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ECONOMIC SHOCKS AND HEALTHCARE CAPITAL INVESTMENTS

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ABSTRACT

Information technology (IT) can enhance firms' long-run performance but is also a risky investment, with high fixed costs and uncertain returns. Whether market events influence this tradeoff has received limited attention. We leverage the healthcare context to empirically examine hospitals' IT investments following economic downturns and public insurance expansions—i.e., large industry shocks in opposite directions. We find novel and symmetrical responses. Recessions restrain investments while expansion policy indirectly stimulates them. Importantly, the IT margin is more elastic than other spending responses to market fluctuations. Supplementary analyses suggest that hospitals' finances and perceptions of uncertainty drive these capital investment adjustments.

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Information technology (IT) advancements and adoption have been engines of economic and productivity growth for decades and may continue to be with wider use of artificial intelligence and other 21st century computing developments (Jorgenson and Stiroh 1999; Jorgenson 2001; Stiroh 2002; Daly and Valletta 2004; Nordhaus 2021). At the more micro level, spurring new IT investments has translated to better firm-level financial performance and higher valuations in equity markets (Anderson, Banker, and Ravindran 2006). Greater IT availability has also transformed how managers within firms coordinate, communicate, and guide production to improve their overall output as well as enhance the quality of the goods and services produced (Dewan and Min 1997; Brynjolfsson and Hitt 2000).

Yet, businesses' appetite for IT is not unlimited and may demonstrate restraint in certain circumstances. Broadly speaking, capital expenditures ("capex") can be some of firms' most influential long-term decisions by providing foundations for eventual efficiency and productivity gains. However, capital investments tend to require significant upfront costs and difficult-to-reverse commitments, while positive impacts on profitability mostly materialize in the long-run––when firms' knowledge over demand, competition, and production is less certain. Firms' challenges in forecasting future events and financial circumstances can therefore curtail these potentially beneficial, but risky, business actions (Bloom, Bond, and Van Reenen 2007; Bloom 2009; Bloom 2014; Cadara and Iacoviello 2022).[1] Capex devoted to IT, specifically, is thought to be even riskier than other capital investments firms commonly undertake, so when contemplating the marginal IT investment, prevailing market uncertainty could push managers toward postponement (Schwartz and Zozaya-Gorostiza 2003; Dewan, Shi, and Gurbaxani 2007).[2]

Despite these complex tradeoffs for firms and a longstanding interest in the productivity impacts of IT, limited economics research has examined if, and how, market fluctuations affect the decision to invest in IT.[3] *A priori* it is not obvious if long-term IT capital budgeting and investment

[1] The literature sometimes refers to firms' weaker affinity for costly and (at least partially) irreversible physical capital investments as reflecting "precautionary delays" in business decision-making.

[2] As described by Dewan, Shi, and Gurbaxani (2007), there can be considerable uncertainty for firms around the economic benefits of IT adoption, the complexity and implementation costs belonging to a given IT investment (e.g., the common experience of cost overruns for a given project), and the rate of its eventual obsolescence.

[3] In terms of firm-level studies, Anderson, Banker, and Ravindran (2006) show that the "Y2K" business and IT uncertainty event was a key driver of new IT investments and enhancements—though this is a highly unique shock to the market. Shared IT experience and knowledge across firms through board-level social networks has recently been found to encourage more IT investments and increase their payoffs as well (Chen *et al*. 2020); however, these

would be sensitive to near-term market events and cash flows. And if firms do respond to changes in market circumstances, it is not clear whether IT capex adjustments would simply mirror other short-run spending decisions or diverge from other business actions. How market shocks influence firms' IT adoption decisions is therefore an empirical question. Answering this question can address an existing gap in the literature and help explain the uneven spread of IT across and within industries.

We ultimately pursue this question by focusing on firms' capital investments devoted to health information technology (i.e., "health IT"), which is a market worth hundreds of billions of dollars itself.[4] Our firms of interest are hospitals operating within the US healthcare system. The US hospital industry is significant in its own right since it is home to some of the highest complexity care and captures over $1 trillion (~30%) of medical spending annually—the largest share of spending among the provider types.[5] The health IT adoption decision is highly relevant for our empirical purposes since hospitals must commit to substantial upfront investment while accepting potentially large adjustment costs and sunk costs tied to health IT procurement. Hospitals also face uncertain payoffs from these investments (e.g., see Dranove *et al*. (2014)) and are regularly exposed to the vagaries of the business cycle as well as industry-targeted policy and regulatory interventions.

We benefit from industry-specific microdata (described in Section I) that captures the near-universe of firms as well as granular information on the timing and type of IT investments made over time. These data lend themselves to causal empirical strategies, with nuanced insights, and can be combined with other rich data available from the industry. Additionally, understanding the drivers of greater health IT adoption among hospitals is a priority for policymakers, who have been

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results tied to social learning phenomena do not inform how firms' managers respond to market dynamics or offer clear policy implications.

[4] For example, see a related industry report available here: https://www.acumenresearchandconsulting.com/healthcare-it-market

[5] National health expenditures are summarized by the Centers for Medicare and Medicaid Services (CMS) here: https://www.cms.gov/files/document/nations-health-dollar-where-it-came-where-it-went.pdf.

engaged in targeted and costly subsidization programs intending to encourage greater health IT use, with only mixed success.[6]

At this time, the factors influencing hospitals' decisions to invest in IT are not well understood. Much of the related economics literature has paid less attention to healthcare providers' upstream technology adoption decision and instead focused on the downstream consequences following adoption (e.g., Miller and Tucker 2011; Lee, McCullough, and Town 2013; Agha 2014; Dranove *et al*. 2014; Horn, Sacarny, and Zhou 2022). Yet, a better understanding of the forces shaping health IT utilization is needed since hospitals, along with other healthcare industries, chronically lag firms in other sectors of the economy when it comes to technology adoption and adaptation (Litwin 2020; Glaser, Vaezy, and Guptill 2024). We therefore add to a modest but growing economics literature analyzing the upstream health technology adoption margin (e.g., Acemoglu and Finkelstein 2008; Miller and Tucker 2009; Richards, Shi, and Whaley 2024) and offer new insights for a longstanding industry and policy conundrum.

Our empirical approach incorporates multiple difference-in-differences and triple differences strategies involving two prominent shocks affecting the hospital industry during the prior decade, which was also a period of strong interest in and effort toward expanding IT investments across the healthcare sector. The first (*negative*) shock is the Great Recession of 2008-2009. While this severe downturn had implications for the entire economy, including the hospital industry (Adelino, Lewellen, and Sundaram 2015; Dranove, Garthwaite, and Ody 2017; Adelino, Lewellen, and McCartney 2022; Aghamolla *et al*. 2024), the depth of its bite varied significantly across the country. We exploit its heterogeneous impact to identify the causal effect of a local economic downturn on hospitals' IT investments, specifically. We then move forward in economic history to leverage a known *positive* shock to the hospital industry: the 2014 Affordable Care Act (ACA) Medicaid expansions. We use state-level variation in the take-up of these public insurance expansions to estimate the policy effects on hospitals' IT adoption behavior. Doing so allows us to build upon prior work by considering a new margin of adjustment to explore if Medicaid expansions' reach extends farther than what is currently documented in the literature (Blavin 2016; Dranove, Garthwaite, and Ody 2016; Kaugman *et al*. 2016; Lindrooth *et al*. 2018; Rhodes *et al*.

[6] Information on federally legislated efforts, such as the Health Information Technology for Economic and Clinical Health (HITECH) Act, can be found here: https://www.healthit.gov/topic/laws-regulation-and-policy/health-it-legislation and https://www.brookings.edu/articles/where-hitechs-28-billion-of-investment-has-gone/

2020; Blavin and Ramos 2021; Callison *et al*. 2021; Dunn, Knepper, and Dauda 2021; Duggan, Gupta, and Jackson 2022; Santos, Singh, and Young 2022).

A common thread between these two shocks is their influence on the prevailing demand and payer mix for hospitals in the present and foreseeable future, which will then alter immediate cash flows as well as perceived levels of uncertainty in opposite directions. More specifically, they both shift the share of uninsured, non-paying patients a hospital sees, which determines the incidence of "uncompensated care" costs they face. Resources devoted to the provision of medical services that eventually go unpaid are known to place a uniquely large burden on the hospital industry. Prior estimates suggest that a hospital will incur as much as $800 in added costs for each additional uninsured person in its catchment area (Garthwaite, Gross, and Notowidigdo 2018). Moreover, these uncompensated care costs can be highly volatile year-over-year, which injects further uncertainty into hospital managers' decision-making (Dranove, Garthwaite, and Ody 2022). For these reasons, in the wake of a substantial market shock, it is plausible that hospital managers will recalibrate their willingness to make risky health IT investments due to changes in current financial circumstances as well as changes to their perceptions of the industry outlook over the coming years (i.e., the level of uncertainty in the hospital care market). Our complementary difference-in-differences analyses—spanning both positive and negative shocks—provide formal and novel tests to establish and quantify hospitals' sensitivity to such market events in each direction.

We find that hospitals' IT investment decisions are sharply influenced by harmful and helpful market shocks in a symmetrical manner. The economic downturn restrains hospitals' investments while hospitals exposed to a Medicaid expansion purchase more health IT. The effects of both shocks are dynamic, becoming larger with time. Three years after the financial crisis, hospitals operating in the most severely impacted areas decrease their IT capital investments by 10% to 15%. Similarly, hospitals affected by the 2014 Medicaid expansions adopt nearly 10% more technology solutions in comparison to hospitals in non-expansion states by 2017. Hospitals' adjustments span a variety of health IT genres, including clinical service-line management, laboratory management, and multiple administrative functions (e.g., back-office management, financials, information systems, and utilization review). The relative effect sizes typically range between 5% to 15% for a given technology purpose; however, some changes are as large as 30% to 67% over baseline levels. These behavior changes are present among for-profit as well as not-for-profit hospitals and are statistically indistinguishable between the two. Interestingly, our heterogeneity analyses do not suggest that the impacts on hospitals' decision-making are fully explained by pure income shocks. Standalone and financially weaker hospitals are not more responsive to either shock—if anything, their responses are more muted at times. And hospitals with relatively greater exposure to the size of the Medicaid expansions do not engage in greater health IT capital investments compared to other hospitals in affected states.

We further augment these findings by supplementing our health IT data with data on two short-term expenses hospitals commonly incur: hiring and direct-to-consumer advertising. Recent work finds that hospitals adjust employment in the presence of revenue shocks and management changes (e.g., Gross *et al*. 2022; Richards, Shi, and Whaley 2024) and that hospital marketing activity sharply shifts with ownership and financial restructuring (Richards and Whaley 2024). For these reasons, such variable spending margins could be plausibly affected by changes in hospitals' cash flow following a recession or public insurance expansion, but seem less likely to be influenced by fluctuations in longer run perceptions of uncertainty facing the industry. In other words, current outlays for labor and ad spend should be somewhat distinct from riskier capital investments and therefore serve as a useful benchmark for our observed changes in health IT purchases. We find that neither shock translates to consistent or pronounced changes along these hospital production and strategic margins, which contrasts with the strong evidence for IT capital take-up. Although not definitive, these supplementary results, in combination with our heterogeneity explorations, suggest that considerations beyond immediate budget constraints impact hospital managers' willingness to invest in IT.

Our paper makes several important contributions. First, we make clear that IT spending is one of the most sensitive and elastic margins for hospitals when adapting to market fluctuations––consistent with the notion that IT investments are particularly risky for businesses (e.g., see Dewan, Shi, and Gurbaxani 2007). This finding is novel and offers useful insight into how and why IT adoption can lag within healthcare industries—despite policymakers', business leaders', and consumers' longstanding appeals for more and better IT use. It also suggests that the underlying factors or how they are weighed by hospital managers differ between IT investments and regular spending decisions. Prevailing market uncertainty is a plausible candidate to explain the contrasting hospital responses across these distinct spending domains. In this way, our results connect to broader empirical economics work interested in the linkage between various policy levers and firms' capex activity in the presence of uncertainty (Bloom 2014; Handley and Limão 2015; Baker, Bloom, and Davis 2016; Gulen and Ion 2016).

Second, we extend the modest literatures focused on hospitals' capital investments in the wake of the Great Recession and Medicaid expansions—two of the largest shocks to the industry in many years. Existing work has shown evidence of post-recession worsening of not-for-profit hospital financial metrics and hospitals' overall capital spend (Adelino, Lewellen, and Sundaram 2015; Adelino, Lewellen, and McCartney 2022). However, the approaches to identification, definitions of capital investments, and the scope of hospitals studied depart from our study. And despite Medicaid's potential impact on healthcare providers, supply-side studies are relatively rare, especially those focused on providers' capital investment behavior.[7] Meille and Post (2023) find no effects in terms of hospitals' fixed assets (i.e., land, buildings, and leased assets) from the recent ACA expansions. Using a considerably different identification strategy, Duggan, Gupta, and Jackson (2022) examine an aggregate measure of capex within a single state (California) and fail to detect any ACA impact on its hospital industry. We are unaware of any other ACA-related empirical studies examining provider capital investment decisions, particularly in relation to one of the fastest growing areas of market and policy interest: health IT.

Third, and finally, Medicaid expansions remain a source of political debate and controversy. Ten states have refused to expand their Medicaid programs, as of 2025—over a decade since the original expansion opportunity was offered. Informed policymaking around the preservation of existing expansions as well as the implementation of new expansions requires a comprehensive understanding of the public insurance program's costs and benefits (i.e., its tradeoffs).[8] Our evidence demonstrates that at least one meaningful supply-side response has been previously overlooked.

In what follows, we describe each of the key data assets used throughout our analyses (Section I). We then describe the respective motivation, data leveraged, and research design as well as report the results for each of our industry shocks in sequence (Sections II-V). We conclude

[7] There is, however, a voluminous literature of demand-side effects from ACA policy provisions. French *et al*. (2016), Gruber and Sommers (2019), and Soni, Wherry, and Simon (2020) provide extensive ACA literature reviews, especially with respect to healthcare access, utilization, and health outcomes. We also review the modest economics literature examining Medicaid expansion effects on healthcare providers in more detail in Section IVA.

