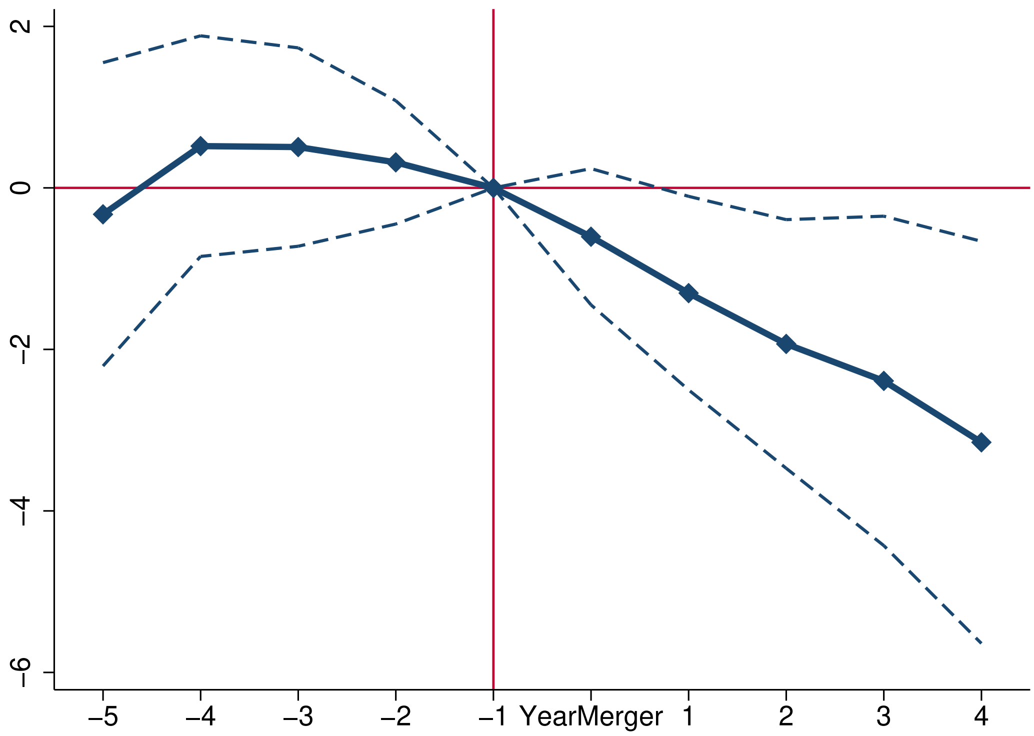
The AHA annual survey reports service lists of over 120 services. Some of them are added to the survey over time. Typically, service is added to the survey several years after the first hospital has adopted it. This fact makes the reporting inaccurate because the first year a hospital adopts a service may be restricted by the time when AHA surveys the service. Table A.1 shows the service lists. Our baseline specification focuses on services offered throughout the sample period 2011 to 2012 (the left column).

We also construct another dependent variable, which is the number of services offered measured by all services reported, including new services (in Table A.1 right column). Figure A.1 shows the estimation results of equation (1) using this alternative dependent variable. As shown, the overall trend is similar to the baseline estimates.

