Health IT Diffusion and Physician Labor Supply

Jason Huh[1] Jianjing Lin[2] and **Lucy Xiaolu Wang**[2,3,4]

[1] Rensselaer Polytechnic Institute
[2] University of Massachusetts Amherst
[3] Max Planck Institute for Innovation and Competition
[4] Canadian Centre for Health Economics

Applied Economics in Digital Health Workshop, ZEW 2025.6.6

Rising US HIT investments enables automation

- The US allocated over $30 billion to health IT adoption via HITECH Act
  - Health Information Technology for Economic and Clinical Health (HITECH) Act and Affordable Care Act (ACA)
- Extensive research on HIT impact on quality and cost
- But: limited understanding of HIT impact on physician labor supply
  - Focus: **C**omputerized **P**rovider **O**rder **E**ntry (CPOE), an advanced HIT and the key component of HITECH Meaningful Use (MU) criteria
    - E-enter treatment orders, integrate patient info and clinical guidelines, and communicate with pharmacy, laboratory, and other departments
  - In contrast, basic HIT systems, e.g., clinical decision systems, store patient data in digital database and provide clinical treatment support
- Research question: How does advanced HIT adoption affect aggregate hospital-based (HB) physician supply at the county level?
  - Extensive margin: physician count per 100k population (main analysis)
  - Intensive margin: patient care volume (supplementary analysis)

Research Question:

Q: How does advanced HIT adoption affect aggregate hospital-based physician supply at the county level?

- Intuitively, aggregate physician rate can go either way (empirical Qs):
  - More: “Time to hire more physicians to take full advantage of HIT!”
  - Less: “Time to automate and reduce docs (recover costs from HIT)!”
  - Same: “Docs come and go, on the net things may stay similar?”
- Exploit the county-level sharp adoption of advanced HIT (CPOE)
- Show how the plausibly exogenous HIT diffusion patterns affect county-level HB physician per 100k pop, the heterogeneity by specialties, physician career stage, physician shortage area status
- Test financial mechanism and downstream impact on care utilization

Preview of Methods and Results

- Methods:
  - Event-study approach à la East et al. (2023), leveraging the sharp increase in adoption rates to separate the sample into treatment and control groups
    - Here: use sharp increase in county-level advanced HIT adoption rate
  - Compare HB physicians per 100k in counties with rapid diffusion vs controls
  - Use De Chaisemartin & d'Haultfoeuille (2024) as our main DiD estimator

- Main results:
  - 10.3% increase in county-level HB physicians per 100k post HIT adoption
    - Effects primarily driven by medical and surgical specialties
  - Stronger effects among early-career docs and in areas with doc shortages
  - Physicians (hospitals) in treated counties received higher payments (profits)
  - Increased outpatient surgeries in counties w/ moderate pre-period volumes

Literature and Contribution

- **The impact of Health IT**: new evidence on how HIT automation affect aggregate physician labor supply (high-skilled labor), and how the effects vary by specialty, career stage, shortage area status, and care utilization.

  (Miller & Tucker, 2011; Agha, 2014; Dranove et al., 2014; McCullough et al., 2016; Freedman et al., 2018; Lu et al., 2018; Wang, 2021; Wang & Bloch, 2023; Lin & Olson, 2024; Glenn, 2024)

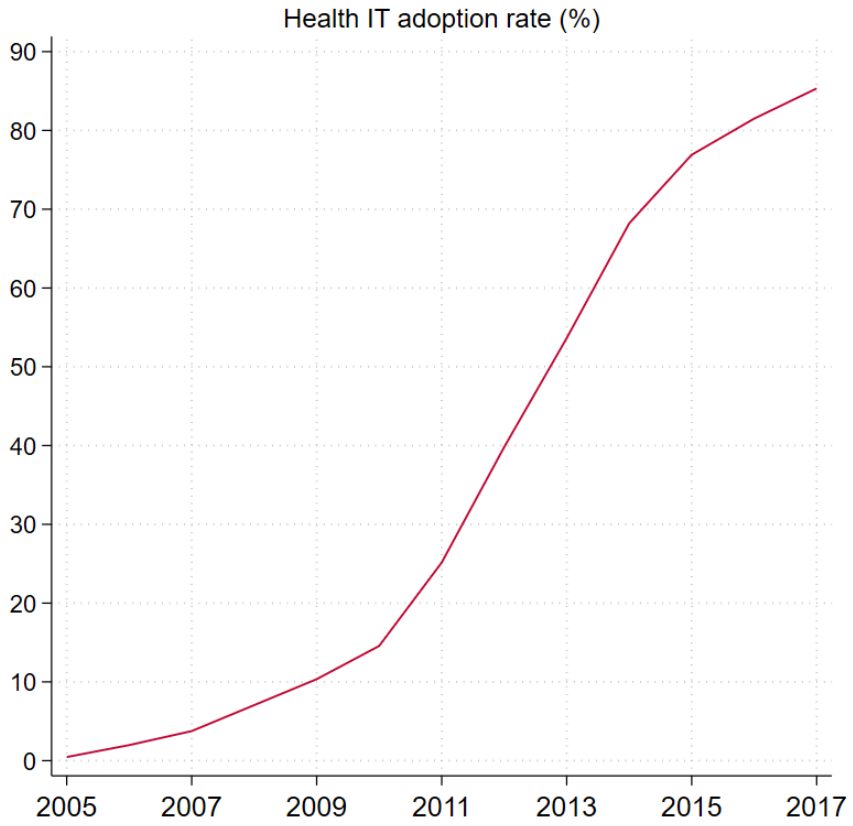
- **Physician labor supply**: new technological angle that combines market-driven incentives and policy-led changes in the past decades, and study how digital technologies affect physicians, hospitals, and care provisions.

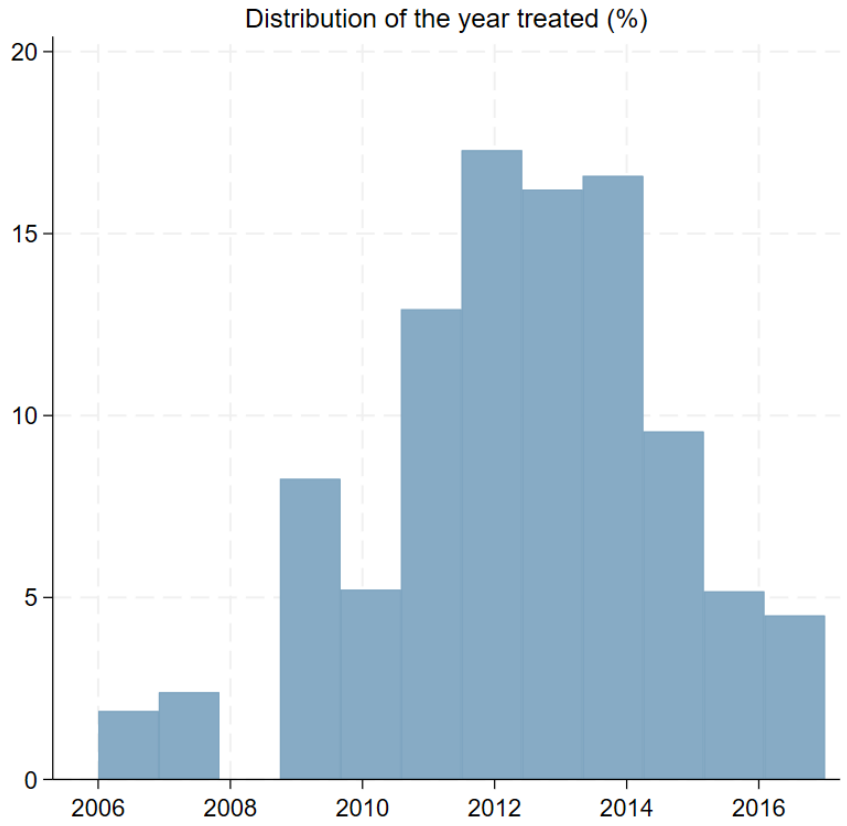
  (Baker & Royalty, 2000; Garthwaite, 2012; Buchmueller et al., 2016; Falcettoni, 2018; Kulka & McWeeny, 2018; Neprash et al., 2018; Huh, 2021; Curto & Bhole, 2022; Huh & Lin 2024; Khoury et al., 2024)

- **Policy implications** and relevant insights for managerial practices. HIT investment can improve workforce efficiency and expand access to care (reduce disparity in access) while sustaining providers' financial health.

Institutional context and HIT adoption trends

- Electronic health records (EHRs), the core component of HIT, were invented in 1970s but saw limited adoption until the 2000s. We focus on hospital HIT.
- 2010s: widespread hospital HIT adoption, driven by federal incentives
  - 2009 HITECH Act (~ $30 billion allocation) on HIT adoption, meaningful use (MU); ACA indirect incentives (initiatives/provisions) require/facilitate HIT use.





HIT adoption measures: CPOE & its functionality

- Computerized Provider Order Entry (CPOE): advanced HIT
  - Enable providers to electronically enter medication, laboratory, and radiology orders, often with built-in clinical decision support tools, core in MU criteria
  - Unlike other HIT component, CPOE directly structures patient data in ways that align with coding and billing requirements, esp. relevant when study health tech adoption where payment mechanisms are important
  - Relatively recent, CPOE is viewed as an automation health care technology

An example of a CPOE interface

- CPOE functionality: enhance efficiency and care quality in several ways
  - stores patient information in a centralized system to ease critical data access
  - provides pre-programmed, institutionally-approved templates to streamline ordering process and adherence to clinical protocols (e.g., legible, complete, …)
  - e-communication (previously manual) accelerates turnaround times: reduce delays between service ordering, results delivery, and payment processing
  - reduces clinician's documentation burdens by min the need for data re-entry
  - uses clinical support systems to auto-detect drug-drug interactions in orders

Conceptual Considerations

- Physician labor supply on the extensive margin is shaped by aggregating individual location choices and broader market dynamics.
- Hospitals' perspectives:
  - HIT investment can affect strategic hiring of docs to fully leverage technology
  - Esp in geo-areas with *moderate* but *growing* demand for medical services
  - If increase patient throughput, boost revenue -> can hire/retain more docs
- Physicians' perspectives
  - Response to HIT diffusion may vary by specialty, career stage, tech-savviness
  - HIT can be a pull factor for early-career physicians adapted to digital tech
- Patients' perspectives
  - HIT can make access to services more convenient with faster scheduling
  - can seek elective procedures earlier and easier (limited sorting within country)

Data Construction

- **Physician supply data**: Area Health Resources Files (AHRF)
  - Hospital-based (HB) physicians: non-federal MDs under hospital contracts providing direct patient care, measured as rate per 100k county population
  - **Specialty categorization**: medical, surgical, general practitioners, others
- **Health IT adoption data**: Healthcare Information and Management Systems Society (HIMSS) Analytics Database
  - Records basic and advanced HIT adoption by hospitals, including CPOE
  - County-level adoption rate weighted by capacity (hospital beds)
- **Medicare provider and service data**: CMS Medicare physician & other practitioners by provider and service dataset (available starting 2013)
- **Market structure and profit data**: Healthcare Provider Cost Reporting Information System (HCRIS), CMS; calculate hospital HHI and profit
- **Sample**: ~2,380 US counties during 2006-2018 outcome years matched with one-year lagged HIT adoption (excl. 2009 b/c missing AHRF data)