[8] Additionally, policies shaping the broader market environment could have similar (indirect) impacts on the industry when compared to narrow health IT subsidization strategies or even amplify subsidization efforts.

by comparing and contrasting the findings across the negative and positive shocks, which strengthens our overall inferences and policy implications (Section VI).

I. Data

A. *HIMSS*

Our primary data come from the Health Information Management Systems Society (HIMSS) annual survey, which provide detailed information on hospital-level health IT use across a variety of business domains (e.g., clinical care and tracking, revenue cycle management, and back-office functions). As previously noted, hospitals' health IT adoption can be accompanied by high adjustment costs and sunk costs tied to these investments. The former costs reflect the potentially high switching costs attached to new personnel training and/or replacement technology as well as contracting with new vendors. The latter costs reflect the low-to-no resale value belonging to a purchased health IT solution.

We rely on HIMSS survey years 2005 through 2017 and construct a hospital-level measure of aggregate number of software health IT solutions implemented and operational in a given year to reflect overall adoption activity over time. We also benefit from granular information on the purpose of a given health IT investment, which we use to construct a complete set of mutually exclusive categories for IT functionality. To keep the estimation and results reporting tractable, we collapse some health IT purposes into an overarching business function. For example, we have a broader measure of 'financials' which captures multiple HIMSS reported purposes, including financial decision support, general financials, and revenue cycle management. Likewise, our constructed category of 'back-office' health IT solutions includes business office software, customer relations management, business intelligence, document management, regulation and standards, and transcription. However, most of our outcome measures map to a single or few reported specific IT purposes.[9] Another interesting feature of these data is the ability to observe

[9] Specifically, "Staffing" incorporates human resources, credentialing, and nursing. "Finance" includes financial decision support, general financials, and revenue cycle management. "Clinical Service Line" includes all categories tied to a specific medical area (e.g., cardiology or radiology) as well as clinical systems. And "Information System" (IS) includes all IS systems, IS infrastructure, IS security, along with health information exchange and health information management categories. We also note that the telemedicine outcome is only used in the Medicaid expansion analyses since it was not included as a category in earlier years of the HIMSS data.

information on health IT vendors. We leverage these data details to construct a measure of total unique vendors a given hospital contracts with in a given year.

As far as we are aware, these data are a novel contribution to the recession-focused and the public insurance expansion-focused supply-side literatures.[10] For both sets of our subsequent analyses (Sections II-V), we restrict to hospitals in the HIMSS data that report a valid Medicare identification number (CCN) that we can use to link to our other data sources. This requirement sacrifices approximately 10% of the total available HIMSS data.

B. *AHA and HCRIS*

We supplement our primary data with information on hospital-level ownership status and financial status contained within the American Hospital Association (AHA) annual surveys and the publicly-available data from the CMS Hospital Cost Reporting Information System (HCRIS), respectively. The AHA data allow us to determine a given hospital's presence or absence of a health system affiliation in a given year, along with other hospital-level characteristics (e.g., for-profit or not-for-profit status). The AHA data also provide information on hospital-level employment. We focus on measures of full-time and part-time registered nurses (RNs) and licensed practical nurses (LPNs), specifically, belonging to a given hospital's workforce in a given year. Nurses of varying skill types are some of the most numerous and vital labor inputs for most hospital operations. For the latter information (i.e., HCRIS), on an annual basis, all hospitals participating in the Medicare system are required to certify and report information on hospital financial measures, including operating revenues and expenses. While the HCRIS data contain system linkages, we analyze financial outcomes at the individual hospital level to parallel our hospital-specific investigations of health IT adoption activity.

C. *Kantar Media*

Our final data asset captures proprietary information on hospital industry marketing spend from Kantar Media (now part of the Vivvix company). The data exist for a host of economic sectors,

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[10] We do note that the data do not contain transaction prices or cost estimates for the health IT solutions. While this is one drawback for the HIMSS data, it is also not surprising, given the very detailed information on each hospital, the IT each hospital has invested in, and with whom the hospital contracts for its IT solutions. In other words, reporting on costs (even in ranges) would likely be viewed as information for a given hospital-vendor negotiation that is too proprietary (i.e., "trade secrets") to report in the HIMSS survey.

firm types, product types, and mediums (e.g., outdoor, radio, television, etc.) and have detailed information on the advertising entity as well as the geographic location of the advertising. The latter is defined as media markets known as "DMAs", which are a longstanding industry construction that reflect collections of counties where common programming and accompanying advertisements take place. We focus on hospital industry advertising behavior in the outdoor (e.g., billboards) and spot television (TV) domains aggregated to the annual level for our years of interest in nominal ('000) dollar terms.

II. Empirical Strategy: Great Recession

A. *Business Cycles and the Hospital Industry*

Existing economics research spanning more than two decades has examined the impacts of economic downturns on population health, especially with respect to mortality (e.g., Ruhm 2000, 2015; Stevens 2015; Finkelstein *et al*. 2024). A parallel literature has taken interest in the supply-side consequences of negative macroeconomic shocks and tends to find that the healthcare labor market is relatively "recession proof" (e.g., Chen, Lo Sasso, and Richards 2018; Li, Richards, and Wing 2019; Dillender *et al*. 2021). Yet, this does not mean that the sector is unaffected by recessions. Complementary studies find that healthcare providers are sensitive to the business cycle to varying degrees, including how the hospital industry coped with fallout from the Great Recession. For example, empirical work finds strategic shifts in hospitals' clinical care to improve profitability and reduction in overall investments when absorbing the negative income shock (via their investment portfolios) that resulted from the 2008 financial crisis and subsequent stock market crash (Adelino, Lewellen, and Sundaram 2015; Adelino, Lewellen, and McCartney 2022)––at least in certain hospital market contexts. Though, earlier work offers more limited evidence of such responses in the aggregate, especially across a wider variety of hospitals (Dranove, Garthwaite, and Ody 2017). Some recent and related research also demonstrates that *ex post* policy responses to the financial crisis (i.e., the Dodd-Frank Act stress tests) raised the cost of borrowing for hospitals which led them to seek out compensatory efficiencies and lower their care quality (Aghamolla *et al*. 2024).[11]

[11] Unrelated to the Great Recession, Rossi and Yun (2024) likewise find that policy lowering hospitals' borrowing costs leads to greater capital expenditures, especially for new buildings.

As previously noted, it is currently unknown if the hospital industry's IT capital investments, specifically, are altered by the business cycle. Hence, we leverage the financial crisis as a negative shock to hospitals' income as well as a source of greater uncertainty for the industry due to suppressed demand and rising uncompensated care costs—which may also be more difficult to predict over managers' planning time horizons. These recession realities motivate our empirical strategy (detailed next) to offer novel evidence of how economic downturns affect hospitals' decision-making, particularly in relation to IT adoption.

B. *Difference-in-Differences Estimation*

Our first difference-in-differences (DD) strategy exploits the spatial variation in the Great Recession's severity and is similar in spirit to recent work focused on the local economic activity and mortality effects of the downturn (Finkelstein *et al*. 2024). Specifically, we focus on the years 2005-2012 and a balanced panel of hospitals present in the HIMSS data for these eight years. Using data from the Bureau of Labor Statistics (BLS) for 2007 and 2009, we calculate the county-level difference in the unemployment rate for the full US across these two years to use as a proxy measure of the Great Recession's local severity (i.e., a recession 'bite' variable). We narrow our focus to counties that fall in the top and bottom quartiles of the recession bite variable's distribution to define our treatment (top) and control (bottom) group geographies for our DD research design.[12] Importantly, the average change in the unemployment rate between 2007 and 2009 for counties in the bottom quartile was 1.7 percentage points while it was 7.1 percentage points for those in the top quartile—i.e., a difference of 5.4 percentage points in terms of Great Recession severity.

The resulting counties belonging to this first component of our empirics are shown in Figure 1. Areas in the Southeast, parts of the upper Midwest, and the West coast comprise most of the severely affected counties while the central US—ranging from Texas to Montana—were more modestly impacted and hence contribute the plurality of our control group counties. We then combine this information with our hospitals from the HIMSS data to restrict to hospital-county pairs that satisfy our DD inclusion criteria. The number and baseline summary statistics for the hospitals operating in these two subgroups of counties that make up our first DD analytic sample

[12] In Section III, we describe and discuss a sensitivity test that exploits the full variation in the recession bite variable and hence includes the full set of analytically eligible hospitals. Neither the strength of our results nor our subsequent inferences are influenced by this modified estimation when compared to our preferred DD design.

are displayed in Table 1. Treatment group hospitals have slightly more operational health IT solutions at baseline, on average; however, the mix and average levels of specific IT solution types is comparable across the recession bite divide in Table 1.

Our subsequent estimations are straightforward. We first rely on a standard "2x2" DD specification that is then followed by an event study specification. The respective estimating equations are as follows:

$$Y_{ht} = \alpha_h + \theta_t + \delta(Treated_h \times Post_t) + \varepsilon_{ht} \quad (1)$$

$$Y_{ht} = \alpha_h + \theta_t + \sum_{\substack{j=2005 \\ j\neq 2006}}^{2012} \delta_j \,(Treated_h \times time = j) + \varepsilon_{ht} \quad (2)$$

Equations (1) and (2) each include hospital (α_h) and year (θ_t) fixed effects. *Treated* is equal to one for hospitals operating in the top quartile of Great Recession severity counties and zero otherwise. The *Post* variable is set to one for the 2008-2012 period, which we view as conservative since the Lehman Bros. investment bank collapse did not occur until late 2008, which precipitated the full financial crisis and subsequent Great Recession. The event study estimation belonging to Equation (2) allows us to formally examine the presence of parallel trending across our two subgroups of hospitals by prior to the recession's inception and capture any dynamic effects from the economic downturn over the 2008-2012 period. Standard errors are clustered at the county level throughout, which we confirm as being more conservative than clustering at the individual hospital level.

C. *Supplementary Analyses*

Since previous work finds that the incidence of uncompensated care is uneven across hospitals (e.g., Dranove, Garthwaite, and Ody 2016; Garthwaite, Gross, and Notowidigdo 2018; Blavin and Ramos 2021; Callison *et al*. 2021), we adapt Equation (1) to formally test for heterogeneous responses in health IT adoption behavior via a DDD design. Specifically, we would expect system-unaffiliated (i.e., standalone) hospitals as well as hospitals financially struggling at baseline to face tighter budget and liquidity constraints (e.g., from higher borrowing costs) following a negative economic shock. Thus, stronger effects among these subsets of hospitals would be consistent with income shocks driving changes to health IT investment decisions.

We first construct an indicator for 'standalone' hospital that is equal to one for any non-government hospital lacking any system affiliation as of 2007. For hospital financial performance, we calculate the annual operating margin per hospital and construct an indicator for non-government hospitals that average a negative margin (i.e., lost money on net) over the 2005-2007 period.[13] The resulting DDD specification is as follows:

$$
\begin{aligned}
Y_{ht} = \alpha_h + \theta_t + \lambda_1(Treated_h \times Post_t) + \\
\lambda_2(BaseCharac_h \times Post_t) + \\
\lambda_3(Treated_h \times Post_t \times BaseCharac_h) + \varepsilon_{ht}
\end{aligned}
\quad (3)
$$

The *BaseCharac* variable in Equation (3) represents a general placeholder for any third 'D' indicator used in our DDD estimation. All other features from Equation (1) remain the same. Of note, using Equation (3) to test for heterogeneous responses among for-profit hospitals exposed to a steeper economic downturn (or ACA Medicaid expansions in Sections IV-V) overwhelmingly shows no detectable difference. The coefficients are predominantly small and nowhere near reaching statistical significance at conventional levels (results available by request).

We then conclude our Great Recession empirics by examining hospitals' hiring of nurse labor and outlays for direct-to-consumer advertising. For the former, we simply use our event study estimation (Equation 2 above) to examine changes in our nurse employment outcomes. Regarding advertising behavior, the underlying proprietary data are not structured for economics research purposes, so there are no traditional hospital-level identifiers, such as those used in common research databases and transaction data. Instead, we know that a given observation of advertising has been classified as pertaining to the hospital industry, the geographic location of the advertising (i.e., the DMA), the amount spent for the advertising (in nominal thousands of dollars terms), and the name of the advertising entity—which is consistent over time in the data. Thus, simply matching the advertising data to our existing hospital-level data is exceedingly difficult for multiple reasons, including severe ambiguities around common hospital names used by separate

[13] Of note, these two versions of the third 'D' measure are correlated but not completely overlapping.

organizations (e.g., "St. Luke's") and allocating system-level reported advertising to underlying system-affiliated hospitals across geographies.

We therefore adapt our DD design and estimation to be at the DMA (media market) level. To do so, we first calculate a DMA-level recession bite measure that aggregates the underlying county-level number employed and unemployed from the BLS data to the DMA that those counties belong to. Recall, DMAs are collections of contiguous counties. At the DMA-level, the top quartile in the recession bite variable corresponds to a 6.5 percentage point change from 2007 to 2009 while the bottom quartile experienced a change of 2.4 percentage points. We then calculate the annual hospital industry advertising (outdoor + TV) spend taking place in each DMA from 2005-2012 to implement an analogous DD design as what was described for our primary HIMSS data analyses in Section IIB. We estimate a new event study specification on a balanced panel of DMAs that fall into either the top or bottom quartile of the DMA-specific recession bite variable distribution. The resulting DD event study model is:

$$Y_{dt} = \phi_d + \theta_t + \sum_{\substack{j=2005 \\ j\neq 2006}}^{2012} \delta_j \,(Treated_d \times time = j) + \varepsilon_{dt} \tag{4}$$

The estimation for Equation (4) closely follows that belonging to Equation (2) in Section IIB, with the main difference being the substitution for DMA fixed effects (ϕ_d) in place of hospital fixed effects and the standard errors clustered at the DMA level, rather than the county level.