Table A.1: List of Services

Baseline Services	New Services
General medical and surgical care (adult)	Angioplasty
General medical and surgical care (pediatric)	Radiation therapy
Obstetrics care	Transplant services
Medical/surgical intensive care	Airborne infection isolation room
Cardiac intensive care	Bariatric/weight control services
Neonatal intensive care	Chaplaincy/pastoral care services
Neonatal intermediate care	Neurological services
Pediatric intensive care	Orthopedic services
Burn care	Wound Management Services
Other special care	Alzheimer Center
Physical Rehabilitation care	Cardiology services center
Alcohol/drug abuse or dependency inpatient care	Chemotherapy
Psychiatric care	Gamma knife
Skilled nursing care	Intensity-Modulated Radiation Therapy (IMRT)
Intermediate nursing care	Electron Beam Computed Tomography (EBCT)
Other long-term care	Multislice spiral computed tomography (MSCT)
Other care	Fertility Clinic
Adult day care program	Genetic testing/counseling
Alcohol/drug abuse or dependency outpatient services	Adult diagnostic catheterization
Arthritis treatment center	Pediatric diagnostic catheterization
Assisted living services	Adult interventional cardiac catheterization
Birthing room/LDR room/LDRP room	Pediatric interventional cardiac catheterization
Breast cancer screening/mammograms	Adult cardiac surgery
Case Management	Pediatric cardiac surgery
Children's wellness program	Patient Controlled Analgesia
Crisis prevention	Shaped beam Radiation System
Dental services	Bone Marrow transplant services
Emergency Department	Heart transplant
Certified trauma center	Kidney transplant
Extracorporeal shock waved lithotripter (ESWL)	Liver transplant
Freestanding outpatient center	Lung transplant
Geriatric services	Tissue transplant
HIV-AIDS services	Other Transplant
Home health services	Blood Donor Center Hospital
Hospice Program	Cardiac Rehabilitation
Hospital-base outpatient care center/services	Computer assisted orthopedic surgery
Nutrition program	Freestanding/Satellite Emergency Department
Occupational health services	Indigent care clinic
Oncology services	Mobile health services
Outpatient surgery	Image-guided radiation therapy
Physical rehabilitation outpatient services	Full-field digital mammography
Primary care department	Multi-slice spiral computed tomography 64 + slice
Psychiatric child/adolescent services	Positron emission tomography/CT (PET/CT)
Psychiatric consultation/liaison services	Robotic surgery
Psychiatric education services	Stereotactic radiosurgery
Psychiatric emergency services	Virtual colonoscopy
Psychiatric geriatric services	Ambulatory surgery center
Psychiatric outpatient services	Inpatient palliative care unit
Psychiatric partial hospitalization program	Endoscopic ultrasound
Computed-tomography (CT) scanner	Ablation of Barrett's esophagus
Diagnostic radioisotope facility	Esophageal impedance study
Magnetic resonance imaging (MRI)	Endoscopic retrograde cholangiopancreatography (ERCP)
Positron emission tomography (PET)	Immunization program
Single photon emission computerized tomography (SPECT)	Proton beam therapy
Ultrasound	Intraoperative magnetic resonance imaging
Retirement housing	Adult cardiac electrophysiology
Sports medicine	Pediatric cardiac electrophysiology
Transportation to health services	Optical Colonoscopy
Urgent care center	Robot-assisted walking therapy
WomenAŽs health center/services	Simulated rehabilitation environment
Other intensive care	Adult cardiology services
Acute long term care	Pediatric cardiology services
Auxiliary	Assistive technology center
Chiropractic services	Electrodiagnostic services
Complementary and alternative medicine services	Prosthetic and orthotic services
Pain Management Program	Pediatric emergency department
Ambulance services	Psychiatric residential treatment
Enabling services	Magnetoencephalography (MEG)
Palliative Care Program	
Hemodialysis	
Sleep Center	
Tobacco Treatment Services	
Cardiac catheterization laboratory	
Reproductive services	
Open heart surgery	

Figure A.1: Merger Effects on Number of Services: Including New Services



Note: Coefficients and the 95% confidence interval of equation (1) using all services as the dependent variable. Only merged hospitals with a merging counterpart within a 30-minute driving distance are included. Standard errors are clustered at the HRR level.

A.2 Alternative Difference-in-Difference Estimators

Our baseline estimates use a staggering difference-in-difference design, with different hospitals merging at different times. The literature has noted potential bias from using a simple "post-merger" dummy variable to capture merger effects. In this section, we show several alternative estimators addressing such bias.

We first estimate the "problematic" specification:

$$y_{it} = \alpha_i + \gamma_t + \lambda \cdot \mathbb{1}[t \leq \text{Merger Year}_i] + \epsilon. \tag{3}$$

The variable of interest is λ, which captures the treatment effects after the merger. Goodman-Bacon (2021) shows that λ is a weighted average of all two-by-two difference-in-difference estimates. These estimates include using later treated as controls for earlier treated, which is what we need, and using already-treated as controls for later treated, which could be problematic if the effects change over time. Goodman-Bacon (2021) suggest a decomposition exercise to take out the bias created by the latter.

Table A.2: Average Merger Effects: Different Estimators

	(1) OLS	(2) Goodman-Bacon (2021)	(3) de Chaisemartin and D'Haultfœuille (2020)
Post Merger	-0.740	-1.011	-0.510
	(0.312)		(0.331)

Note: All three columns include only merged hospitals with a merging counterpart within a 30-minute driving distance. Column (1) uses OLS to estimate the coefficient of a dummy variable indicating post-merger, with hospital fixed effects and year fixed effects controlled. Standard errors are clustered at the HRR level. Column (2) reports the average difference-in-difference effects estimated based on earlier treated versus later controls as in Goodman-Bacon (2021). Column (3) reports the average effects estimator as in de Chaisemartin and D'Haultfœuille (2020). Standard errors are bootstrapped 100 times.