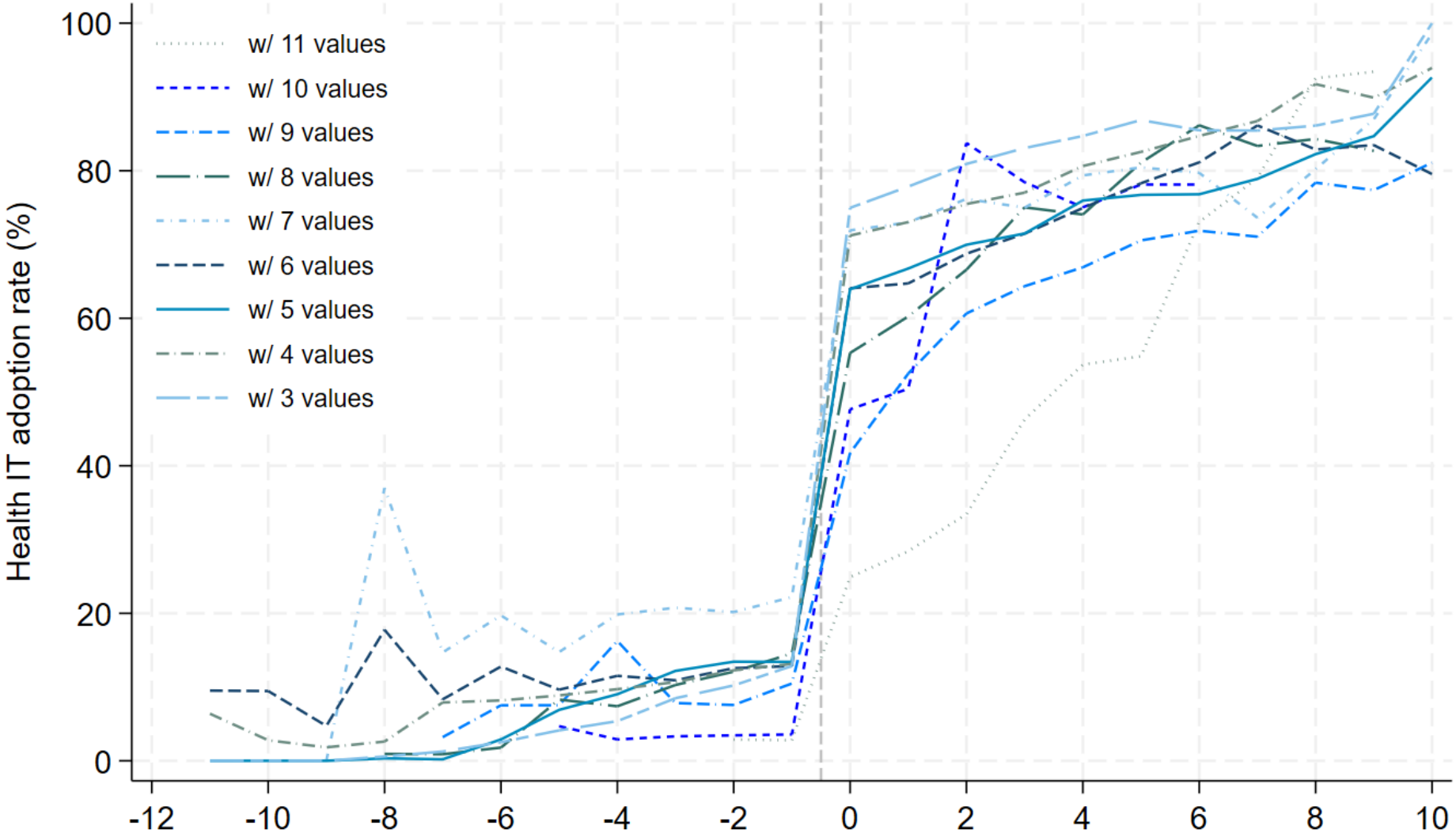
data.HRSA.gov

HIMSS℠

CMS
CENTERS FOR MEDICARE & MEDICAID SERVICES

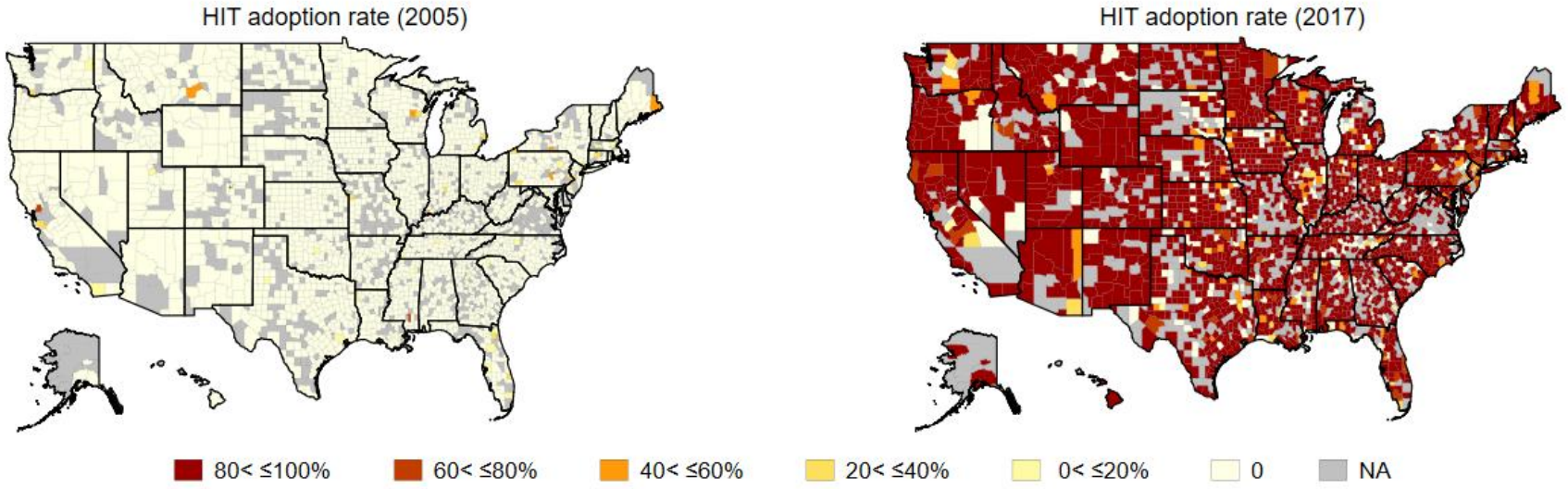
HIT treatment measure: sharp jumps in HIT rates

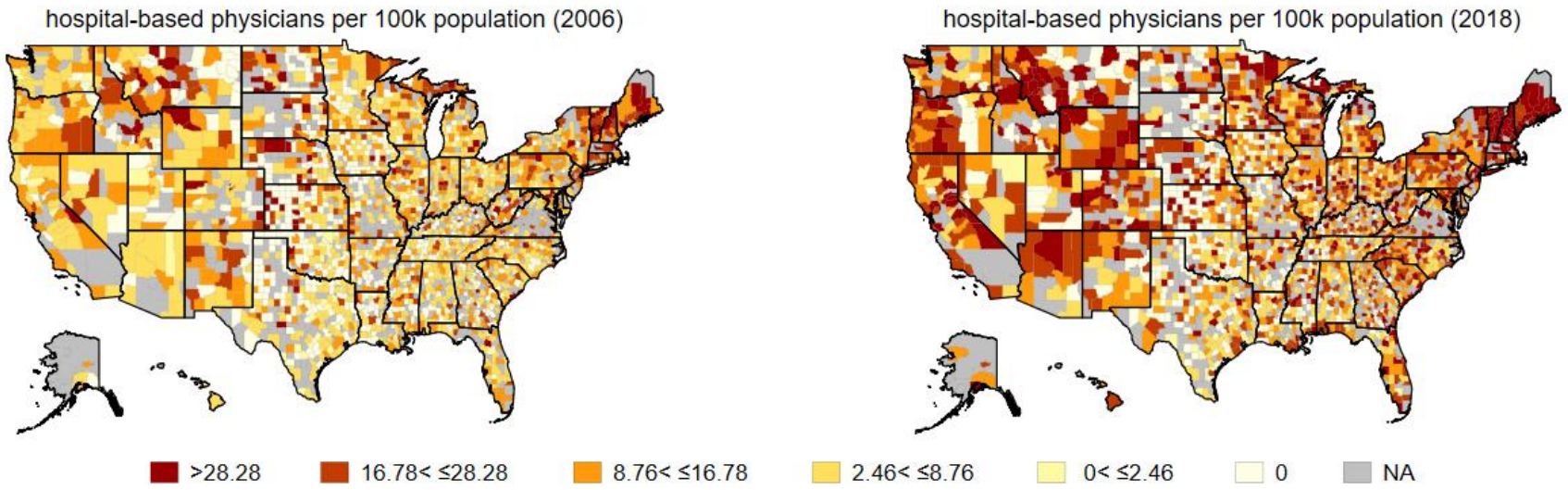
- Define treatment/control group à la the strategy in East et al. (AER 2023)
- Sharp jump in year τ if adoption rate: i) 0→ +, or ii) increase 100+% at τ



Geographic variation in HIT and physician supply

- Outcome periods 2006-2018 with one-year lagged HIT 2005-2017





Summary statistics in pre-treatment period

	Overall	Never-treated	Ever-treated
HB physician counts per 100k population	10.27 (11.6)	10.30 (12.8)	10.27 (11.5)
Health IT adoption rate (%)	1.46 (5.39)	0 (0)	1.64 (5.69)
% 65+ population	15.7 (4.07)	17.2 (4.35)	15.5 (4.00)
% black	9.10 (14.4)	9.44 (15.6)	9.05 (14.2)
Population density	239 (1,722)	107 (520)	256 (1,815)
Income per capita	32,356 (8,325)	34,872 (10,304)	32,046 (7,996)
Unemployment rate (%)	6.65 (2.29)	6.65 (2.35)	6.65 (2.28)
Hospital HHI	0.80 (0.27)	0.92 (0.15)	0.78 (0.27)
Medicare Advantage penetration rate (%)	4.06 (7.73)	2.87 (5.58)	4.21 (7.95)
% above college degree	12.6 (5.7)	11.4 (5.1)	12.8 (5.7)
# counties	2,394	265	2,129

Empirical strategy: dynamic DiD & event studies

- Staggered DiD design exploits the variation in the timing of the sharp increase in county HIT adoption (De Chaisemartin & d'Haultfoeuille, 2024)

$$Y_{it} = \beta_0 + \boldsymbol{\beta_1}\, Treat_{i(t-1)} + \gamma\, X_{it} + \lambda_{st} + \delta_i + \delta_t + \varepsilon_{it}$$

  - Y_{it} : physician supply in t matched with one-year lagged HIT treatment (t-1)
  - X_{it}: county-year observables controls: per-capita income, unemployment rate, %pop(65+), %Black, pop density, HHI (hospital), 2005-valued {Medicare advantage penetration rate, % college+ educated} × linear time trends
  - λ_{st}: state-specific time trends, where s denotes the state of county i
  - δ_i & δ_t: county and year fixed effects; ε_{it} clustered at the state level
  - Regressions are weighted by county-year level population