III. Great Recession Effects on Health IT Investments

Our first DD results are displayed in Table 2. Both the number of operational health IT solutions and the total number of vendors is differentially and negatively impacted by the Great Recession for hospitals exposed to a more severe local downturn. Averaged over the 2008-2012 period, health IT adoption is reduced by 8% while the number of vendors is 10% lower when compared to the pre-recession levels in Table 1. The similar magnitude of decrease between the number IT solutions and number of vendors suggests that consolidating vendors is not clearly a strategy used by hospital managers when facing a worsening business climate. The corresponding event study results are found in Figure 2. While both outcomes are trending in parallel across our treatment and control hospitals over the 2005-2007 period, there is a stark divergence soon after the financial crisis.[14] The coefficient magnitudes also grow with time, with the largest negative effects present in 2011-2012—three to four years after the onset of the Great Recession (Figure 2). By 2011, health IT adoption has been restrained by roughly 11% (5 health IT solutions) or more relative to the treatment groups baseline adoption activity in Table 1. Given the known difference in the recession bite variable between these two subgroups of hospitals described in Section IIB (i.e., 5.4 percentage points), the estimates from Table 2 and Figure 2 imply an approximately 1.5% to 2% decrease in health IT investments for every one percentage point increase in recession severity.

As a robustness check, Appendix Figure A1 repeats our event study estimation but includes the full set of analytically eligible hospitals from the HIMSS data (i.e., not restricting to those in the top or bottom quartile for Great Recession bite) and uses the continuous measure of recession bite (i.e., a treatment intensity measure), rather than the previously used constructed binary variable to dichotomize treatment and control status. The resulting patterns from panel (a) and panel (b) in Appendix Figure A1 are virtually identical to those found in Figure 2, with the exception that the coefficient magnitudes are unsurprisingly smaller than our main analyses that intentionally capture the differential between the most and the least impacted hospitals. This exercise confirms that our main DD approach is not generating misleading estimates or incorrect inferences.

Tables 3 and 4 offer DD estimates for each of our mutually exclusive health IT genres of interest. The estimates are uniformly negative and statistically significant at conventional levels in Table 3 and Table 4. Event study results for each of these outcomes is reported in Appendix Figure A2 and Appendix Figure A3. Overall, the event study findings mirror those displayed in Figure 2 and reinforce the inferences drawn from Tables 3 and 4. They also tend to show dynamic effects, with the largest decreases during the 2011 and 2012 years. Relative to baseline adoption levels for hospitals in the top quartile of recession bite (Table 1), these deepest declines reflect changes of 7-67% for given type of health IT solution. The one exception is the EHR outcome in Appendix Figure A2. The event study results are more equivocal for this type of health IT investment, so we caution against concluding that it was specifically affected by the economic downturn. Additionally, the contemporaneous 2009 HITECH Act is known to have generated greater EHR adoption across the US hospital industry during this time period (Gold and McLaughlin 2016;

[14] Recall, the Lehman Bros. investment bank collapsed in the early fall of 2008.

Adler-Milstein and Jha 2017), so our lack of clear findings for this specific type of IT investment is unsurprising.[15]

Our DDD estimates for hospital-level heterogeneity are found in Appendix Table A1. There is no indication that plausibly more budget- and liquidity-constrained hospitals (i.e., standalone facilities or those with a negative average operating margin over the 2005-2007 period) drive the observed changes in health IT adoption behavior observed in Table 2 and Figure 2. Within three of the four columns in Appendix Table A2, the DDD coefficient is even oppositely (i.e., positively) signed. The pattern of DDD findings does not imply that hospital managers within these subgroups of facilities are insensitive to the economic downturn, but it does suggest that considerations beyond immediate cash flow may influence the willingness to make the marginal IT capital investment.

Figures 3 and 4 present the event study estimates for nurse employment and advertising expenditures, respectively. Despite being regular and important domains of hospital spending, neither margin is strongly affected by the recession shock. There are no clear patterns in terms of hospital employment of full-time RNs, full-time LPNs, or part-time LPNs. The only labor source that shows a post-Great Recession decline in our analytic sample is part-time RNs (panel (b) in Figure 3), which represents just 29% of the nursing workforce for the average treatment group hospital in 2007. The corresponding event study estimates for part-time RNs suggest an approximately 13% decline for hospitals in severely impacted areas, on average, relative to those experiencing a more limited downturn, which affects about 4% of the hospitals total employed nurses—given that part-time RNs only comprise 29% of hospitals' nurse labor at baseline. Otherwise, the size of hospitals' nursing workforce seems largely unaffected by the Great Recession, which contrasts with the findings for health IT adoption overall and by type of IT solution noted above. Similarly, the results in Figure 4 do not offer compelling evidence that marketing activity within the hospital industry was curtailed following the economic downturn. The estimates suggest either slightly increasing levels of advertising or at least holding steady during the fallout from the financial crisis. Again, at a minimum, there is a noteworthy departure in the hospital response when comparing the marketing domain to what is observed along the

[15] The HITECH Act provided financial incentives to expand electronic health record adoption by providers by tying subsidizes to "meaningful use" of EHRs for hospitals and physicians. Importantly for our study, these incentives were provided nationally and were not tied to differences in the local business cycle or state Medicaid expansion decisions.

health IT adoption margin. Moreover, ignoring the health IT investment constraints caused by negative economic shocks risks underappreciating the broader and longer-lasting impacts of a substantive downturn in the business cycle on the hospital industry.

IV. Empirical Strategy: Medicaid Expansions

A. *Medicaid Insurance and the Hospital Industry*

We now turn our attention to the Medicaid public insurance program. This means-tested insurance benefit has been a prominent fixture of the US healthcare system for nearly 60 years, but Medicaid's size has also fluctuated over time due to state and federal policymaking. The potential benefits to individuals and households from access to a heavily subsidized insurance program are straightforward. Yet, the downstream benefits to hospitals are not immediately obvious and depend on two important and interdependent aspects of the US healthcare system: comparatively high rates of uninsurance and a high prevalence of unpaid medical bills.[16] The resulting incidence of uncompensated care costs and related uncertainty determines the incidence of benefits from economic policies that reduce it.

Existing research makes clear that the uncompensated care burden is largely borne by the hospital industry and that the Medicaid program plays a mitigating role. Estimates from the most recent Medicaid expansions tied to the Affordable Care Act (ACA) suggest an approximately 25-50% decline in unpaid medical bills for affected hospitals, relative to pre-expansion levels, and improved finances overall (Blavin 2016; Dranove, Garthwaite, and Ody 2016; Kaugman *et al*. 2016; Lindrooth *et al*. 2018; Rhodes *et al*. 2020; Blavin and Ramos 2021; Callison *et al*. 2021; Dunn, Knepper, and Dauda 2021; Duggan, Gupta, and Jackson 2022; Santos, Singh, and Young 2022). Thus, hospitals face considerable financial risk tied to fluctuations in the rate of uninsurance present in their local market. Expanding coverage to medical care consumers therefore shields healthcare providers from high and hard-to-predict uncompensated care costs in the present and for the foreseeable future.[17]

[16] Both are often lamented features of the US system, with the latter also receiving increased attention by researchers, consumer advocates, and policymakers in recent years (Batty, Gibbs, and Ippolito 2022; Kumar and Adashi 2023; Kluender *et al*. 2024).

[17] Medicaid is also known to be countercyclical—bolstering medical care demand during economic downturns (Benitez, Perez, and Chen 2021; Benitez, Perez, and Seiber 2021). Relatedly, existing research calculates that a substantive portion of Medicaid spending operates as a transfer from government coffers to the hospital industry (Garthwaite, Gross, and Notowidigdo 2018; Finkelstein, Hendren, and Luttmer 2019). The relative permanence of

The ACA became law in 2010 and arguably represented the most substantial health policy reform in the US healthcare system since the founding of the Medicare and Medicaid programs a half-century prior. The legislation included a variety of policy levers to ultimately shrink the share of the US population lacking health insurance. One of the most influential mechanisms to accomplish this policy priority was a national expansion of the public insurance program for low-income individuals and households (i.e., Medicaid). Medicaid is a state and federal partnership program in terms of its financing and administration; however, the ACA intended to bring more uniformity to Medicaid eligibility across states and to have the federal government shoulder the vast majority of the financial burden from program expansion. The expansions were originally intended to take place across the country in January of 2014 (or before in some circumstances), but during the summer of 2012, the US Supreme Court ruled that states must be allowed to opt-out of the proposed ACA Medicaid expansions—an option that many states decided to exercise. Further details of the ACA insurance provisions and subsequent estimates of coverage take-up can be found within Frean, Gruber, and Sommers (2017) and Gruber and Sommers (2019), among others.

Regarding the Medicaid program and provider behavior, earlier work took interest in how pediatric labor markets and supply responded to public insurance provision targeting children in the 1990s and early 2000s (Garthwaite 2012; Chen, Lo Sasso, and Richards 2018). Related work from Buchmueller, Miller, and Vujicic (2016) explored practice substitution behavior toward lower skilled labor use (i.e., dental hygienists) following greater Medicaid involvement in dental service markets. More recently, a growing, but still small, literature has focused on the policy changes linked to the ACA. Specifically, Matta, Chatterjee, and Venkataramani (2024) find that high-earning health workers benefited from improved compensation following their states' ACA Medicaid expansions. Meanwhile, Dillender (2022) documents increased job postings by healthcare firms, especially those tied to lower skilled work, and DiNardi (2021) finds evidence consistent with more licensed practical nurses and registered nurses shifting into full-time positions in ACA expansion states. Results from Tarazi (2020) and Meille and Post (2023) are

Medicaid expansions is also important for our purposes. Doubts around policy permanence can lead to weaker investment and encourage further "precautionary delays" (Rodrik 1991). Likewise, other work finds that temporary price shocks have limited impact on provider behavior (Chen *et al*. 2018; Chen *et al*. 2022). Public insurance expansions are rarely reversed, however.

likewise consistent with positive impacts of Medicaid expansions on hospitals' nurse retention and/or hiring. Though, Barnes *et al*. (2023) show that primary care physician practices actually slow their hiring of non-physician clinicians (e.g., nurse practitioners) when facing greater exposure to the Medicaid market following the recent expansions. Notwithstanding the known impact on hospitals' uncompensated care burden, there is no existing evidence that recent ACA Medicaid expansions forestalled obstetric unit closures within hospitals, improved circumstances for safety net hospitals, or translated to more community benefit spending (Kanter *et al*. 2020; Stoecker *et al*. 2020; Chatterjee, Qi, and Werner 2021; Chatterjee, Werner, and Joynt Maddox 2021; Carroll *et al*. 2022). However, Lindrooth and colleagues (2018) find a lower likelihood of full hospital shutdown following the public insurance expansions, and Nikpay (2022) shows that a post-expansion increase in Medicaid volumes can trigger other Medicaid-linked subsidies for hospitals. As noted previously, only limited empirical work has examined hospitals' capex decisions following Medicaid expansions, with no known work on health IT investments, specifically.

B. *Difference-in-Differences Estimation*

Our primary estimation strategy for identifying Medicaid expansion effects (i.e., our second market shock of interest) is also a standard DD research design. Our implementation closely follows Brevoort, Grodzicki, and Hackmann (2020), where the authors leverage the 2014 Medicaid expansions in isolation to examine effects on household finances and medical debt. More specifically, the authors consider control, comparison states to be those that have not expanded their Medicaid program as of 2017 (19 states) and exclude "early" and "late" adopting states (13 states, plus the District of Columbia)—leaving 19 treatment group states that all implemented their ACA Medicaid expansions on January 1st, 2014. The simultaneous implementation of these policies across states avoids the empirical complications from differential timing in treatment (e.g., see Goodman-Bacon (2021)).

The resulting geographic spread of our treatment and control group states is displayed in Figure 5. We then restrict our analytic sample to a balanced panel of hospitals present in the HIMSS data every year from 2009 through 2017 and operating in one of these policy-relevant states. Within Table 5, we can see the levels of our health IT investment measures averaged over the 2009-2012 period for each subset of analytic hospitals corresponding to their 2014 Medicaid expansion status. At baseline, the average hospital within each group has nearly sixty health IT solutions operational in a given year and contracts with more than a dozen unique IT vendors. The number of solutions tied to a given business purpose ranges from less than one to as many as fourteen, on average (Table 5). Importantly, hospitals' health IT adoption patterns closely mirror each other across the Medicaid expansion divide prior to our 2014 policy shocks of interest.

Just as before, for our primary outcomes, we conduct a "2x2" DD estimation that is then followed by an event study specification. The respective estimating equations mirror Equation (1) and Equation (2), with the exception of two variable definitions:

$$Y_{ht} = \alpha_h + \theta_t + \delta(Treated_h \times Post_t) + \varepsilon_{ht} \tag{5}$$

$$Y_{ht} = \alpha_h + \theta_t + \sum_{\substack{j=-5 \\ j\neq -2}}^{3} \delta_j \,(Treated_h \times time = j) + \varepsilon_{ht} \tag{6}$$

Equations (5) and (6) each include hospital (α_h) and year (θ_t) fixed effects, paralleling what was done in Section II. Now, the treatment indicator (i.e., *Treated*) is equal to one for hospitals operating in 2014 Medicaid expansion states and zero otherwise. Similarly, the *Post* variable is now set to one for the 2014-2017 period. We also believe defining the post-expansion period in this way is conservative since hospitals knew their respective state's policy decision in late 2012––making 2013 a policy announcement year. However, the event study estimation belonging to Equation (6) allows us to formally examine any anticipatory behavior by hospitals prior to the expansions taking place, along with assessing the validity of the parallel trends assumption. Standard errors are clustered at the state level, which we confirm as being more conservative than clustering at the individual hospital level.

C. *Supplementary Analyses*

Following the approach in Section IIC, we adapt Equation (5) to formally test for heterogeneous responses via DDD estimation. The resulting specification is as follows:

$$Y_{ht} = \alpha_h + \theta_t + \lambda_1(Treated_h \times Post_t) +$$
$$\lambda_2(BaseCharac_h \times Post_t) +$$
$$\lambda_3(Treated_h \times Post_t \times BaseCharac_h) + \varepsilon_{ht} \quad (7)$$

The *BaseCharac* variable in Equation (7) again represents a general placeholder for any third 'D' indicator used in our DDD estimation. All other features from Equation (5) remain the same. And we again focus on two key sources of potential heterogeneity: health system affiliation and baseline hospital financial performance. For the former, we construct an indicator for 'standalone' hospital that is equal to one for any non-government hospital lacking any system affiliation as of 2012. For hospital financial performance, we calculate the annual operating margin per hospital and construct an indicator for non-government hospitals that average a negative margin (i.e., lost money on net) over the 2009-2012 period. The rationale mirrors that from Section IIC. Specifically, if Medicaid expansion effects on health IT capital investments are largely operating through positive income shocks to hospitals, then we would expect these subsets of hospitals to demonstrate a disproportionate policy response.