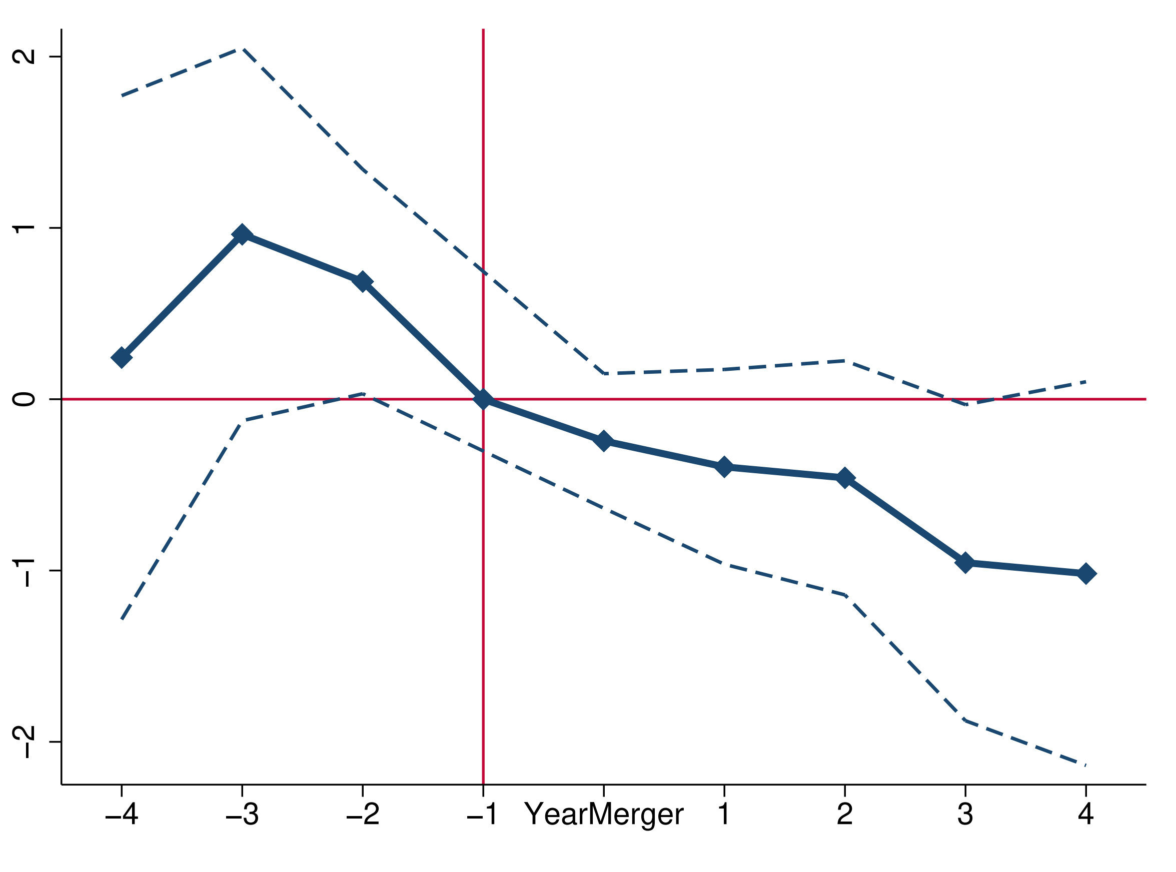
Table A.2 shows that the simple difference-in-difference estimates of γ in equation (3) is -0.740, while the de-biased estimate is -1.011, slightly larger. The fact is consistent with Figure 4, where there is an increasing treatment effects over time.

Next, we estimate the treatment effects using the estimator proposed by de Chaisemartin and D'Haultfœuille (2020). The average effects are -0.510. We further estimate the full placebo and dynamic effects using their method. We bootstrap the standard errors 100 times. The overall evolution is similar to our baseline estimates, except that the standard errors are larger.

A.3 Internal Validity Check

The main threat to our identification strategy is the selection of merger time. In other words, if there exists a correlation between the merger time and the time-path of the service change of hospitals, our results may be biased. In this part, we present evidence to address the internal validity concern.