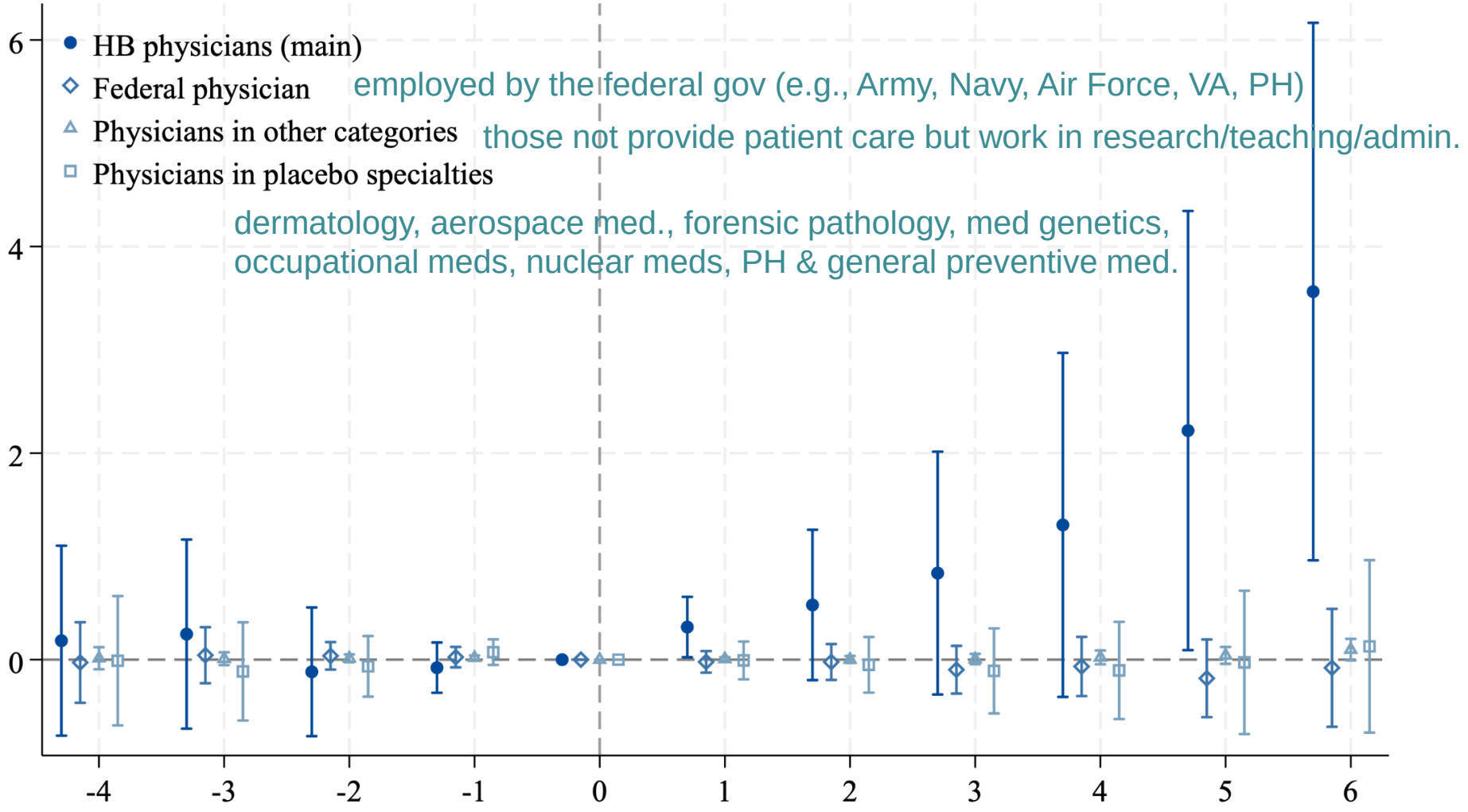
- Event study specification:

$$Y_{it} = \beta_0 + \sum_{\tau=-4,\, \tau\neq 0}^{6} \boldsymbol{\beta_1^{\tau}} \times 1\{\, t = \tau \,\} EverTreated_i + \gamma X_{it} + \lambda_{st} + \delta_i + \delta_t + \varepsilon_{it}$$

  - Reference period t=0, treatment occurred in year 1 (as in dCDH 2024 setup)

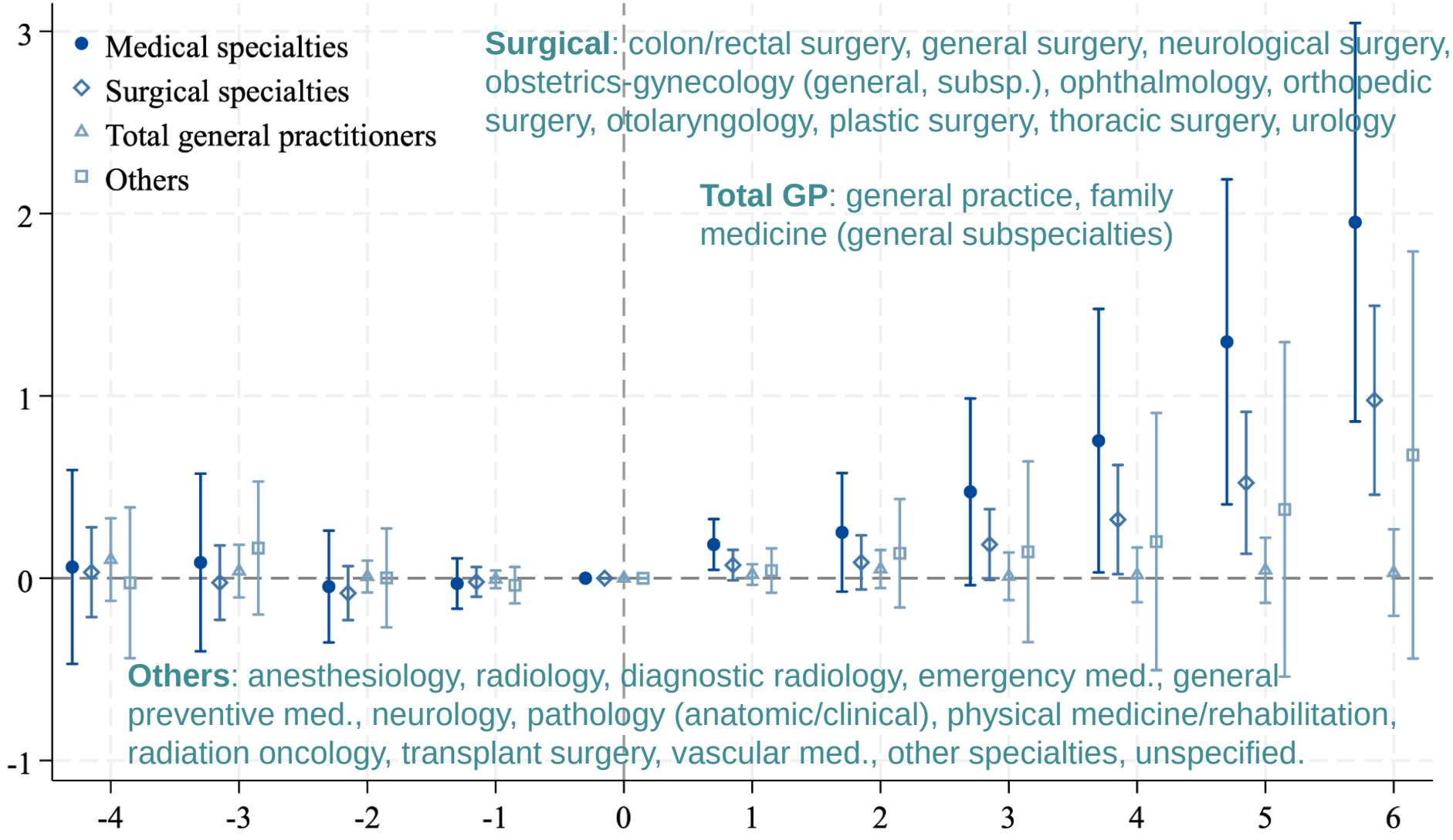
HIT diffusion & HB physician: main results

- Main outcome: HB physicians per 100k pop. *vs.* three falsification groups



Heterogeneity cross-specialty within HB physicians

Medical: allergy and immunology, cardiovascular disease, gastroenterology, internal medicine (general, subspecialties), pediatrics (general, subspecialties, cardiology), pulmonary disease.



Surgical: colon/rectal surgery, general surgery, neurological surgery, obstetrics-gynecology (general, subsp.), ophthalmology, orthopedic surgery, otolaryngology, plastic surgery, thoracic surgery, urology

Total GP: general practice, family medicine (general subspecialties)

Others: anesthesiology, radiology, diagnostic radiology, emergency med., general preventive med., neurology, pathology (anatomic/clinical), physical medicine/rehabilitation, radiation oncology, transplant surgery, vascular med., other specialties, unspecified.

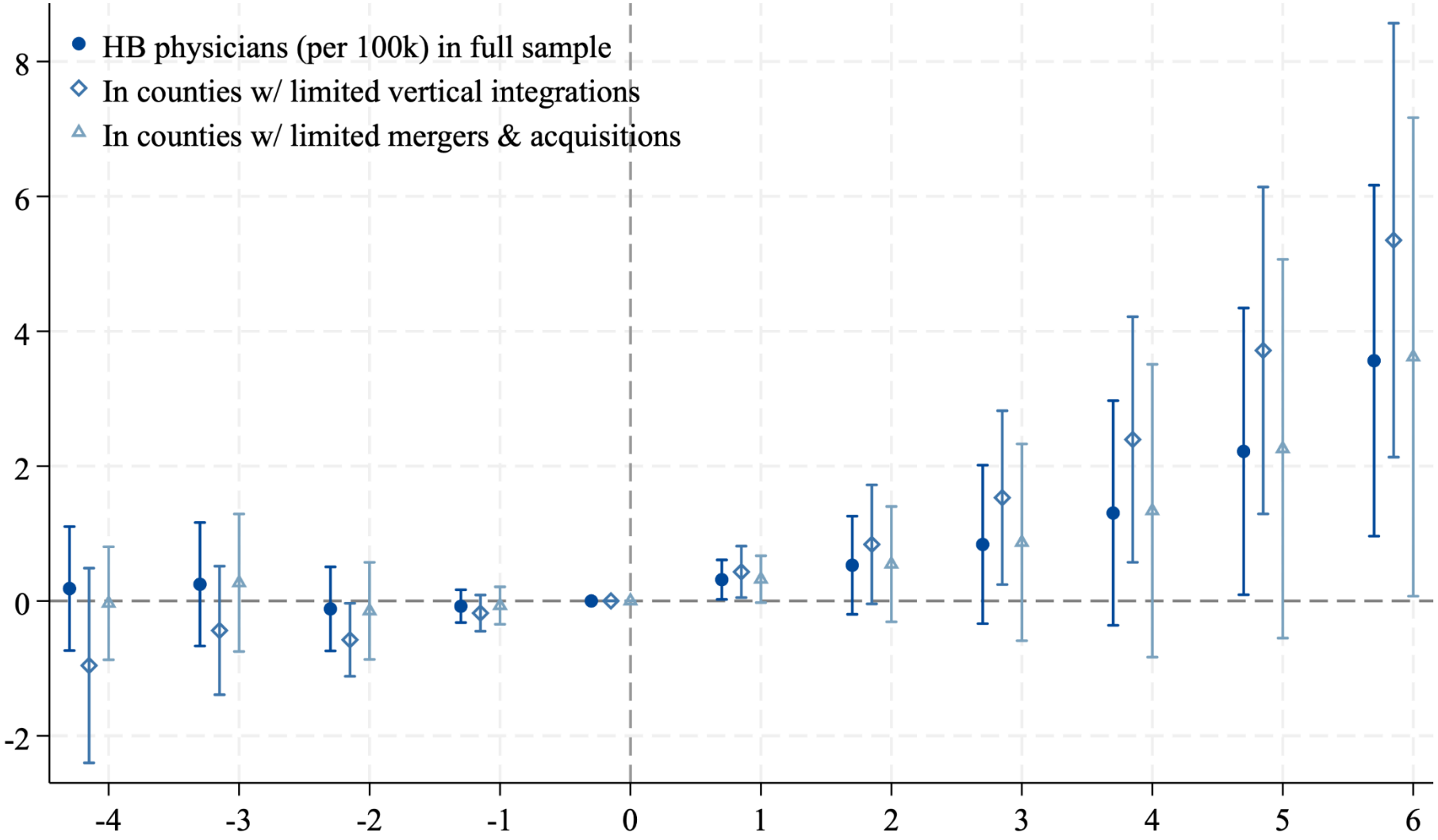
HIT Diffusion or Physician Practice Consolidation?