To help further rule out competing interpretations for why hospitals would increase capital investments and/or other business expenses following Medicaid expansions specifically, we subsequently use our DDD estimation described via Equation (7) to follow related studies (e.g., Dranove, Garthwaite, and Ody 2016; Lindrooth *et al*. 2018; Dunn, Knepper, and Dauda 2021) that leverage geographic variation in the likely impact of ACA Medicaid expansions. We use information from the Census Small Area Health Insurance Estimates for 2013 to create an indicator equal to one for hospitals operating in counties that are above the national median in terms of share of the adult (age 18-64) population below 138% of the Federal Poverty Level and zero otherwise. Hospitals in these localities should be disproportionately exposed to the expansion in terms of the size of the potential market affected by the policy change. We also leverage state-level Medicaid payment denial rates provided by Dunn *et al*. (2024) to assess any heterogeneous effects for hospitals in plausibly more difficult contracting and payment regimes (i.e., areas with higher denials or administrative costs) with respect to their state's Medicaid program. The former DDD analysis speaks to the potential role of improved cash flow post-expansion to drive increased hospital spending while the latter focuses on the effects of more demanding contracting requirements that could incentivize stronger IT capital spending to minimize transaction costs and/or losses of payment.

We then conclude our Medicaid expansion empirics by examining hospitals' hiring of nurse labor and outlays for direct-to-consumer advertising. Paralleling what was done for the Great Recession effects in Section IIC, we simply use our event study estimation (Equation 6 above) to examine changes in our nurse employment outcomes. Regarding advertising behavior, as previously noted, the underlying proprietary data are not structured for economics research purposes, so we modify our approach. Specifically, we adapt our DD estimation from Section IVB to be at the distinct hospital industry advertising entity level and aggregate the total spending by the advertiser on television and outdoor (e.g., billboards) mediums to the annual level. We also stratify a given advertiser entity's spending as taking place in our treatment or control Medicaid expansion states.[18] Doing so allows specific hospital systems that span the 2014 expansion status divide to enter the data twice since the geographic location of the advertising is clear in the data––and hence can be correctly attributed to and reflective of a policy response. The corresponding DD event study estimation is:

$$Y_{at} = \eta_a + \theta_t + \sum_{\substack{j=2009 \\ j \neq 2012}}^{2017} \delta_j \left(Treated_a \times time = j \right) + \varepsilon_{at} \tag{8}$$

The estimation closely follows that belonging to Section IVB, with the main difference being the substitution for advertiser fixed effects (η_a) in place of hospital fixed effects and standard errors clustered at the advertiser level.

V. Medicaid Expansion Effects on Health IT Investments

Table 6 provides our first set of DD estimates for aggregate health IT adoption and number of contracted health IT vendors. Hospitals affected by the 2014 Medicaid expansions demonstrate a

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[18] For media markets (DMAs) that span state borders (e.g., the St. Louis media market), we classify the media market as being in the treatment group if any of the media market's included states participated in the 2014 Medicaid expansions. Likewise, media markets are those that exist within a state or states that all satisfy control group inclusion criteria described in Section IVB.

differential and statistically significant increase in the number of purchased IT solutions as well as the number of vendors used in comparison to hospitals in non-expansion states. The relative change over baseline levels (Table 5) for treated hospitals is approximately 6% and 10%, respectively. The corresponding event study estimates in Figure 6 reinforce the interpretations from Table 6. Treatment and control hospitals are trending in parallel over the 2009-2012 period, and then in 2013 (i.e., the policy announcement period), the divergence begins and grows over time. By 2017, Medicaid expansions have caused exposed hospitals to make 10% more capital investments tied to health IT and to utilize 18% more health IT vendors than the counterfactual scenario where no Medicaid expansions occur—and hence the size of the current uncompensated care burden and the risk of a future burden persist. Using the back-of-the-envelope values from Brevoort, Grodzicki, and Hackman (2020), which assumes an average increase of 4.4 percentage points in the nonelderly insured population among these 19 expansion states over this post-period, our estimates from Table 5 and Figure 6 imply a 1.4% to 2.3% increase in hospitals' IT capital investments for every one percentage point gain in the nonelderly insured rate.

Tables 7 and 8, along with Appendix Figures A4 and A5, provide a decomposition of the overall Medicaid expansion effect according to the specific health IT purpose. The "2x2" DD estimates in Table 7 reveal increases in IT focused on specific clinical service lines (e.g., cardiology care or emergency department care) as well as laboratory services that are statistically significant at conventional levels. The remaining DD estimates in Table 7 are positively signed but insufficiently precise. The event studies in Appendix Figure A4 also support a causal interpretation for Medicaid effects for these specific types of health IT adoption, and mirror the findings from Figure 6 where the positive effects materialize during policy announcement and become larger with time. An even broader range of IT purposes tied to more administrative—as opposed to clinical—functions demonstrate positive policy responses to the 2014 Medicaid expansions (Table 8). Back-office management, financial-focused, information systems, and utilization review software solutions all show substantive and statistically significant policy effects in Table 8. Staffing (i.e., human resource management) and supply chain IT margins also have positive DD coefficients in Table 8 but fail to reach statistical significance. The resulting event study findings (Appendix Figure A5) for the four key outcomes in Table 8 again lend themselves to a causal interpretation for Medicaid expansion effects. There are no differential upward trends for affected hospitals during the 2009-2012 pre-period, and following the individual states' announcement to participate in the 2014 expansions (i.e., the 2013 period in our analytic data), we witness a divergence between hospitals in the expansion states when compared to those whose state legislatures decided to forgo the ACA's expansion offer. There are also dynamics in the effects across all four health IT types, with back-office management and information system-related IT showing more pronounced gains over time. By the end of our study period, these two genres of IT solutions have increased by roughly 30% and 25% over baseline levels (Table 5), respectively, in response to the policy shock. The relative effect sizes by 2017 for financial IT and utilization review IT adoption measures are approximately 5% and 10%, respectively (Appendix Figure A5).

Before moving to our heterogeneity analyses that parallel Section II, we use our DDD estimation to first explore the potential for a 'recession recovery' (or catchup) effect from the 2014 Medicaid expansions. Recall from Section II, the Great Recession differentially restrained hospitals' health IT investments in areas where the severity of the recession was the deepest, with the effects largest several years after the onset of the precipitating financial crisis. Since some of these areas were then exposed to 2014 ACA expansions, it is possible that the positive policy shock allowed them to recover lost ground in terms of health IT adoption. Additionally, given the potential overlap of these two shocks, the positive Medicaid expansion effect we estimate could also capture mean reversion of the negative effect from the recession. Appendix Table A2 offers a formal test of these hypotheses, which are ultimately rejected. There is no evidence of a stronger policy response or any indication that our overall Medicaid expansion findings are driven by the subset of hospitals previously and most severely exposed to the Great Recession.

Appendix Table A3 restricts our focus to nongovernmental hospitals and explores any heterogeneous public insurance expansion effects for 'standalone' hospitals (i.e., hospitals with no health system affiliation as of 2012) and 'financially weak' hospitals (i.e., hospitals averaging a negative operating margin over the 2009-2012 period) in sequence.[19] While the effect sizes and corresponding estimates' precision do vary across outcomes in Appendix Table A3, the pattern is consistent. Namely, the DDD coefficients belonging to either subgroup of expansion state hospitals are negatively signed and typically meaningful in size. These results indicate that smaller and more financially vulnerable hospitals do not drive the observed expansion effects documented in Table 6 and Figure 6.

[19] Of note, these two versions of the third 'D' measure are correlated but not completely overlapping.

Appendix Table A4 offers analogous heterogeneity analyses for nongovernmental hospitals when focused on their surrounding market circumstances. Here, we focus on the subgroups of hospitals that either have plausibly greater exposure to the expansions (i.e., the potential Medicaid market is larger) or that operate in a state with known high rates of Medicaid payment denials for providers. The former aims to capture any differential response by those potentially experiencing larger revenue effects from the public insurance expansion while the latter focuses on any heterogeneous effects among those facing more difficult contracting environments as a higher denial rate insurer captures a larger share of their underlying payer mix. Both could incentivize greater capital investments via a larger income shock (former) or transaction cost minimization (latter), which would be independent of prevailing perceptions of uncertainty within the industry. However, the evidence in Appendix Tables A4 does not support such inferences. Neither subgroup demonstrates a stronger response to the policy shock. The DDD estimates are even negatively signed for the number of operational health IT solutions (columns 1 and 2 in Appendix Table A4).

Figures 7 and 8 present the Medicaid expansion effects for affected hospitals' employment of nurses and marketing spend. The collection of findings does not point to clear policy responses, which contrasts with the results for health IT capital investments discussed above. There is only suggestive evidence of an upward trend in full-time RN employment post-expansion in Figure 7. The estimates are noisy in the post-period, and there are some indications of an upward trend already underway years prior to the 2014 expansions. The hospital industry's advertising spend is unremarkable in Figure 8. Hospitals exposed to Medicaid expansions appear to follow a consistent trend in advertising activity from 2009 through 2017. We therefore fail to detect any hospital responses to the Medicaid expansions in terms of nurse hiring or direct-to-consumer advertising activity—two spending domains that are important to hospitals and also relatively easy to adjust with changes to firms' budget constraints.

Taken together, the patterns across our various DDD findings in Section V, coupled with the anticipatory behavior changes (i.e., policy announcement effects) previously highlighted in our main DD event study results (Figure 6) and the null findings for other hospital spending margins, go against a pure income shock interpretation for our Medicaid expansion findings. Something beyond immediate increases in cash flow or managing more complex Medicaid billing causes hospitals to engage in greater capital investment activity tied to health IT.

VI. Conclusion

Information technology is a known opportunity for firms to enhance business functions and improve performance on a host of productivity and financial metrics. However, like all capital investments, IT adoption can be costly and risky, with much of the payoff realized over the long-run. How managers balance these tradeoffs when considering an IT investment could be further influenced by market events that affect their bottom lines and business expectations for the future.

Leveraging rich data from the hospital industry and two substantive economic shocks in opposite directions (i.e., one negative and one positive), we provide novel evidence that hospital managers' decisions over the marginal health IT investment are highly sensitive to fluctuations in market circumstances. Economic downturns restrain investment while public insurance expansions indirectly promote it. In other words, hospitals demonstrate consistent and symmetrical actions when facing negative or positive market shocks. We also find corresponding and dynamic effects across a wide range of health IT types, with relative magnitude changes ranging from low single-digit percent changes to as much as a 67% change over baseline adoption behavior (Figure 9).

The observed changes in IT investment are also not mirrored along more variable hospital spending margins (i.e., nurse labor inputs and marketing expenditures. This contrasts with recent economics work focused on policy-induced revenue shocks as well as organizational shifts within the hospital industry and the effects on short-run spending behavior (e.g., Gross *et al*. 2022; Gupta, La Forgia, and Sacarny 2024; Richards, Shi, and Whaley 2024; Richards and Whaley 2024). At a minimum, the juxtaposition of our findings across hospital spending domains (i.e., IT, nurse labor, and advertising) makes clear that hospitals prioritize the IT capital investment margin differently when facing changes in financial and market circumstances. This is a new empirical insight that can also help explain the uneven adoption patterns within the healthcare sector—despite long running efforts to stimulate it.

The contrasting findings may additionally point toward a deeper understanding of hospital resource allocation and investment appetite as markets evolve. It is difficult to attribute the effects on health IT investments and lack of effects for other salient business expenses solely to adjustments in budget constraints following an income shock. We would generally expect a shift in the budget constraint to affect a variety of spending domains—not just risky and long-run capital investments. Our heterogeneity analyses also do not suggest that the IT adoption response is driven by lower-resourced hospitals or more difficult contracting environments, and the positive effects on capital investments we capture coincide with Medicaid expansion policy *announcement*, which is before any direct effects on hospital revenues occur. We also do not observe similarly sharp or consistent changes in hospitals' contemporaneous financial outcomes following our shocks of interest (Appendix Figures A6 and A7). Taken together, the underlying decision factors and/or how they are weighed by managers must differ between IT capex and regular spending commitments. We posit that post-shock changes to perceptions of financial uncertainty facing the industry could be one plausible mechanism to explain the observed and unique effects on health IT procurement.

Relatedly, while existing work finds limited to no effects on other capex domains from these shocks, as previously noted, the apparent conflict with our findings is perhaps reconciled by the fact that these health IT investments are unlikely to be central to a hospital's strategic direction or brand value. Building out an enhanced suite of IT capabilities can facilitate better hospital functioning over time. But if a hospital wishes to increase its inpatient capacity, build a new orthopedic surgery center, or expand the geographic reach of its outpatient services, these capital investments are more likely to be central to its core business strategy and future market position. If true, then it is less surprising that hospitals' fixed assets (e.g., land and buildings) are less sensitive to market shocks than background technology investments aiming to improve efficiency.

Finally, beyond complementing the recession-focused analyses, the Medicaid expansion effects we identify carry substantive policy relevance. Garthwaite, Gross, and Notowidigdo (2018) calculate that the implied "savings" for states refusing to expand Medicaid through the ACA is smaller in magnitude than the size of the uncompensated care costs imposed on their hospitals by not expanding. We additionally show a previously overlooked, indirect consequence of state policymakers' decisions—namely, they are restraining technological investment within their own hospital industry. Doing so further challenges ongoing attempts by US healthcare firms to catch up to other economic sectors in terms of leveraging technology advancements to improve performance. Likewise, while Carey *et al*. (2020) and Barkowski, Jun, and Zhang (2024) find no spillover effects from Medicaid expansions onto the care received by other patient groups, the health IT investments we document have the potential to generate positive externalities to other patient-payer groups over time. The deployment of health IT is typically not payer-specific so economies of scope belonging to these capital investments could enhance access, foster more efficient care delivery, and/or streamline scheduling/billing services for all patients receiving care from affected hospitals and health systems. Ignoring these downstream consequences from Medicaid expansions with respect to suppliers can understate the economic benefits from these specific policy interventions. We therefore shed new light on an understudied component of these large and regularly debated policies.