Figure A.2: Merger Effects on Number of Services: de Chaisemartin and D'Haultfœuille (2020) Method



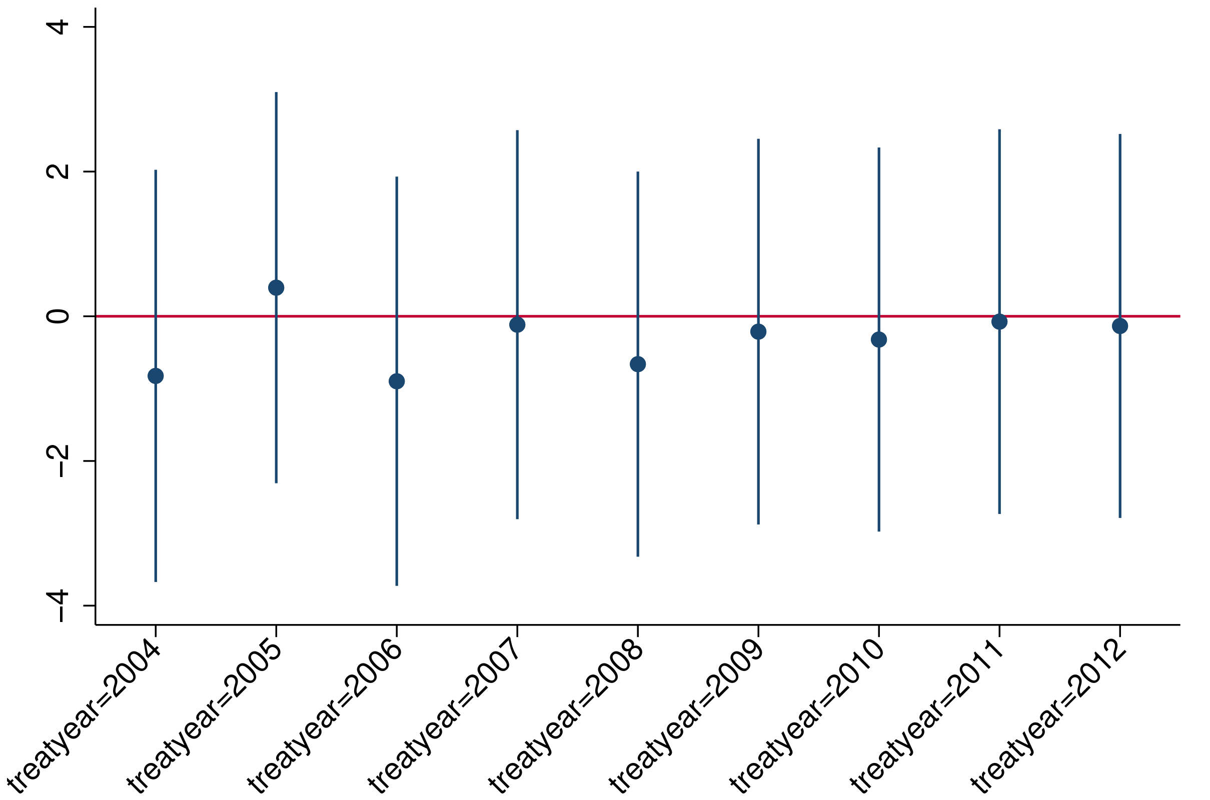
Note: Coefficients and the 95% confidence interval using the de Chaisemartin and D'Haultfœuille (2020) estimator. Only hospitals with a merging counterpart within a 30-minute driving distance are included. Standard errors are bootstrapped 100 times.

We conduct the validity test as De Janvry et al. (2015) to examine the correlation between the merger time and the pre-merger service changes. We use regression of pre-merger changes of the number of services on the indicators for the merger years:

$$\Delta n_{it} = \gamma_t + \sum_{k \geq t} \delta_k \cdot \mathbb{1}[\text{Merger Year}_i = k] + \epsilon_{it}, \quad \forall\ t \leq \text{Merger Year}_i. \tag{4}$$

The dependent variable Δn_{it} is the number of services of hospital i, $n_{it} - n_{it-1}$ and γ_t stands for the year fixed effects. The parameter of interest is δ_k, which shows the relationship between the merger time (year k) and the change of the number of services with year fixed effects controlled. The joint significance of the merger time effects would imply that pre-merger service change is

Figure A.3: Internal Validity Check



Note: Coefficients and the 95% confidence interval from the estimation of equation (4) using the change in the number of services as the dependent variable and observations before merger. Only merged hospitals with a merging counterpart within a 30-minute driving distance are included. Standard errors are clustered at the HRR level.

related to the merger time. Figure A.3 shows the point estimate and the 95% confidence intervals of the coefficients of each merging year. We find that the merger year does not correlate with the pre-merger change of services. The results further confirm the validity of our empirical design.