- Consolidations (vertical/horizontal) may expand physician networks and accelerate HIT adoption within health systems simultaneously…
  - A system is defined as either an independent hospital or an integrated health care delivery network w multiple hospitals and affiliated non-hospital facilities
  - Health systems acquire physician practices to get more patients (Baker et al., 2016)
  - Systems, w greater financial & tech capacities, often adopt HIT early (Agha 2014)

- We identify health system that experienced …
  - a merger & acquisition (M&A), if the # hospitals within the system increased in a given year compared to the previous year.
  - a vertical integration (VI), if the # ambulatory care units within the system increased in a given year compared to the previous year.

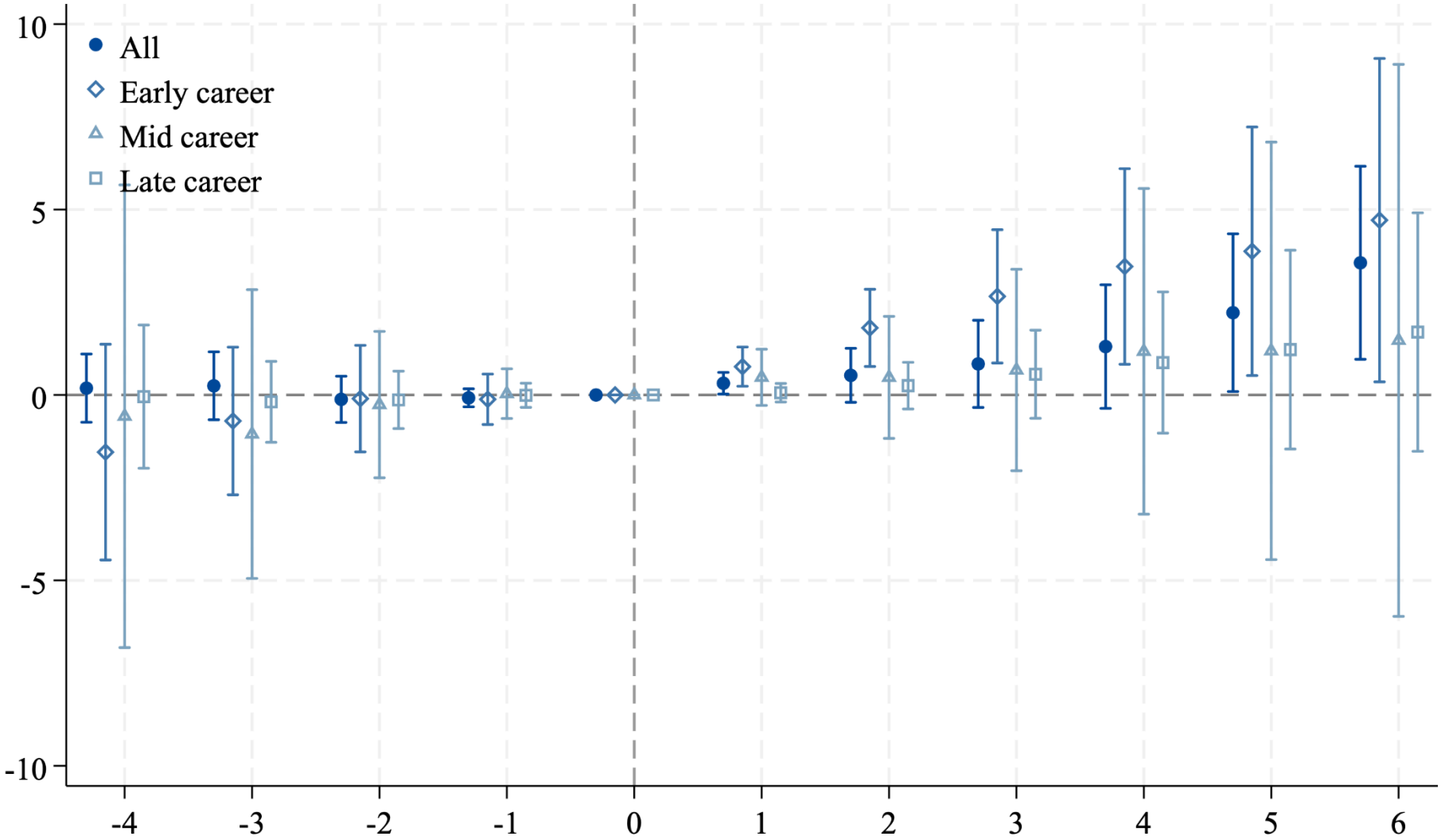
- Aggregate: county-level, substantial M&A/VIs if > median (over sample)
  - 0.167 for M&As and 0.25 for VIs (VIs are more common than M&As here)

Robust results in counties with limited consolidation



Heterogeneity by physician career stage (age group)

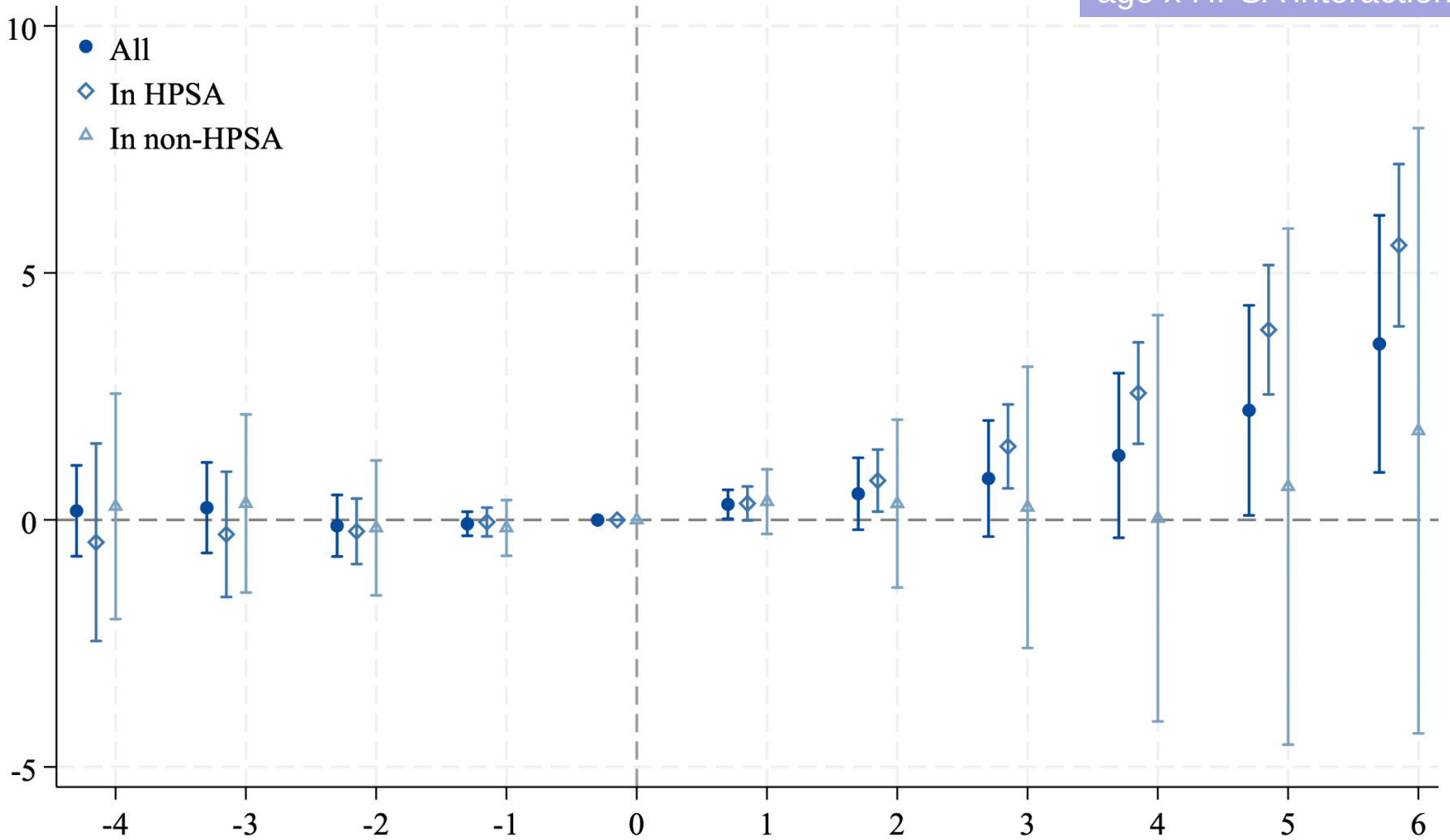
- Early-career (under 45), mid-career (45-64), late-career (65+)
  - Note: AHRF does not distinguish HB vs office-based physician by age groups



Heterogeneity by Physician Shortage Area Status

- by Health Professional Shortage Area (HPSA) designation status
  - A county is ever-HPSA if at least part of the county was ever designated as having a shortage of primary care practitioners.