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MAIN RESULTS

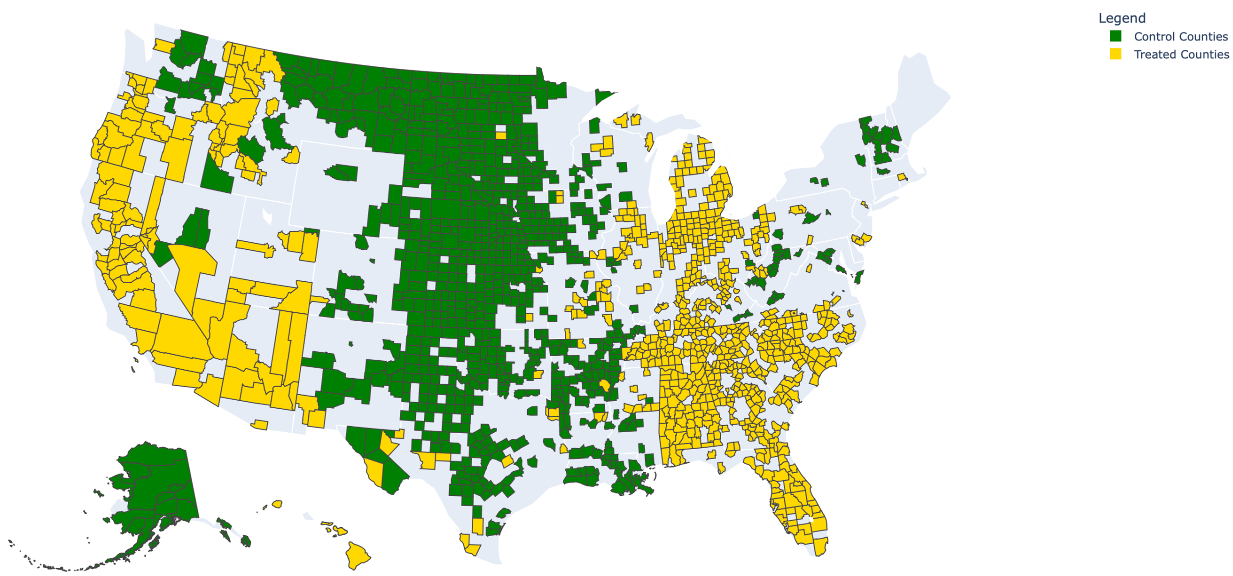


FIG 1. COUNTY LEVEL ANALYTIC SAMPLE INCLUSION STATUS BY INTENSITY OF GREAT RECESSION

Notes: Treated counties are those in the top quartile of percentage-point change between 2007 and 2009. Control counties are those in the bottom quartile of percentage-point change between 2007 and 2009. All other counties are excluded from the analytic sample.

TABLE 1—SUMMARY STATISTICS FOR HEALTH IT SOLUTIONS ADOPTION 2005-2007 STRATIFIED BY GREAT RECESSION INTENSITY

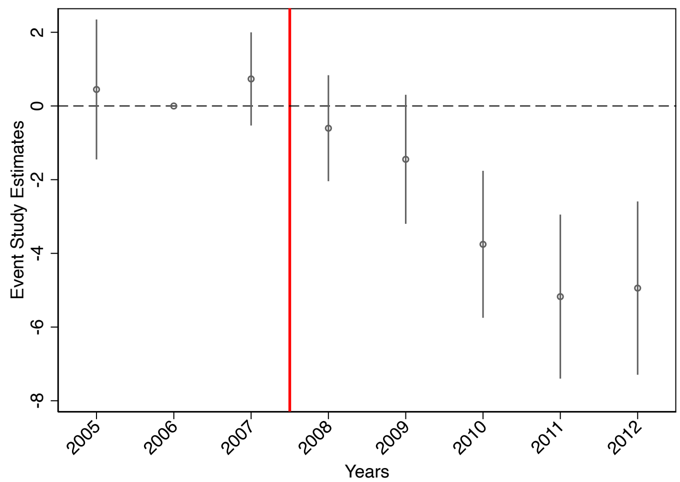
	Top Quartile of Recession Bite	**Bottom Quartile of Recession Bite**
	Mean (SD)	Mean (SD)
Total Health IT Solutions	45.8 (14.1)	40.4 (17.7)
Total Health IT Vendors	11.4 (4.4)	10.2 (4.8)
Care Delivery Health IT Solutions		
Clinical Service Line	9.6 (6.0)	8.1 (6.4)
EHR	2.9 (1.8)	2.5 (1.9)
Laboratory	2.8 (1.4)	2.3 (1.7)
Pharmacy	0.9 (0.4)	0.7 (0.5)
Administrative Health IT Solutions		
Back-Office	0.3 (0.6)	0.4 (0.7)
Financials	10.5 (3.1)	9.3 (3.8)
Info Systems	8.4 (3.3)	7.9 (3.6)
Staffing	7.5 (2.9)	6.7 (3.5)
Supply Chain	1.2 (0.6)	1.0 (0.6)
Utilization Review	1.7 (0.8)	1.5 (0.9)
Hospitals (N)	869	461

Notes: Analytic data are from HIMSS and span 2005 to 2007 for a balanced panel of hospitals used in the main difference-in-differences estimations.

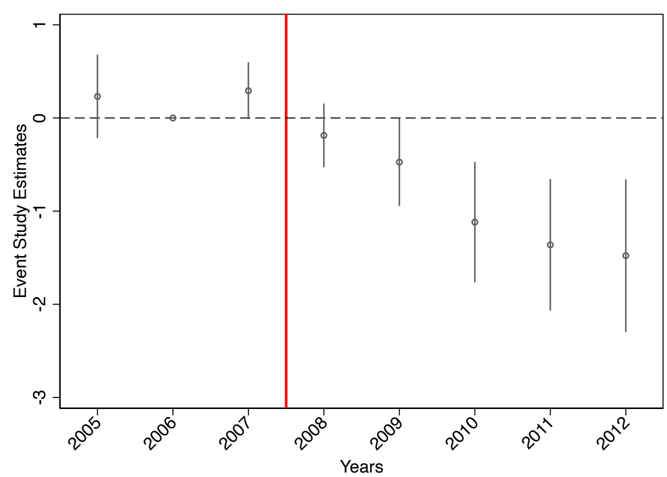
TABLE 2—GREAT RECESSION EFFECTS ON HEALTH INFORMATION TECHNOLOGY (IT) ADOPTION AND CONTRACTING

	Total Health IT Solutions	Total Health IT Vendors
	(1)	(2)
Severe Recession x Post	–3.578***	–1.098***
	(0.747)	(0.247)
Hospital FE	Yes	Yes
Year FE	Yes	Yes
Hospitals	1,330	1,330
Observations	10,640	10,637

Notes: Analytic data are from HIMSS and include a balanced panel of hospitals. Standard errors clustered at the FIPS level. *** P value at 0.01 ** P value at 0.05



(a) Total Health IT Solutions



(b) Total Health IT Vendors

FIG. 2. EVENT STUDY ESTIMATES FOR GREAT RECESSION EFFECTS ON IT ADOPTION AND CONTRACTING

Notes: Solid vertical bar indicates the start of the Great Recession following the Lehman Brothers investment bank collapse in 2008.

TABLE 3—GREAT RECESSION EFFECTS ON CARE DELIVERY HEALTH INFORMATION TECHNOLOGY (IT) SOLUTIONS ADOPTION

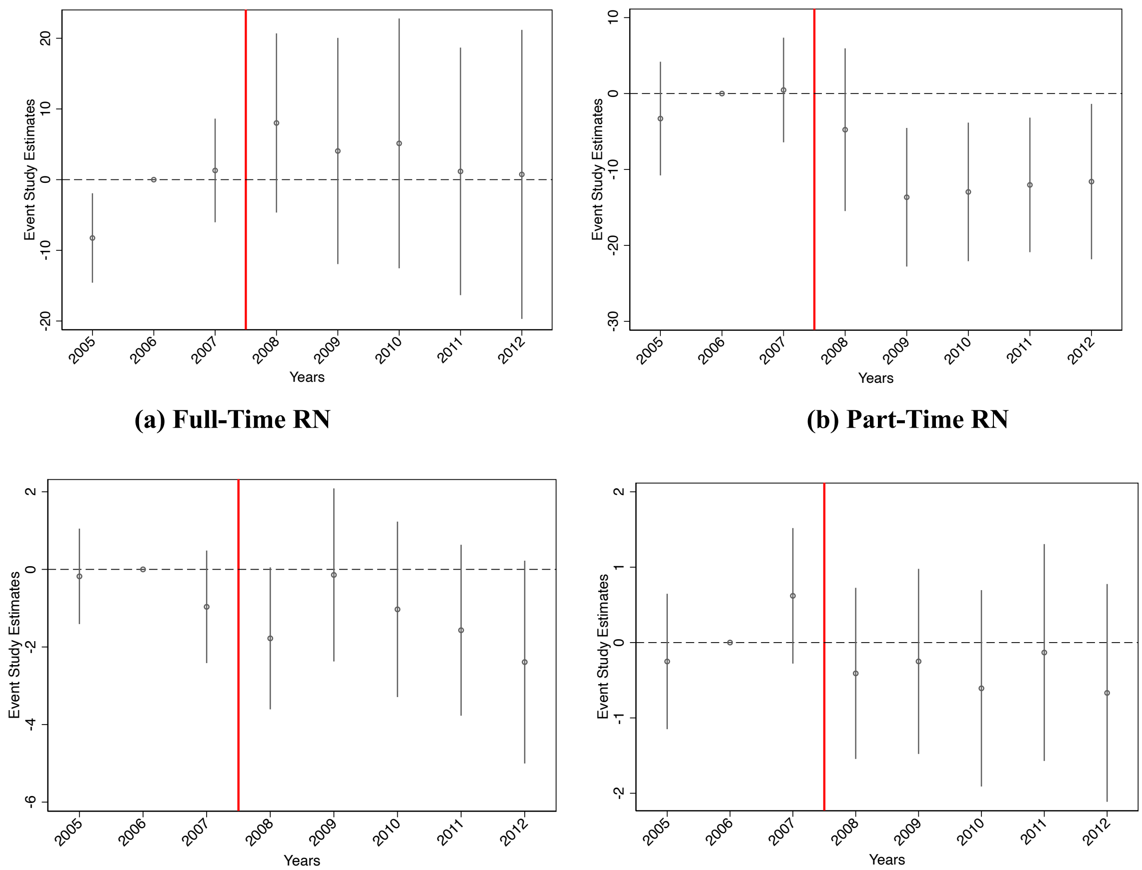
	Clinical Service Line	EHR	Laboratory	Pharmacy
	(1)	(2)	(3)	(4)
Severe Recession	–0.685***	–0.202**	–0.275***	–0.058***
x Post	(0.249)	(0.104)	(0.080)	(0.021)
Hospital FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Hospitals	1,330	1,330	1,330	1,330
Observations	10,637	10,637	10,637	10,637

Notes: Analytic data are from HIMSS and include a balanced panel of hospitals. Standard errors clustered at the FIPS level. *** P value at 0.01 ** P value at 0.05

TABLE 4—GREAT RECESSION EFFECTS ON ADMINISTRATIVE HEALTH INFORMATION TECHNOLOGY (IT) SOLUTIONS ADOPTION

	Back-Office	Financials	Info Systems	Staffing	Supply Chain	Utilization Review
	(1)	(2)	(3)	(4)	(5)	(6)
Severe Recession x Post	–0.108**	–0.800***	–0.565***	–0.432***	–0.106***	–0.167***
	(0.054)	(0.175)	(0.198)	(0.142)	(0.028)	(0.046)
Hospital FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Hospitals	1,330	1,330	1,330	1,330	1,330	1,330
Observations	10,637	10,637	10,637	10,637	10,637	10,637

Notes: Analytic data are from HIMSS and include a balanced panel of hospitals. Standard errors clustered at the FIPS level. *** P value at 0.01 ** P value at 0.05



(a) Full-Time RN

(b) Part-Time RN

(c) Full Time LPN

(d) Part-Time LPN

FIG. 3. EVENT STUDY ESTIMATES FOR GREAT RECESSION EFFECTS ON HOSPITAL STAFFING

Notes: Nurse employment levels from AHA data 2005-2012. There are 1,323 hospitals in the analytic sample for these outcomes. In 2007, treatment group hospitals employed 257 full-time RNs, 22 full-time LPNs, 119 part-time RNs, and 9 part-time LPNs, on average.

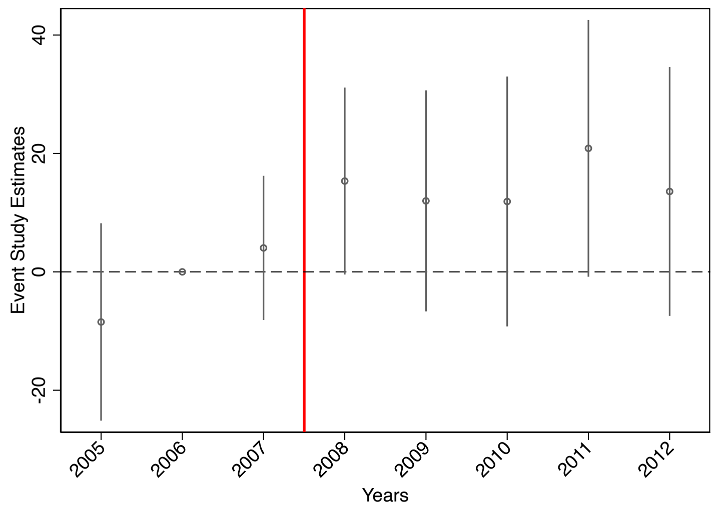


FIG. 4. EVENT STUDY ESTIMATES FOR GREAT RECESSION EFFECTS ON HOSPITAL INDUSTRY ADVERTISING

Notes: Treatment group advertisers spent $69.4 (‘000 nominal dollars) on average during the 2005-2007 period. Control group advertisers spent $65.2 (‘000 nominal dollars) on average during the same period. Analytic sample includes a balanced panel of 911 distinct advertising entities at the advertiser x DMA level.