age x HPSA interaction



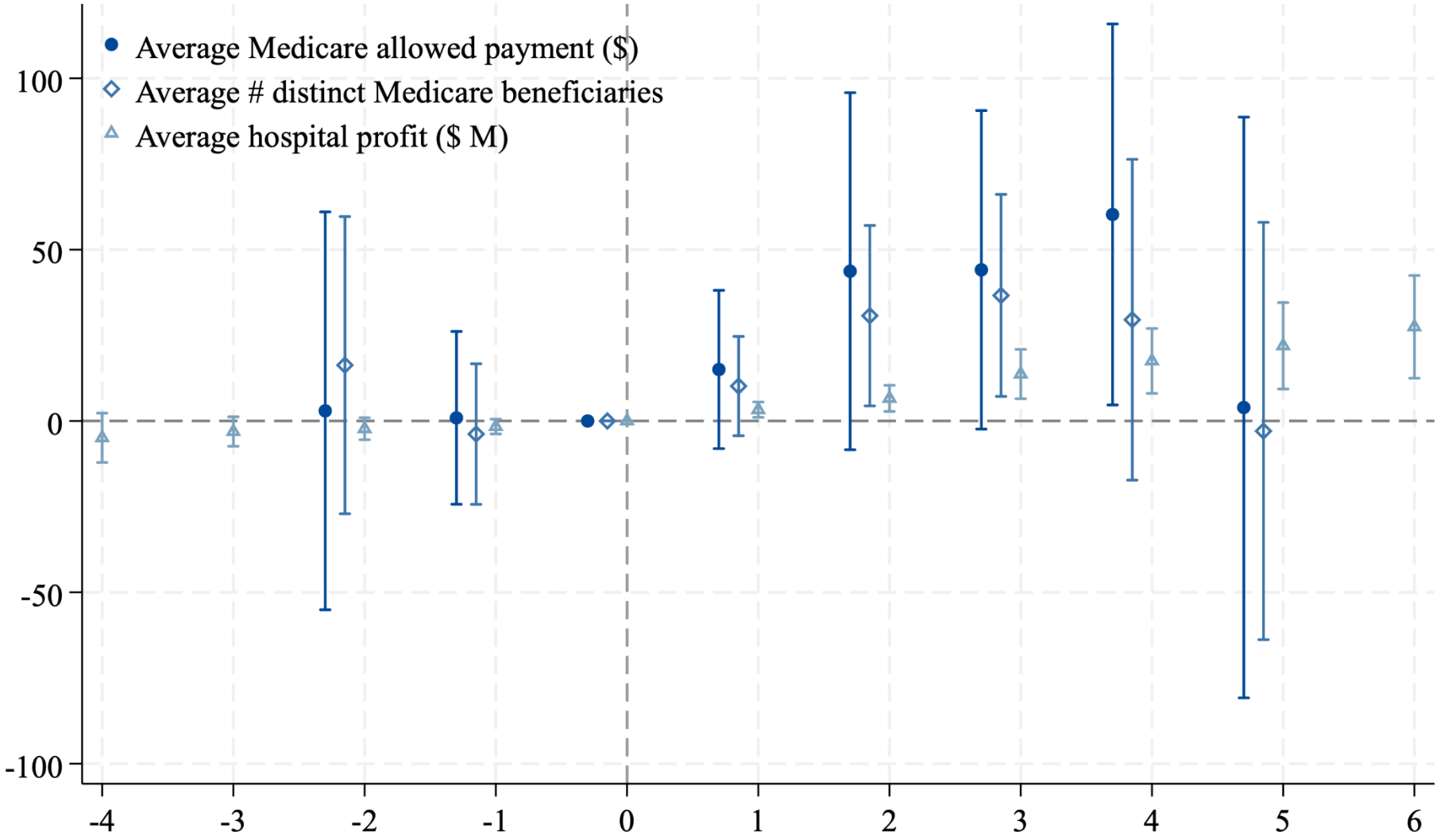
Potential Mechanism: the Financial Impact of HIT

- HIT investment costs $$$ and time… Is it worthwhile?
- Do HB physicians benefit financially from practicing in areas with HIT?
- Do hospital benefit financially from HIT and the comp. human capital?

- Ideally, we want detailed data on physician payments across payers
- In practice, we use three proxies for physician/hospital's performance:
  - [physician] 1) avg Medicare-allowed amounts per HB physician (incl. Medicare payments, patient deductibles and coinsurance, and any third-party contributions), 2) avg # of distinct Medicare beneficiaries per HB physicians
    - id. HB docs as these w 90+% services in hosp. inpatient/ER (CMS defn.), then compute county-level avg measures over all HB docs by county
  - [hospital] 3) average hospital profit across hospitals within each county

- Test a financial mechanism through which HIT affects/retains HB docs

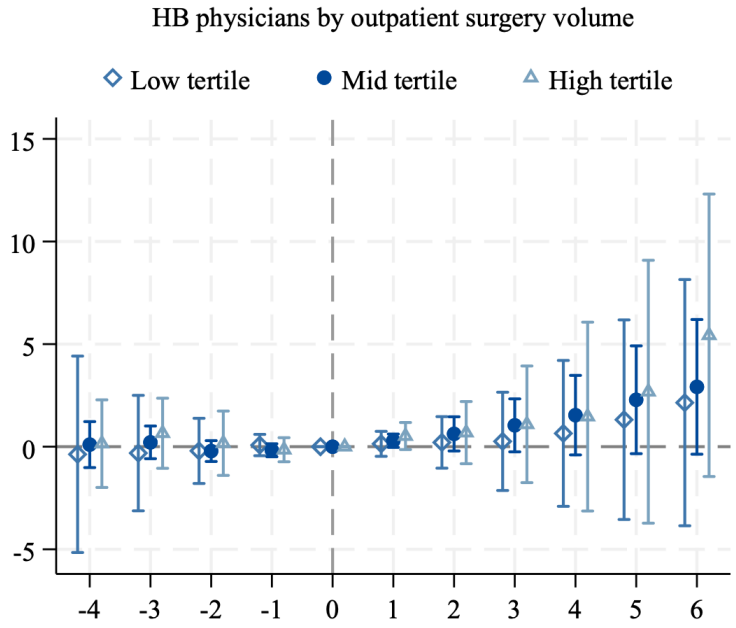
Increased financial metrics for physicians & hospitals

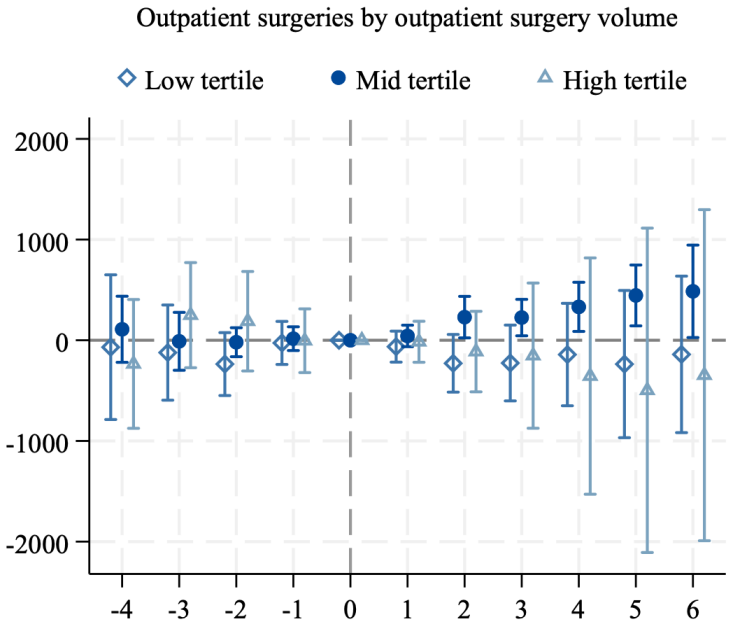


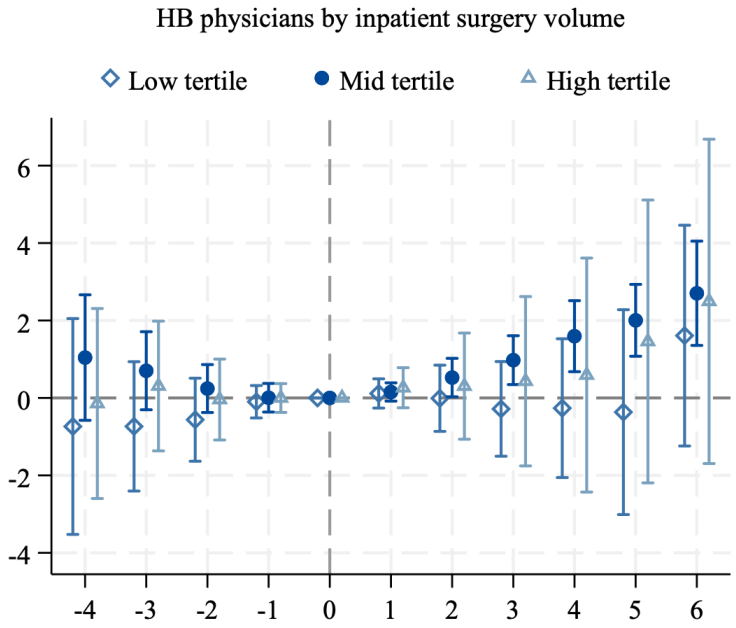
Heterogeneity by utilization: doc supply & care vol.

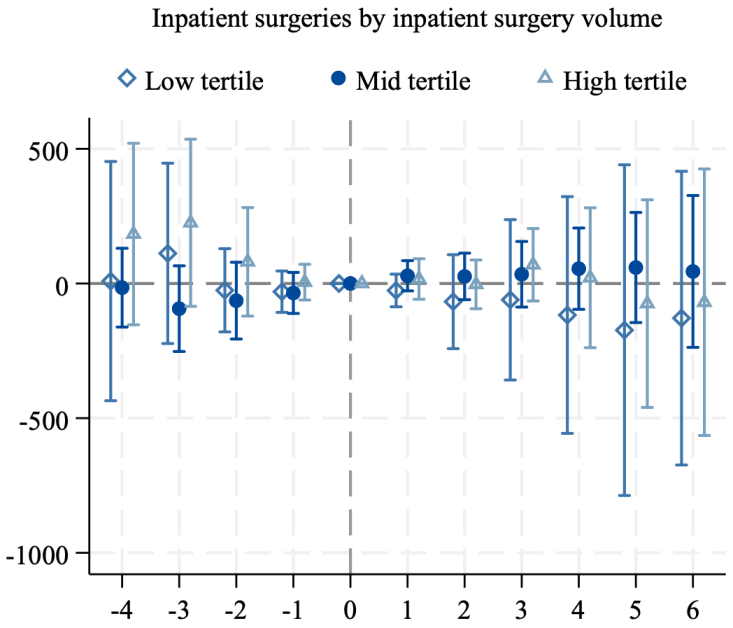
- Knowing that $ goes up. Given the interplay between provider capacity and service demand, how about patient care utilization post treatment?
- Specifically, whether physician supply responses to HIT diffusion vary by pre-period local health care utilization levels? And how this, in turn, influences subsequent service use? (demand-supply dynamics)
- Two main utilization measures: outpatient and inpatient surgical operations at short-term general hospitals, per 100k pop (county level)
  - Other measures: outpatient visits and Medicare inpatient discharges
  - Outpatient elective surgeries has the highest profit margins, thus are where we expect highest increases in docs/vols (extensive, intensive margin)
  - Inpatient surgery volume may not respond, but more HB docs are still good
  - Esp. where the pre-period demand are moderate (geo w growth potentials)

Heterogeneity by utilization, by surgery tertiles









other yvars

Robustness checks

- Alternative subsamples
  - Counties with ≤ 5 distinct adoption rates
  - Counties that never had zero HB physicians
  - Balanced panel with ≥ 4 periods before and after treatment

subsample

- Alternative model specifications
  - Models without state-specific time trends
  - Models without county-year level controls

specifications

- Alternative staggered DiD estimators
  - Borusyal et al., 2024; Callaway & Sant'Anna, 2021; Sun & Abraham, 2021

estimators

- Alternative HIT measures
  - CPOE or physician documentation (PD), another advanced HIT

measures

Limitations and Future Work

- Analyses based on *aggregate* data
  - ☺ mitigate concerns about patient sorting (limited sorting at county level)
  - ☹ limit our ability to disentangle changes at the physician level (e.g., replacing retiring physicians w junior docs, PCP vs specialists, roles…)
- Focus on *digital* tech but not fully capture *physical* med tech (data limit)
  - comprehensive controls mitigate concerns that other tech drive the results
- Cannot distinguish more nuanced *source* of responses
  - domestic vs international physicians, initial vs lateral practice location choices
- Not directly link with downstream *health outcomes*: HIT or docs?
  - HIT is one element within broader, team-based care delivery process
  - We demonstrate there can be direct and indirect effects via physician supply