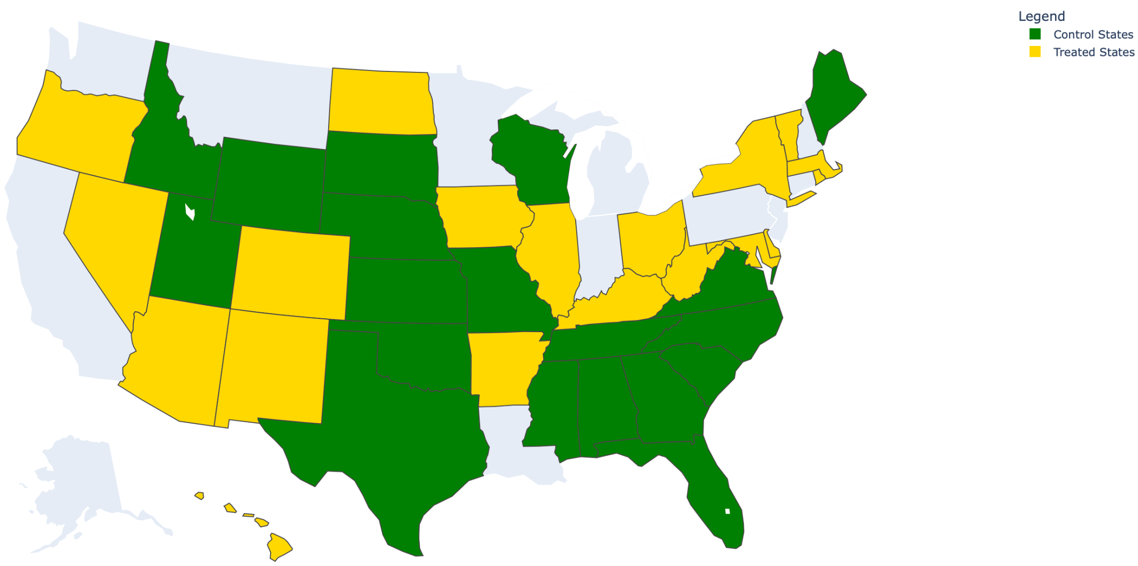


FIG 5. STATE LEVEL ANALYTIC SAMPLE INCLUSION STATUS BY MEDICAID EXPANSION STATUS THROUGH 2017

Notes: Treatment, control, and exclusion criteria follow Brevoort, Grodzicki, and Hackman (2020). There are 19 treatment states in total and 19 control states in total. Excluded states are a mixture of early and late expansion adopters.

TABLE 5—SUMMARY STATISTICS FOR HEALTH IT SOLUTIONS ADOPTION 2009-2012 STRATIFIED BY ACA MEDICAID EXPANSION STATUS

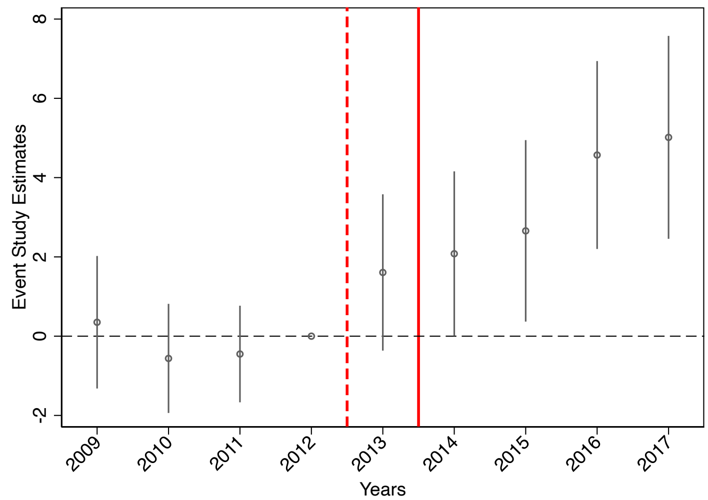
	2014 Medicaid Expansion States	**Non-Expansion States**
	Mean (SD)	Mean (SD)
Total Health IT Solutions	57.3 (18.1)	55.9 (21.1)
Total Health IT Vendors	13.7 (6.4)	13.6 (7.5)
Care Delivery Health IT Solutions		
Clinical Service Line	14.4 (6.3)	13.3 (7.0)
EHR	4.0 (2.1)	3.9 (2.1)
Laboratory	3.5 (1.6)	3.1 (1.7)
Pharmacy	0.9 (0.3)	0.9 (0.3)
Telemed	0.2 (0.4)	0.2 (0.4)
Administrative Health IT Solutions		
Back-Office	2.0 (1.1)	1.9 (1.2)
Financials	11.5 (3.6)	11.7 (4.0)
Info Systems	10.2 (4.0)	10.4 (4.7)
Staffing	7.9 (3.1)	7.7 (3.4)
Supply Chain	1.2 (0.6)	1.2 (0.6)
Utilization Review	1.8 (1.1)	1.8 (1.2)
Hospitals (N)	1,181	1,737

Notes: Analytic data are from HIMSS and span 2009-2012 for a balanced panel of hospitals used in the main difference-in-differences estimations.

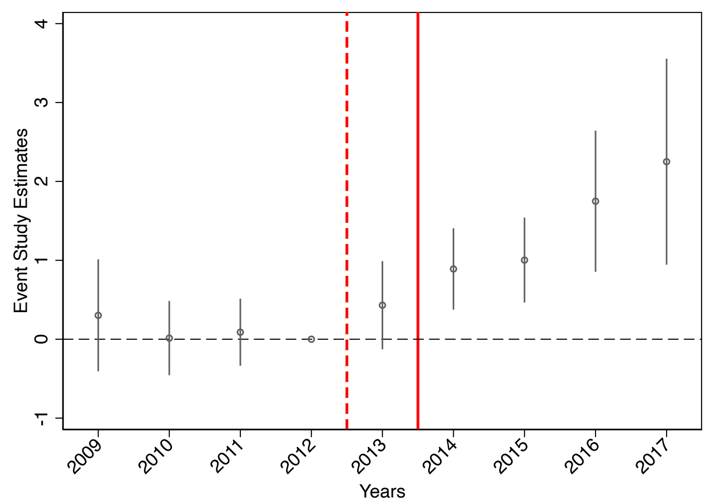
TABLE 6—MEDICAID EXPANSION EFFECTS ON HEALTH INFORMATION TECHNOLOGY (IT) ADOPTION AND CONTRACTING

	Total Health IT Solutions	Total Health IT Vendors
	(1)	(2)
Expansion State x Post	3.391***	1.306***
	(0.827)	(0.395)
Hospital FE	Yes	Yes
Year FE	Yes	Yes
Hospitals	2,918	2,918
Observations	26,262	26,260

Notes: Analytic data are from HIMSS and include a balanced panel of hospitals. Standard errors clustered at the state level. *** P value at 0.01 ** P value at 0.05



(a) Total Health IT Solutions



(b) Total Health IT Vendors

FIG. 6. EVENT STUDY ESTIMATES FOR MEDICAID EXPANSION EFFECTS ON IT ADOPTION AND CONTRACTING

Notes: Solid vertical bar indicates the start of the Medicaid expansions in 2014. The dashed vertical bar represents the period between the summer 2012 Supreme Court decision and 2014 expansion implementation.

TABLE 7—MEDICAID EXPANSION EFFECTS ON CARE DELIVERY HEALTH INFORMATION TECHNOLOGY (IT) SOLUTIONS ADOPTION

	Clinical Service Line	EHR	Laboratory	Pharmacy	Telemed
	(1)	(2)	(3)	(4)	(5)
Expansion State x	0.611***	0.037	0.172**	0.037	0.058
Post	(0.183)	(0.157)	(0.080)	(0.025)	(0.035)
Hospital FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Hospitals	2,918	2,918	2,918	2,918	2,918
Observations	26,262	26,262	26,262	26,262	26,262

Notes: Analytic data are from HIMSS and include a balanced panel of hospitals. Standard errors clustered at the state level. *** P value at 0.01 ** P value at 0.05

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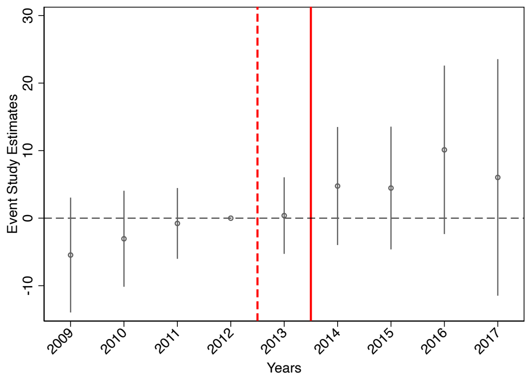
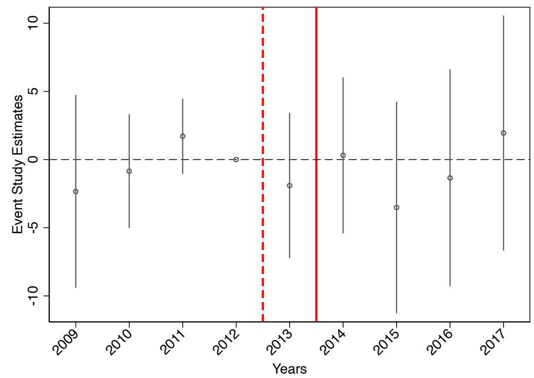
TABLE 8—MEDICAID EXPANSION EFFECTS ON ADMINISTRATIVE HEALTH INFORMATION TECHNOLOGY (IT) SOLUTIONS ADOPTION

	Back-Office	Financials	Info Systems	Staffing	Supply Chain	Utilization Review
	(1)	(2)	(3)	(4)	(5)	(6)
Expansion	0.320***	0.611***	1.260***	0.049	0.071	0.166***
State x Post	(0.124)	(0.227)	(0.367)	(0.131)	(0.047)	(0.062)
Hospital FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Hospitals	2,918	2,918	2,918	2,918	2,918	2,918
Observations	26,262	26,262	26,262	26,262	26,262	26,262

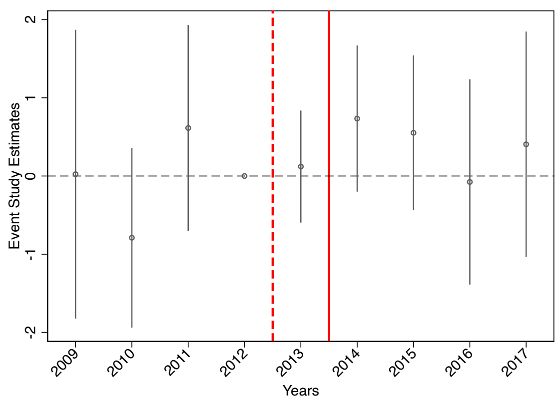
Notes: Analytic data are from HIMSS and include a balanced panel of hospitals. Standard errors clustered at the state level. *** P value at 0.01 ** P value at 0.05



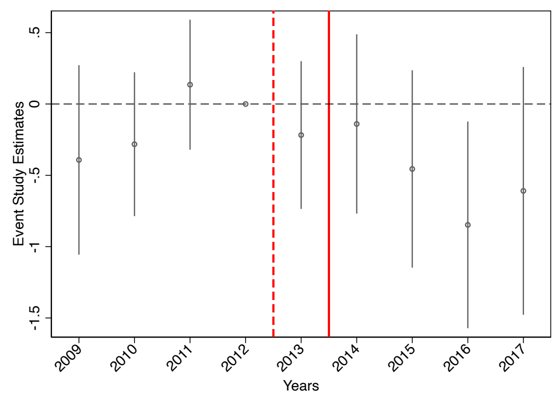
(a) Full-Time RN



(b) Part-Time RN



(c) Full Time LPN



(d) Part-Time LPN

FIG. 7. EVENT STUDY ESTIMATES FOR MEDICAID EXPANSION EFFECTS ON HOSPITAL STAFFING

Notes: Nurse employment levels from AHA data 2009-2017. There are 2,887 hospitals in the analytic samples for these outcomes. In 2012, treatment group hospitals employed 274 full-time RNs, 14 full-time LPNs, 124 part-time RNs, and 6 part-time LPNs, on average.

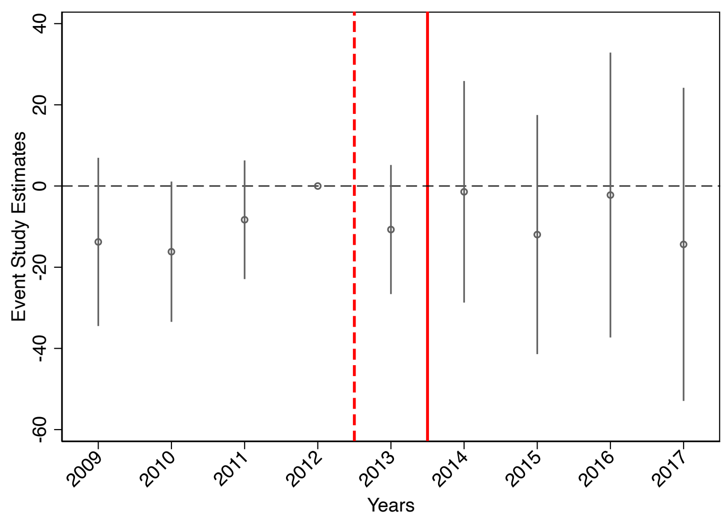


FIG. 8. EVENT STUDY ESTIMATES FOR MEDICAID EXPANSION EFFECTS ON HOSPITAL INDUSTRY ADVERTISING

Notes: Treatment group advertisers spent $97.9 (‘000 nominal dollars) on average during the 2009-2012 period. Control group advertisers spent $111.8 (‘000 nominal dollars) on average during the same period. Analytic sample includes a balanced panel of 1,501 distinct advertising entities.