Conclusion & Discussion

- We find that aggregate HB physician supply (county-level) **increases** after rapid adoption of advanced HIT, with effects concentrated among
  - More increases in medical/surgical specialties: tied with data & scheduling
  - Early-career physicians: age ≤ 45, more movable and tech savvy
  - Health professional shortage areas (HPSA): places w excess demand to care

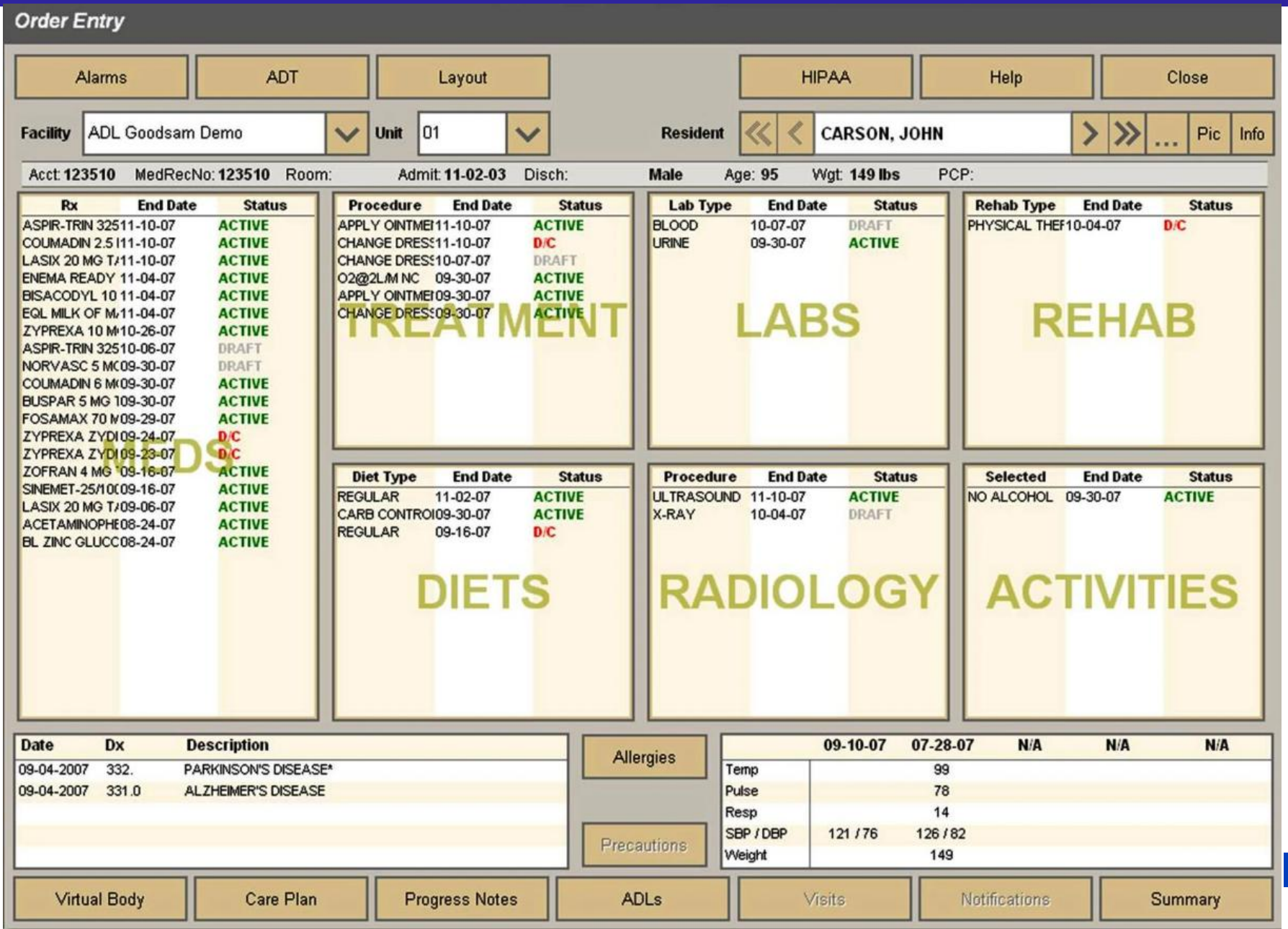
- Mechanism: treated counties showed better financial performance
  - Higher (per physician) avg Medicare allowed payments and patients treated
  - Increased hospital profits, and greater outpatient surgical volumes

- Policy and managerial implications
  - Strategic HIT investment can attract (/retain) physicians to underserved areas
  - HIT (automation) appears to complement physician labor rather than substitute
  - Health tech diffusion may help reduce geographic disparity in care access

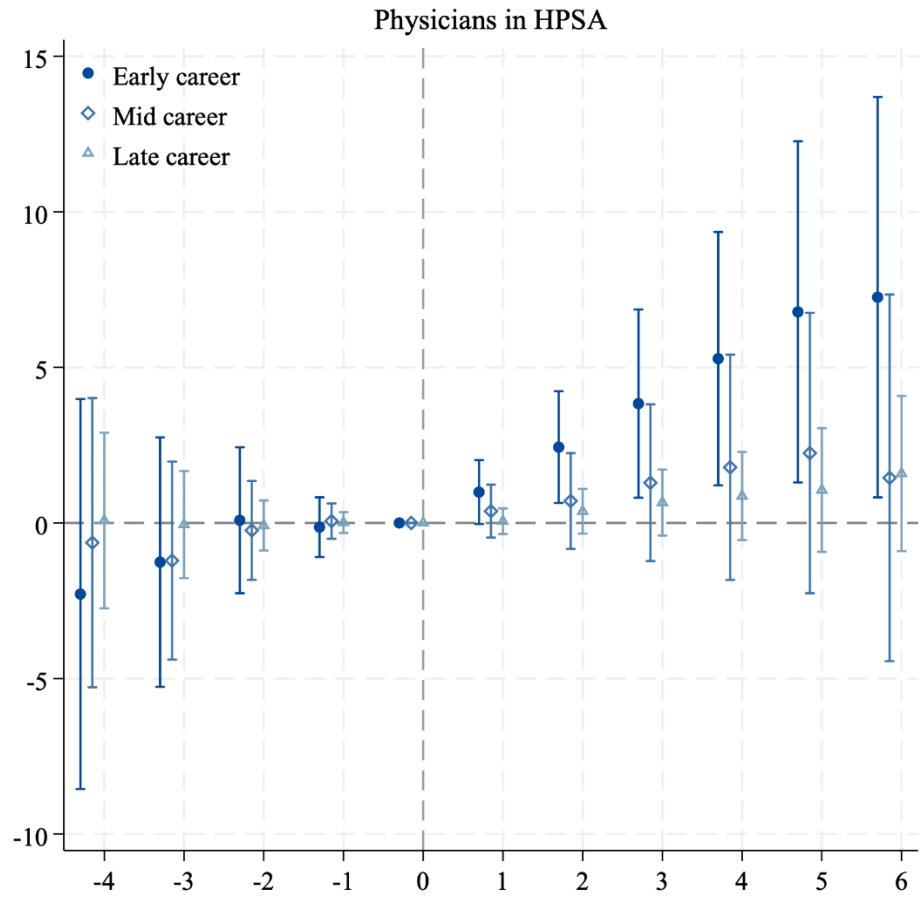
Health IT Diffusion and Physician Labor Supply

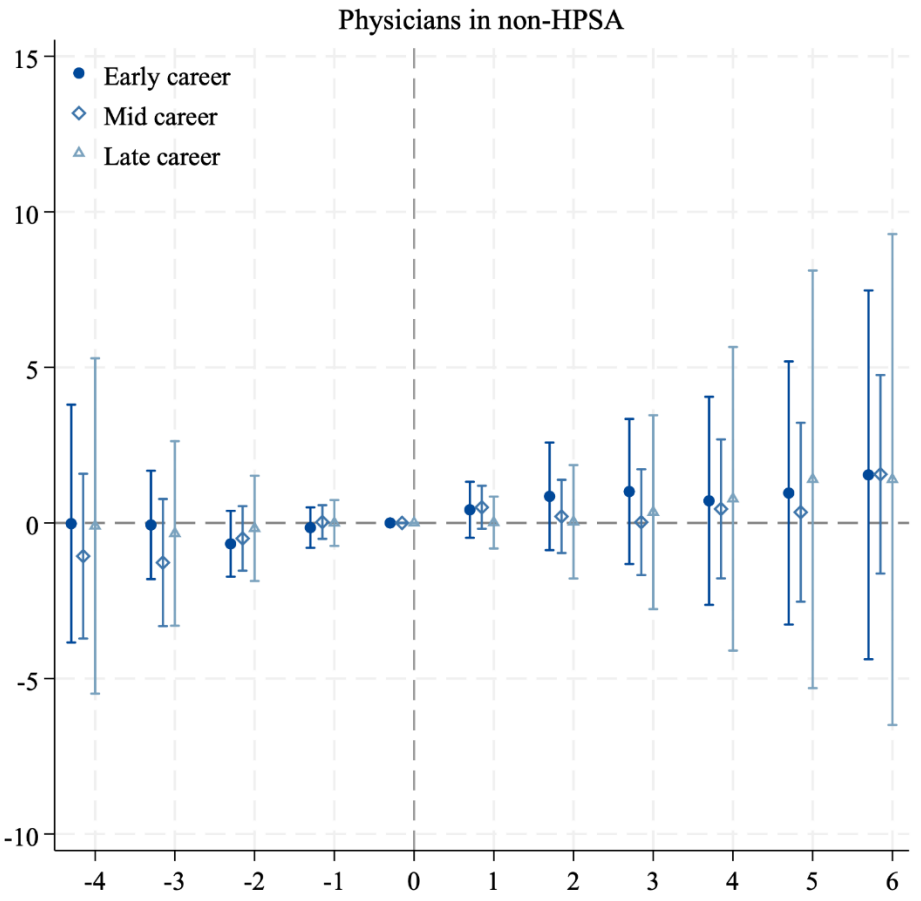
Jason Huh (RPI), Jianjing Lin (UMass Amherst), Lucy X Wang (UMass Amherst; MPI; CCHE)
Emails: huhj2@rpi.edu, jianjinglin@umass.edu, xiaoluwang@umass.edu

An Example of a CPOE Interface



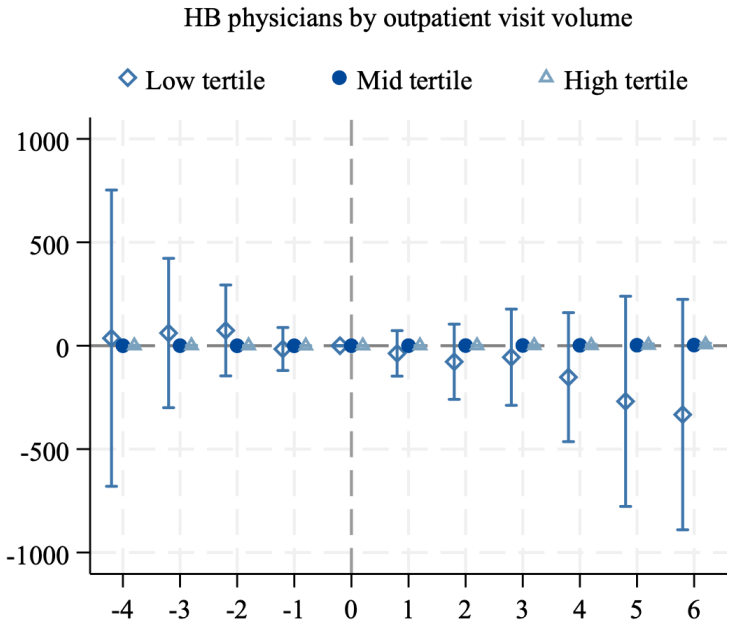
Heterogeneity by career stage and HPSA status