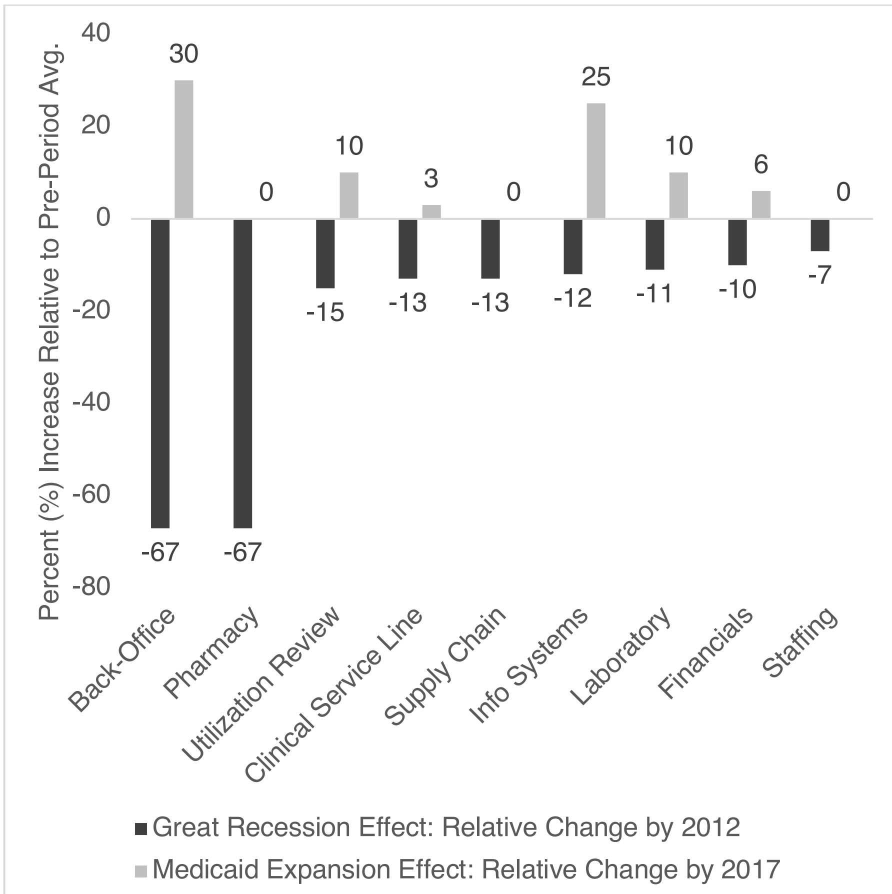
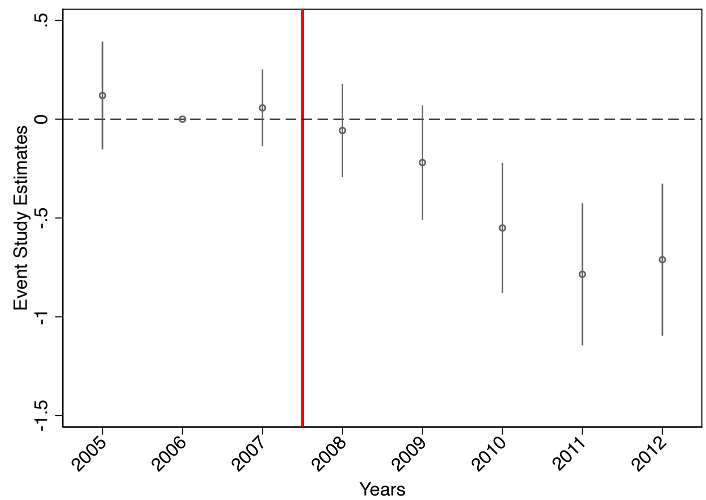


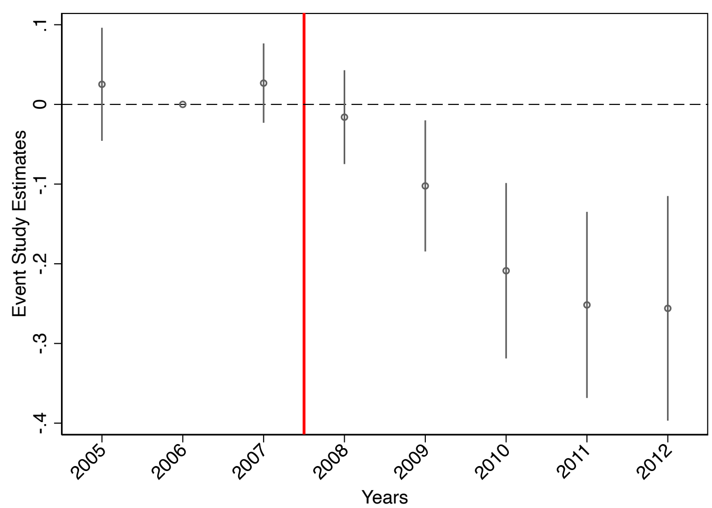
FIG. 9. RELATIVE EFFECT SIZES FOR EACH SHOCK COMPARED TO TREATED GROUP PRE-PERIOD MEAN

Notes: Estimates used from event students pertaining to each specific health IT solution found in Appendix Figures A2-A5.

Appendix



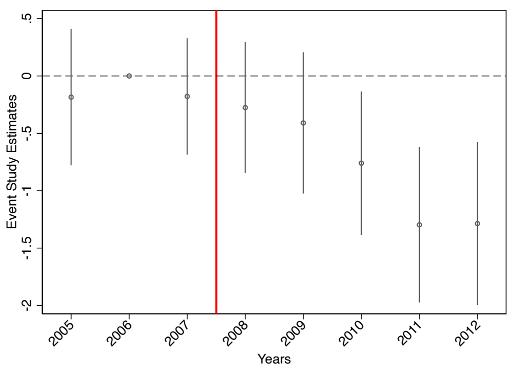
(a) Total Health IT Solutions



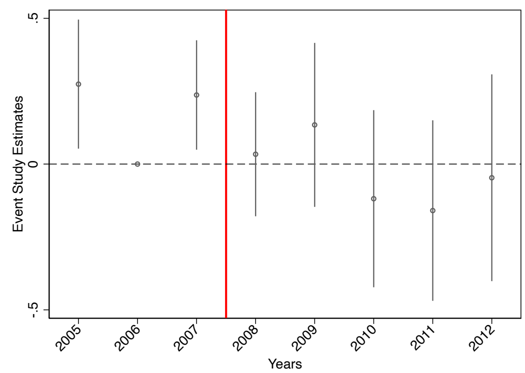
(b) Total Health IT Vendors

APPENDIX FIG. A1. EVENT STUDY ESTIMATES FOR GREAT RECESSION EFFECTS USING CONTINUOUS TREATMENT MEASURE ON IT ADOPTION

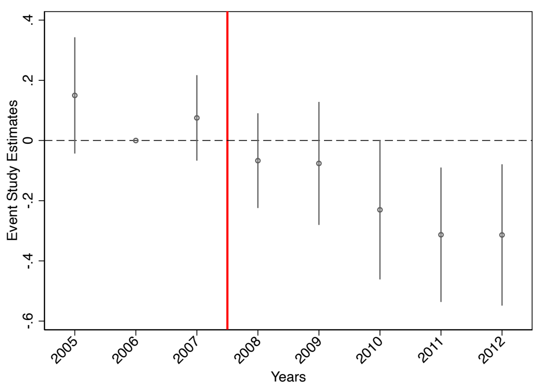
Notes: Solid vertical bar indicates the start of the Great Recession following the Lehman Brothers investment bank collapse in 2008. Analytic sample does not subset to top and bottom quartiles of Great Recession impact; instead, all relevant counties and their percentage-point change in unemployment is used for the DD event study estimation.



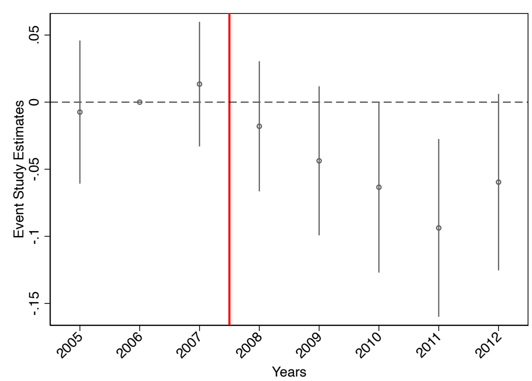
(a) Clinical Service Line



(b) EHR



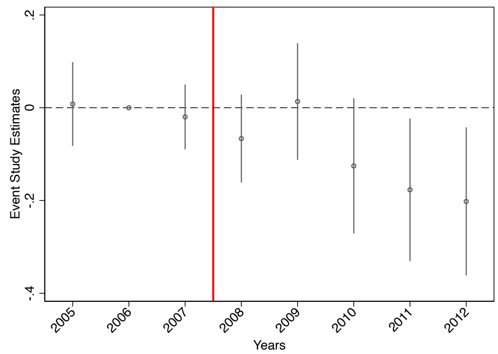
(c) Laboratory



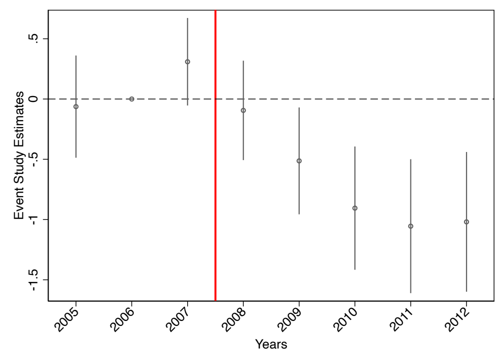
(d) Pharmacy

APPENDIX FIG. A2. EVENT STUDY ESTIMATES FOR GREAT RECESSION EFFECTS ON IT SOLUTIONS ADOPTION

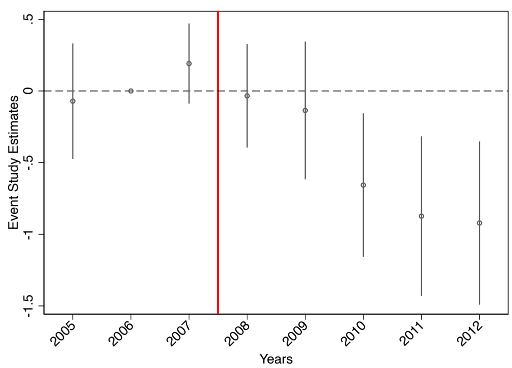
Notes: Analytic data from HIMSS.



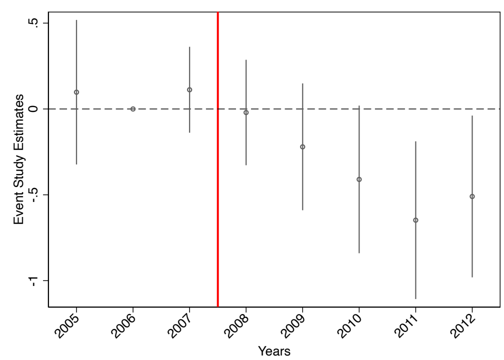
(a) Back-Office



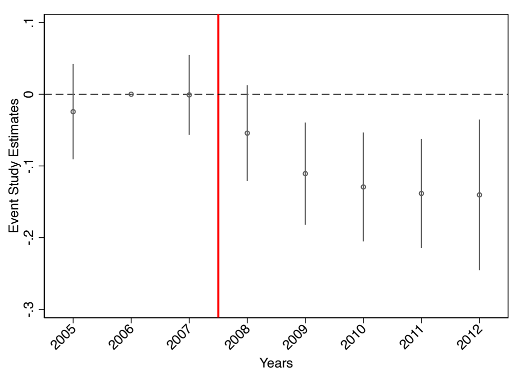
(b) Financials



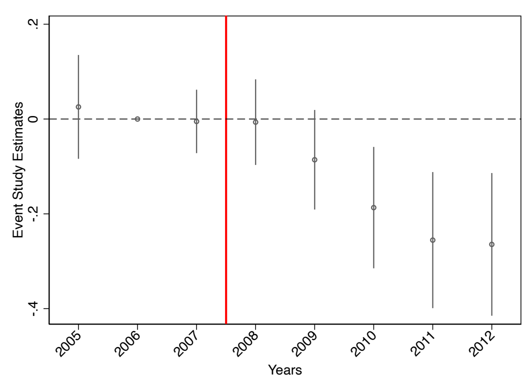
(c) Info Systems



(d) Staffing



(e) Supply Chain



(f) Utilization Review

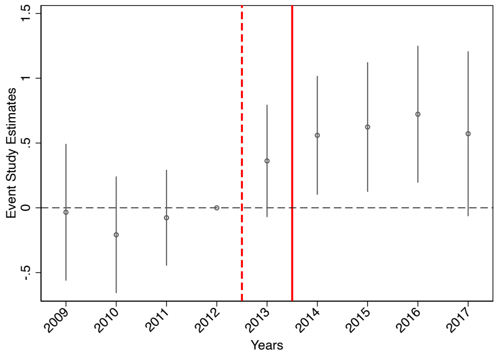
APPENDIX FIG. A3. EVENT STUDY ESTIMATES FOR GREAT RECESSION EFFECTS ON IT SOLUTIONS ADOPTION

Notes: Analytic data from HIMSS.

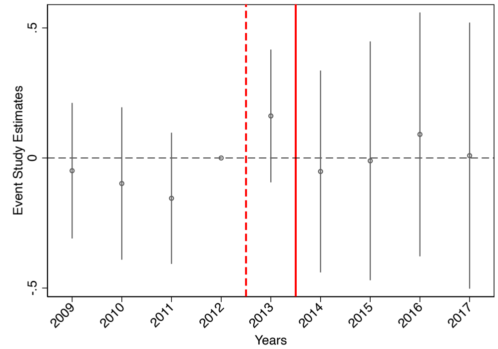
APPENDIX TABLE A1—HETEROGENEOUS GREAT RECESSION EFFECTS ON HEALTH INFORMATION TECHNOLOGY (IT) ADOPTION AND CONTRACTING BY NON-GOVERNMENT HOSPITALS ACCORDING TO HOSPITAL CHARACTERISTICS

	Total Health IT Solutions	Total Health IT Solutions	Total Health IT Vendors	Total Health IT Vendors
	(1)	(2)	(3)	(4)
Expansion State x Post	–4.713***	–4.069***	–1.598***	–1.399***
	(0.988)	(0.976)	(0.341)	(0.333)
Expansion State x Post x Standalone	1.518		1.235**	
	(1.729)		(0.570)	
Expansion State x Post x Financially Weak		–0.861		0.390
		(1.981)		(0.622)
Hospital FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Hospitals	1,078	1,038	1,078	1,038
Observations	8,624	8,304	8,621	8,301

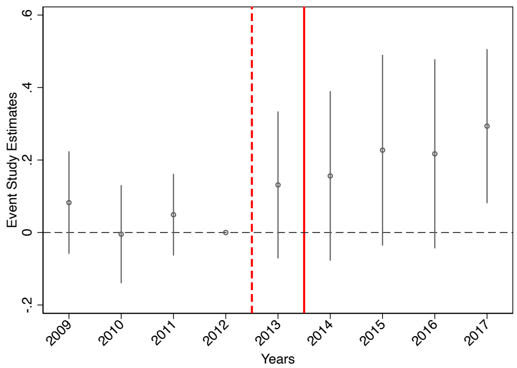
Notes: Analytic data are from HIMSS. Government hospitals are excluded from the sample. “Standalone” is binary variable equal to one for hospitals not system-affiliated as of 2007 and zero otherwise. “Financially Weak” is a binary variable equal to one for hospitals averaging a negative operating margin during the 2005-2007 period and zero otherwise. Standard errors clustered at the FIPS level. *** P value at 0.01 ** P value at 0.05.



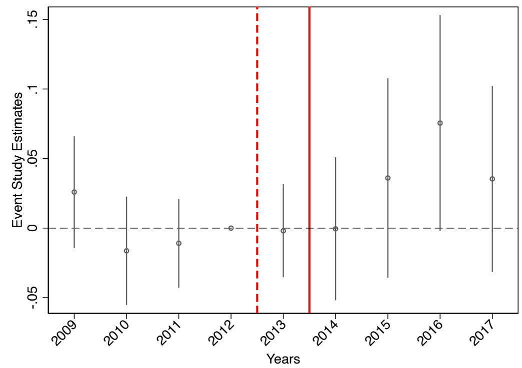
(a) Clinical Service Line



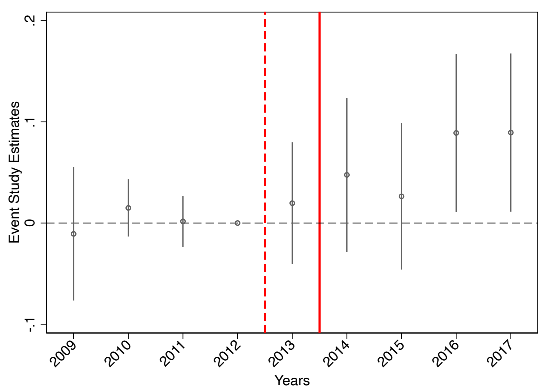
(b) EHR



(c) Laboratory



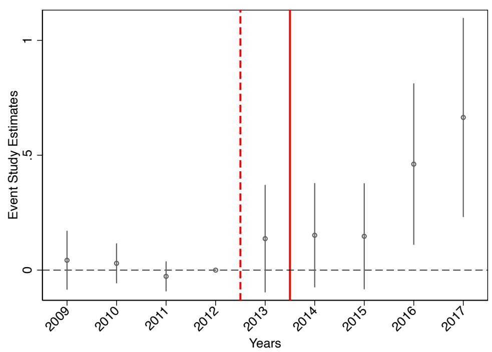
(d) Pharmacy



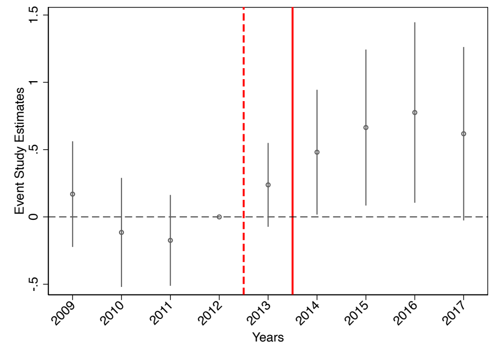
(e) Telemed

APPENDIX FIG. A4. EVENT STUDY ESTIMATES FOR MEDICAID EXPANSION EFFECTS ON IT SOLUTIONS ADOPTION

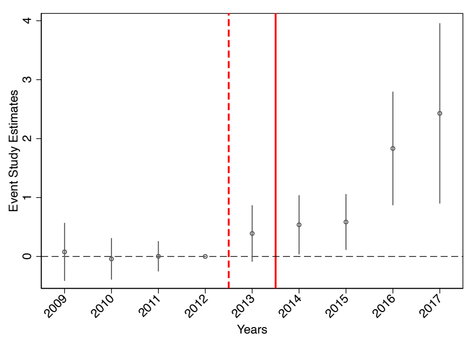
Notes: Analytic data from HIMSS.



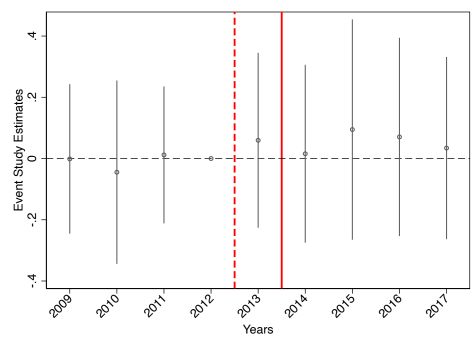
(a) Back-Office



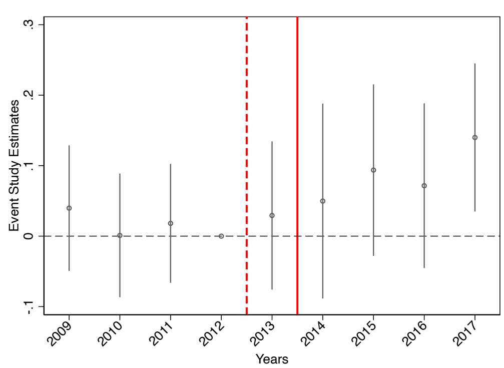
(b) Financials



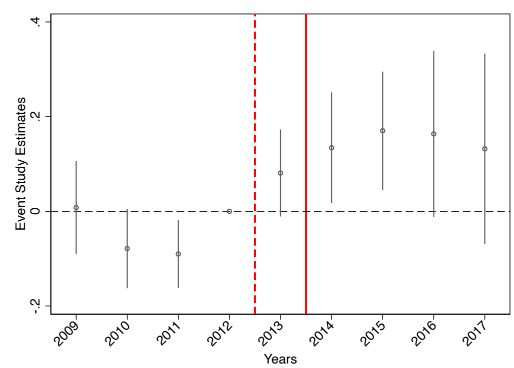
(c) Info Systems



(d) Staffing



(e) Supply Chain



(f) Utilization Review

APPENDIX FIG. A5. EVENT STUDY ESTIMATES FOR MEDICAID EXPANSION EFFECTS ON IT SOLUTIONS ADOPTION

Notes: Analytic data from HIMSS.

APPENDIX TABLE A2—HETEROGENEOUS MEDICAID EXPANSION EFFECTS ON HEALTH INFORMATION TECHNOLOGY (IT) ADOPTION AND CONTRACTING BY HOSPITALS IN AREAS IMPACTED MOST BY THE GREAT RECESSION

	Total Health IT Solutions	Total Health IT Vendors
	(1)	(2)
Expansion State x Post	3.388***	1.573***
	(0.863)	(0.425)
Expansion State x Post x Severe Recession	–0.623	–1.258**
	(1.237)	(0.524)
Hospital FE	Yes	Yes
Year FE	Yes	Yes
Hospitals	2,869	2,869
Observations	25,821	25,819

Notes: Analytic data are from HIMSS. "Severe Recession" is binary variable equal to one for hospitals located in counties within the top quartile of recession bite (as defined in Section II) and zero otherwise. Standard errors clustered at the state level. *** P value at 0.01 ** P value at 0.05.

APPENDIX TABLE A3—HETEROGENEOUS MEDICAID EXPANSION EFFECTS ON HEALTH INFORMATION TECHNOLOGY (IT) ADOPTION AND CONTRACTING BY NON-GOVERNMENT HOSPITALS ACCORDING TO HOSPITAL CHARACTERISTICS

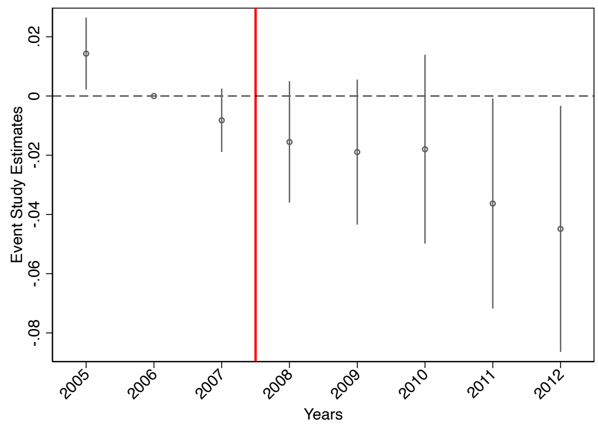
	Total Health IT Solutions	Total Health IT Solutions	Total Health IT Vendors	Total Health IT Vendors
	(1)	(2)	(3)	(4)
Expansion State x Post	4.943***	4.924***	1.357***	1.539***
	(1.380)	(1.103)	(0.454)	(0.429)
Expansion State x Post x Standalone	–3.871		–0.099	
	(2.095)		(0.579)	
Expansion State x Post x Financially Weak		–2.773**		–0.375
		(1.292)		(0.510)
Hospital FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Hospitals	2,218	2,098	2,218	2,098
Observations	19,962	18,882	19,962	18,882

Notes: Analytic data are from HIMSS. Government hospitals are excluded from the sample. “Standalone” is binary variable equal to one for hospitals not system-affiliated as of 2012 and zero otherwise. “Financially Weak” is a binary variable equal to one for hospitals averaging a negative operating margin during the 2009-2012 period and zero otherwise. 40% and 37% of the treatment and control group hospitals are standalone facilities, respectively. 36% and 39% of the treatment and control group hospitals are in the financially weak category, respectively. The correlation coefficient (ρ) between the “Standalone” and “Financially Weak” indicators is 0.13 and 0.08 for the treatment group and control group hospitals, respectively. Standard errors clustered at the state level. *** P value at 0.01 ** P value at 0.05.

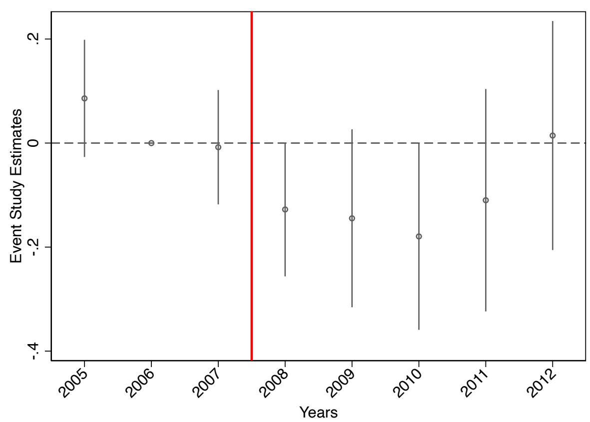
APPENDIX TABLE A4—HETEROGENEOUS MEDICAID EXPANSION EFFECTS ON HEALTH INFORMATION TECHNOLOGY (IT) ADOPTION AND CONTRACTING BY NON-GOVERNMENT HOSPITALS THAT ARE NOT FINANCIALLY WEAK AT BASELINE AND ACCORDING TO GEOGRAPHIC MARKET

	Total Health IT Solutions	Total Health IT Solutions	Total Health IT Vendors	Total Health IT Vendors
	(1)	(2)	(3)	(4)
Expansion State x Post	6.411***	6.508***	1.108	1.353**
	(1.894)	(1.863)	(0.560)	(0.544)
Expansion State x Post x High Potential Market	–2.043		0.803	
	(2.403)		(0.639)	
Expansion State x Post x High Medicaid Denial State		–1.253		0.552
		(2.480)		(1.031)
Hospital FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Hospitals	1,071	1,071	1,071	2,243
Observations	9,639	9,639	9,639	20,185

Notes: Analytic data are from HIMSS. Government hospitals as well as "Financially Weak" hospitals are excluded from the sample. "High Potential Market" is binary variable equal to one for hospitals located in counties in the top quartile of uninsured 18–64-year-olds under 138% FPL in 2013 and zero otherwise. "High Denial State" is a binary variable equal to one for hospitals located in states in the top quartile of Medicaid denial rates for submitted provider reimbursements and zero otherwise. Standard errors clustered at the state level. *** P value at 0.01 ** P value at 0.05.



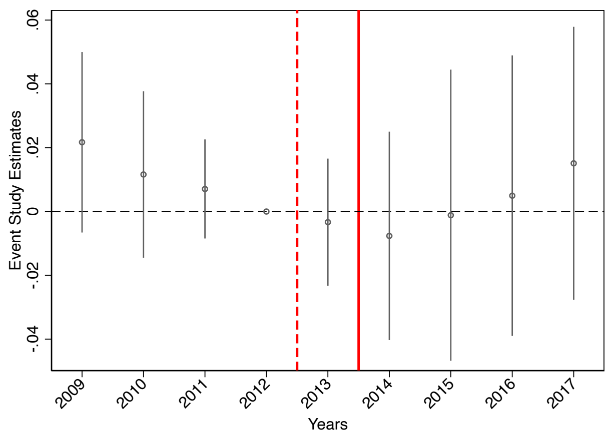
(a) Operating Revenue (in logs)



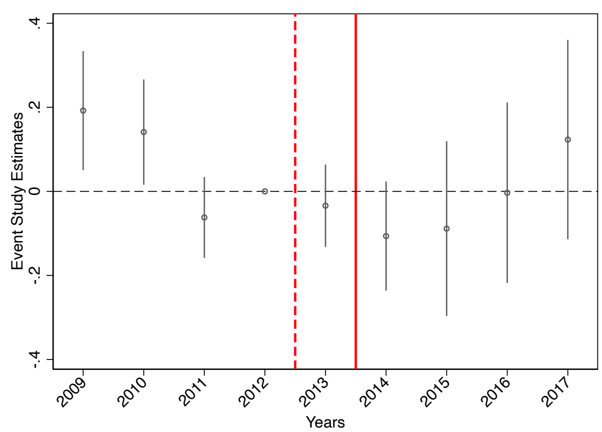
(b) Other Income (in logs)

APPENDIX FIG. A6. GREAT RECESSION EFFECTS ON HOSPITAL FINANCIAL METRICS

Notes: Outcomes are from HCRIS.



(a) Operating Revenue (in logs)



(b) Other Income (in logs)

APPENDIX FIG. A7. MEDICAID EXPANSION EFFECTS ON HOSPITAL FINANCIAL METRICS

Notes: Outcomes are from HCRIS.