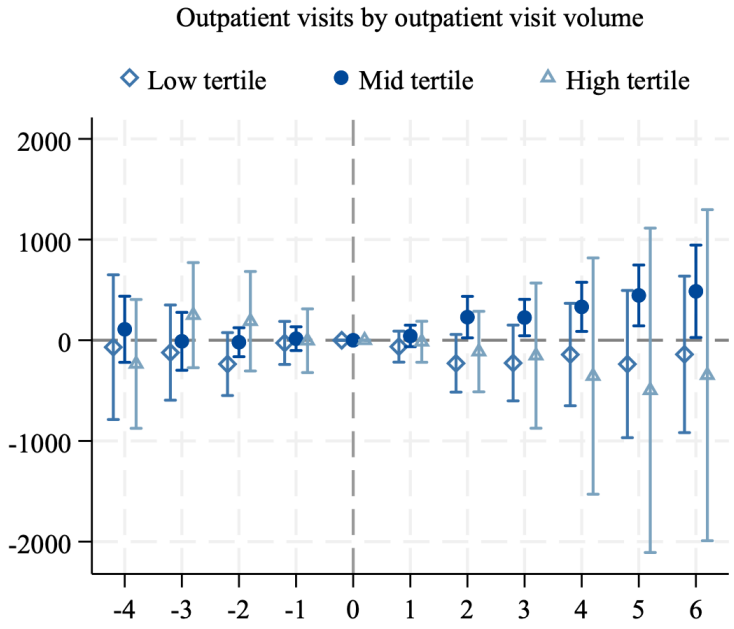


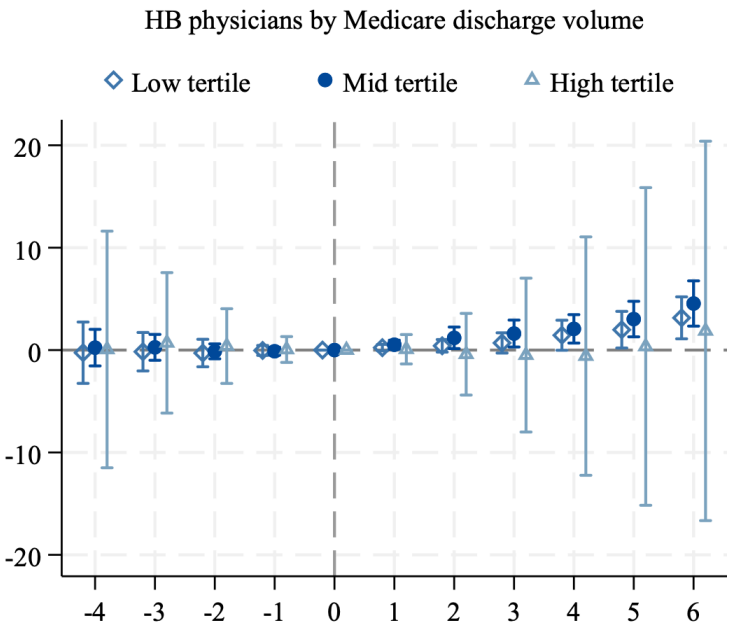


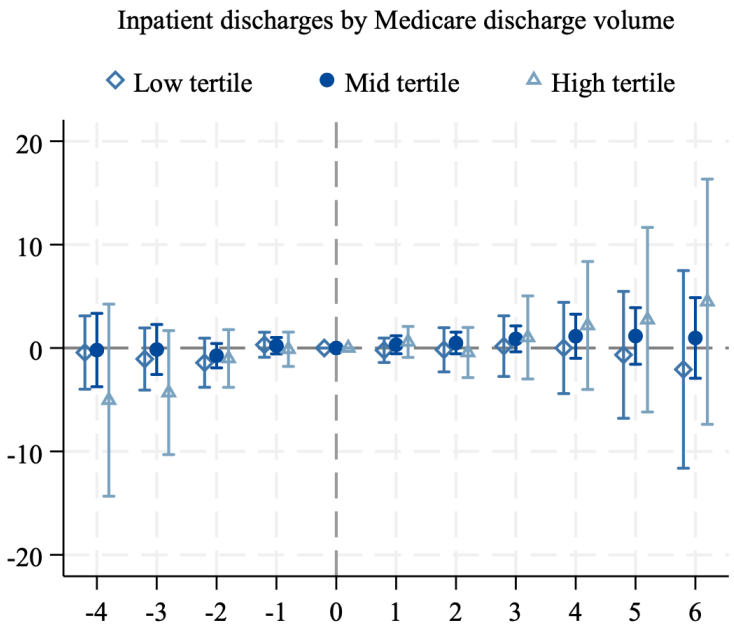
back

Heterogeneity by other utilization measures



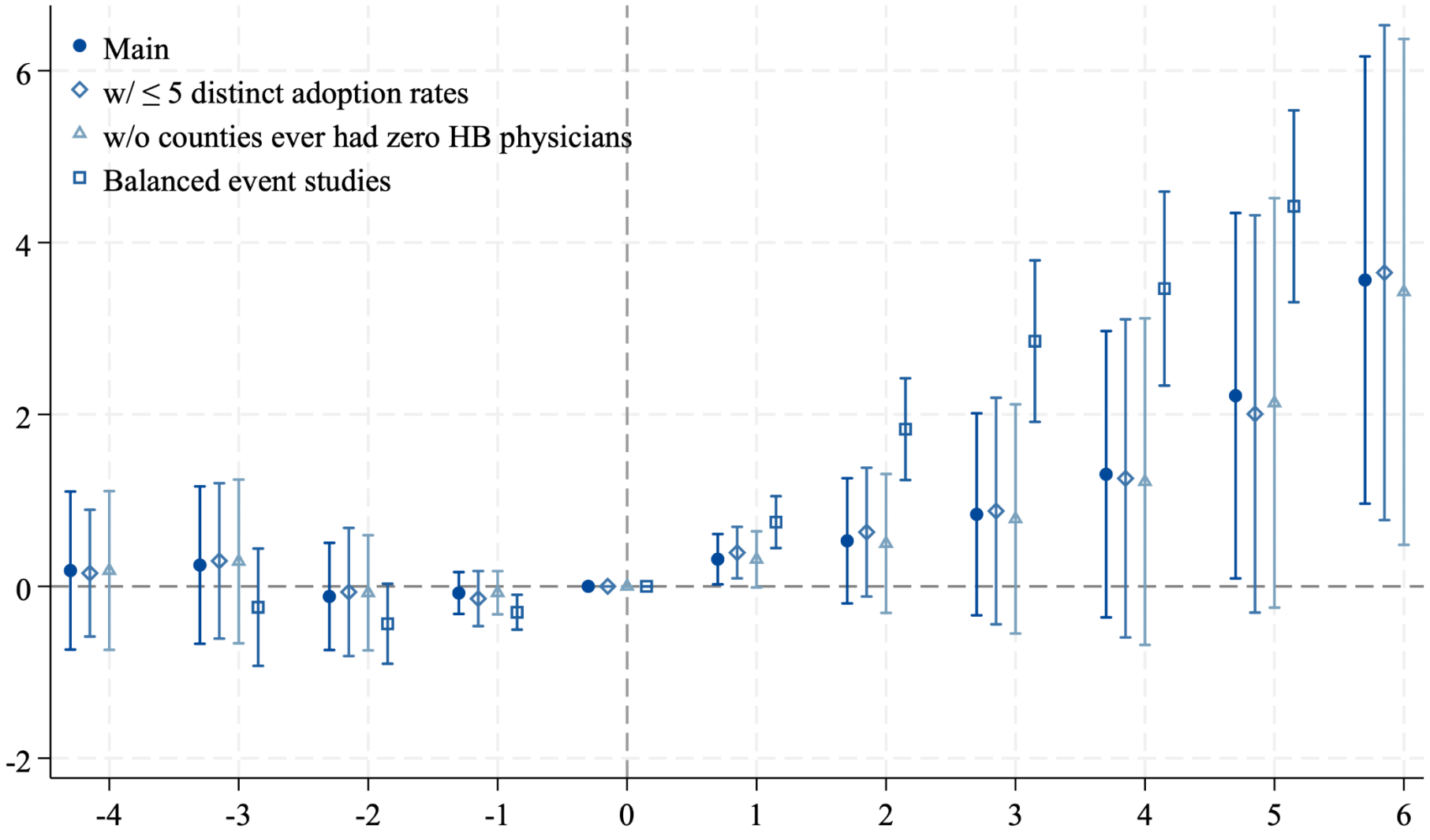






back

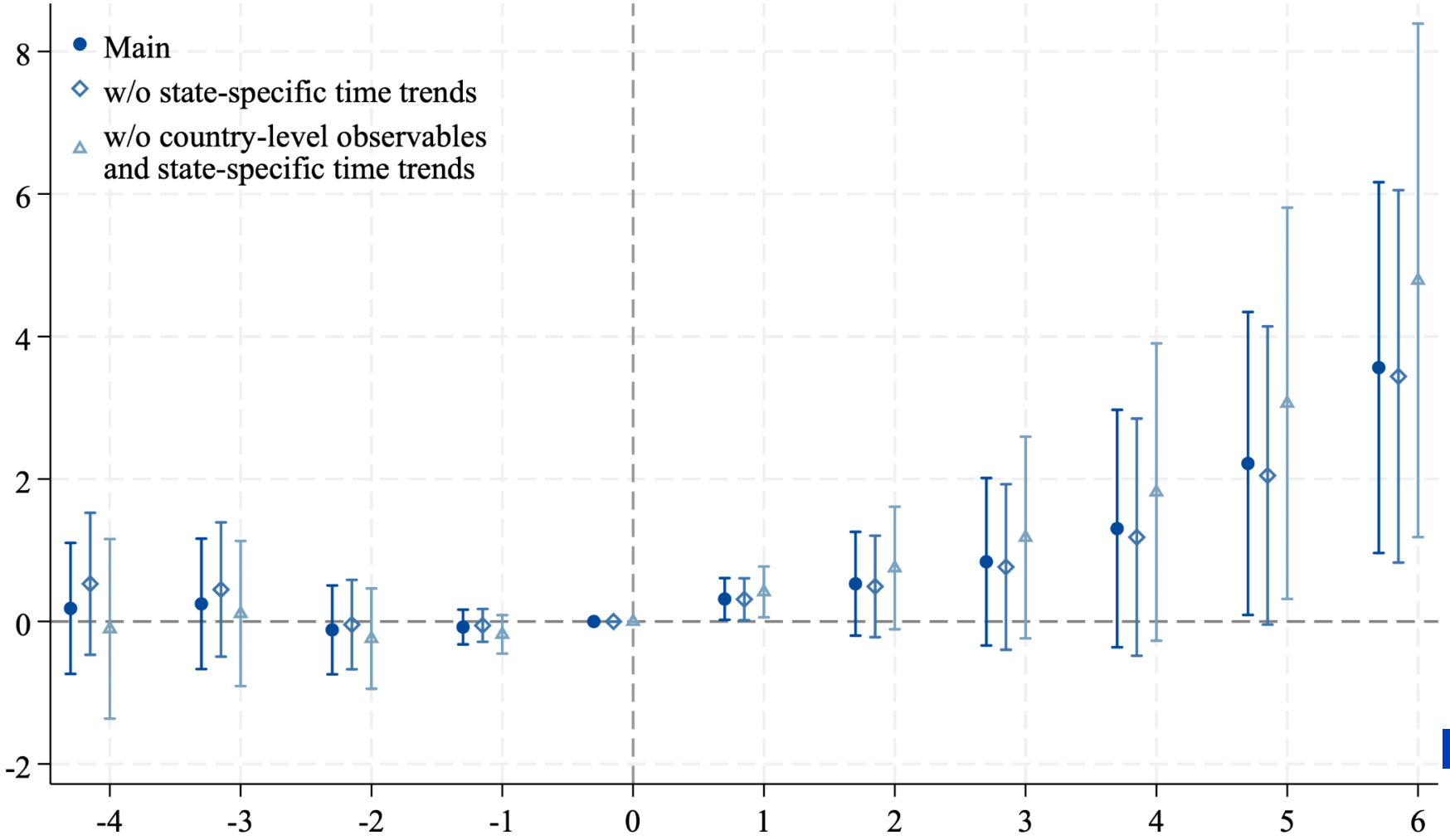
Robustness check: subsample sensitivity checks



back

Robustness check: specification checks

- Note the main specification always include state-specific time trends and county-level (including county-year level) observables.

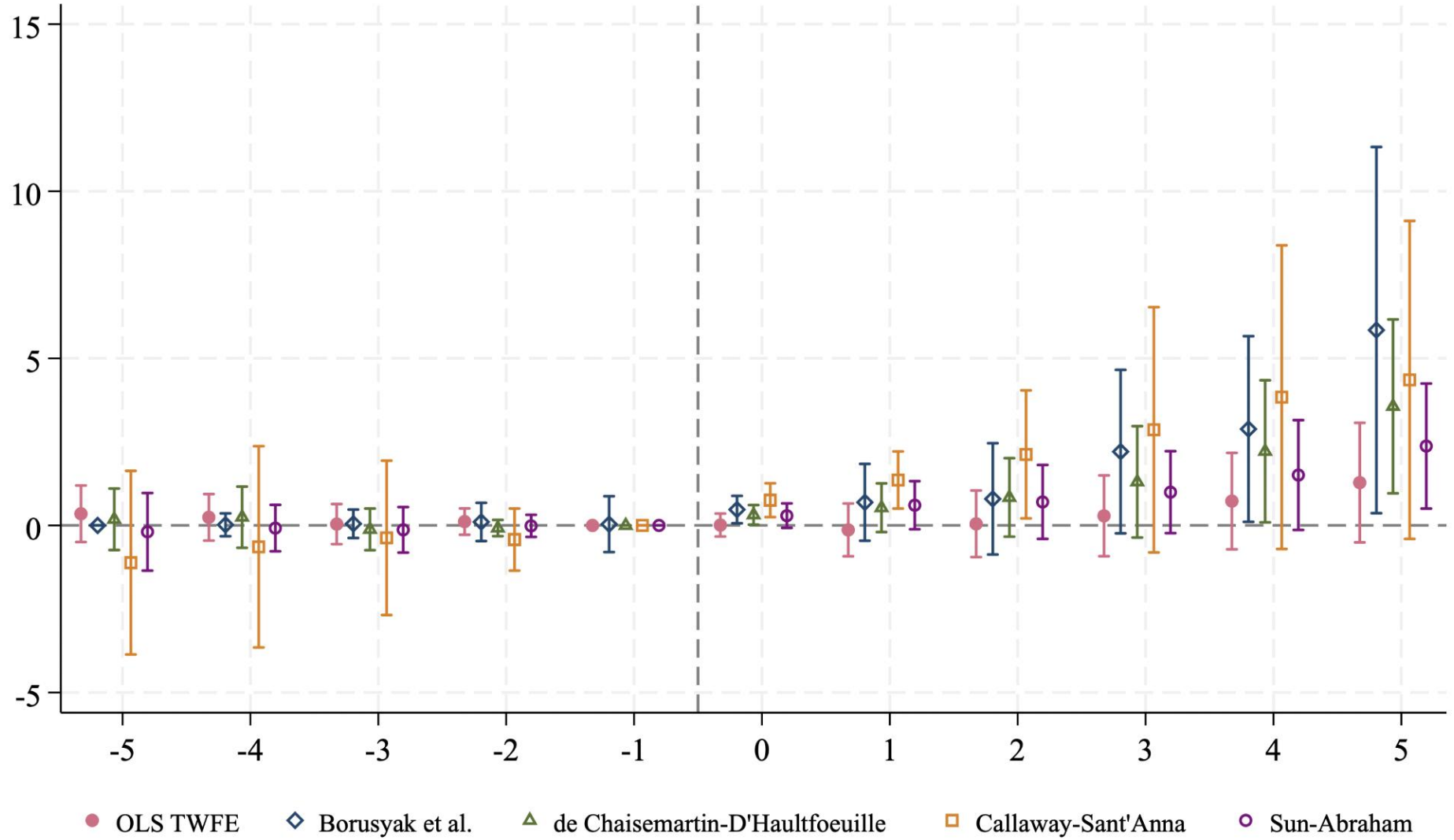


back

Alternative DiD estimators for the main outcome

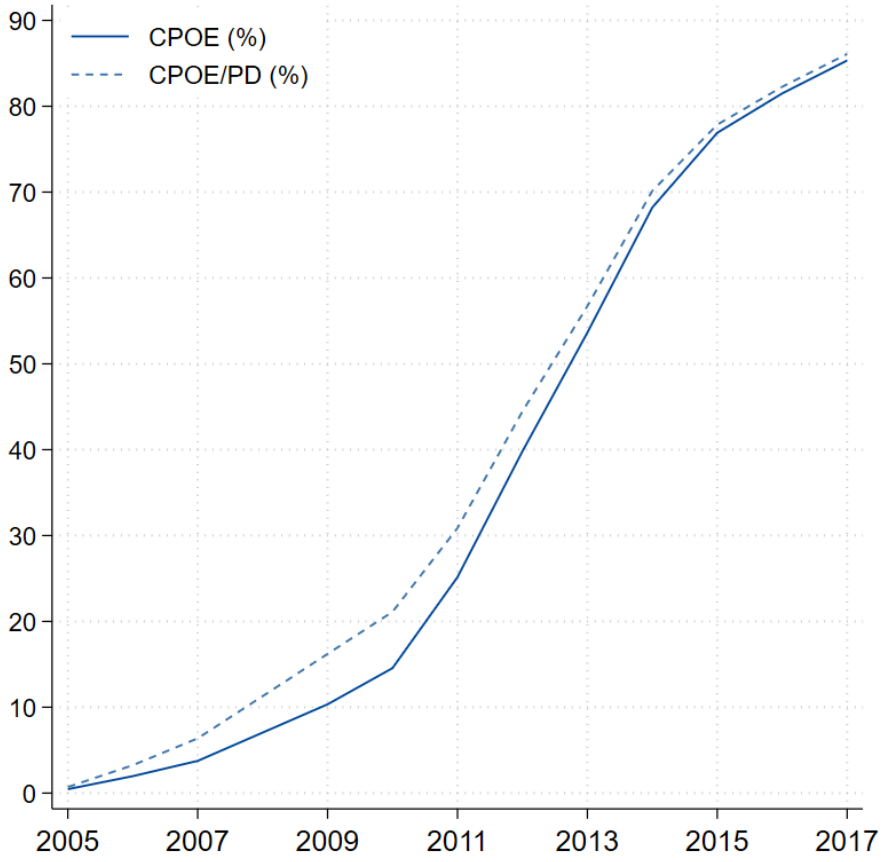
- All estimators use t=-1 as the reference except Borusyak et al., which uses the earliest period as the baseline period.

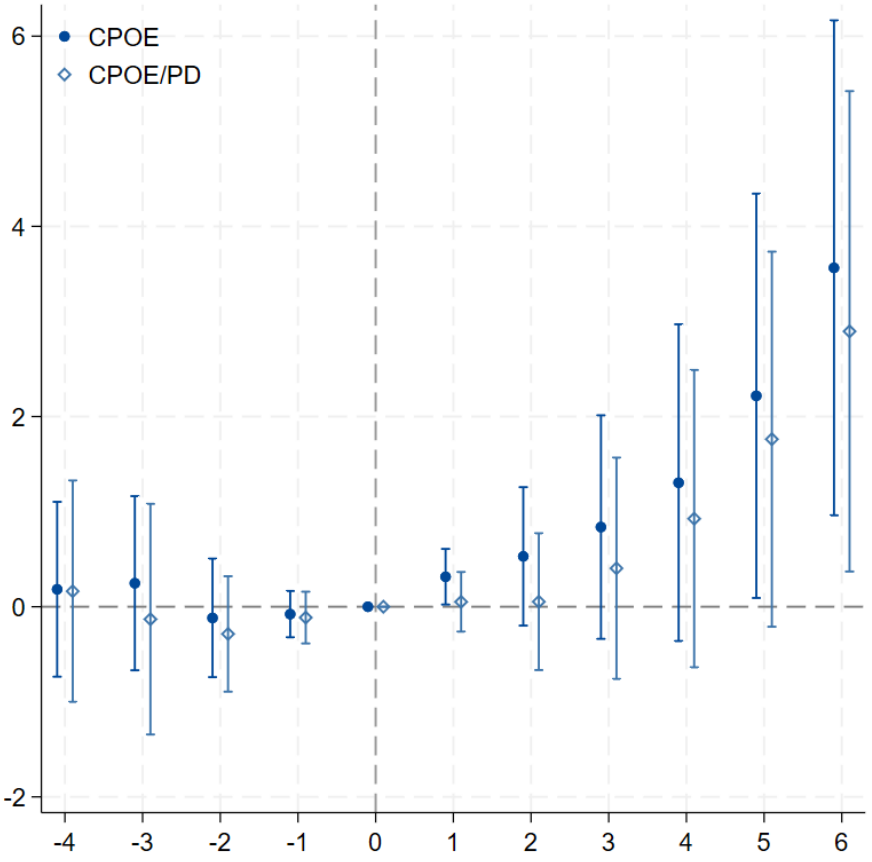
back



Alternative HIT measures: CPOE/PD adoption

- Alt. HIT adoption measures: county-level sharp adoption of either CPOE or physician documentation (PD) – another advanced HIT component (noted in Dranove et al., 2014) but not core for HITECH act MU criteria.





back