Owning the Agent: Hospital Influence on Physician Behaviors

Supplemental Appendix

Haizhen Lin
Indiana University & NBER

Ian M. McCarthy
Emory University & NBER

Michael Richards
Baylor University

Christopher Whaley
RAND Corporation

August 2022

This appendix details several aspects of our analysis and supplemental results. The sections follow in the same order as is mentioned the main text.

A First-stage Results

We present the first-stage results underlying our IV estimates in Table App.1, which shows a strong relationship between our PPIS price shock and the probability of integration between a physician and hospital. The estimate and standard error on the first-stage PPIS price shock coefficient translate to an F-statistic of 300. The sign of the coefficient is also consistent with what we would expect given the nature of the instrument as well as our initial analysis in the main text. Specifically, we find that practices with larger potential revenue gains due to site-based payment differentials are also more likely to be acquired.

B Initial OLS Estimates

Ordinary least squares (OLS) estimates are summarized in Table App.2, with estimated effects on log payments and episode claims in columns 1, 2, respectively. As discussed in the text, we dot not interpret these results as causal; however, the estimates remain informative as to the range of possible effects under some unforeseen violations of the standard IV assumptions. To this end, Table App.2 reveals an economically small and statistically insignificant positive relationship between vertical integration and log payments. We also estimate a relatively small but statistically significant negative relationship between vertical integration and claims. Our general takeaway from this analysis is that the OLS results are in-line with the qualitative conclusions from our IV analysis — namely, the results suggest no economically meaningful increase in spending and a reduction in total episode claims following vertical integration.

Mirroring our IV analysis in the main text, we present a specification curve for our OLS estimates in Figure App.1. The top panel presents results for episode payments, and the bottom panel presents results for number of claims in the episode. In both cases, the highlighted dot denotes our main specification (i.e., the full sample and the "Hospital VI" specification). The figures again offer some reassurance that the estimates from the main specification are robust to a range of specification/sample restriction combinations.

C Vertical Integration and Quality of Care

As discussed in the main text, vertical integration between physicians and hospitals may also affect quality of care. Here, we present the results of our supplemental analysis using mortality, readmissions, and complications as our measures of quality, where we identify complications based on the incidence of surgical site infections or sepsis. We identify surgical cite infections from the ICD-9 diagnosis codes 567.22, 998.32, 998.32, 998.5, 998.51, or 998.59, and we identify sepsis from the ICD-9 diagnosis codes 038 (with any suffix numbers), 785.52, 790.7, 995.91, 995.92, 998.0. "Any" complication is then defined as either a surgical site infection or diagnosis of sepsis within the episode.

The empirical analysis is otherwise identical to that of the main text, with results summarized in Table App.3. All estimated coefficients for vertical integration are economically small and statistically insignificant. Coupled with existing literature finding little effect of vertical integration

on quality of care (Carlin *et al.*, 2015; Koch *et al.*, 2018), we argue that it is unlikely that quality improvements are driving our estimates. Note also that our specification curves in Figure App.1 and in the main text show that our main findings on spending and utilization are largely unaffected by the inclusion or exclusion of quality measures as covariates.

D Event Studies

In the main text, we present initial event studies based on Callaway & Sant'Anna (2020) for our overall payment and claims outcomes. In this appendix section, we repeat that analysis for other outcomes considered in the paper. Results for components of each episode are presented in Figures App.2 and App.3, and results for physician referral patterns within an episode are in Figures App.4. In all cases, period 0 denotes the first year of integration. Note that, as in the main text, the event studies in Figures App.2-App.4 employ the repeated cross-section version of Callaway & Sant'Anna (2020) without any adjustments for covariates. This implies that we do not adjust for fixed effects for each hospital-physician pair, nor do we impose any balance requirements on the hospital-physician panel. The results nonetheless qualitatively match those of our preferred IV estimates, but with smaller effect sizes in most cases.

At the physician level, our panel is more balanced than at the level of the hospital-physician pair. Therefore, we can more feasibly pursue the panel version of Callaway & Sant'Anna (2020) without losing as much of our data. We present event study estimates without fixed effects (e.g., the repeated cross-section version of Callaway & Sant'Anna (2020) in Figures App.5 and App.7, and we present estimates with fixed effects (e.g., the panel version of Callaway & Sant'Anna (2020)) in Figures App.6 and App.8. One important practical difference between these two sets of results is that the panel versions also impose balance in the panel over each two year period.

With either the panel or repeated cross-section version of our event studies, we consistently find evidence of an increase in claims and spending going to outpatient facilities; however, conclusions for professional services and inpatient services (and thus total claims and spending) differ depending on the different versions of estimator employed. In the case of physician services, the panel version of our event studies better aligns with our IV estimates while the repeated cross-section version suggests an increase in claims. Conversely, in the case of inpatient services, the repeated cross-section version aligns with our IV estimates while the panel version suggests an increase in claims

with little change in spending.

Our takeaway from Figures App.5-App.6 is that, while the event studies are inconclusive with regard to inpatient and professional services, they do not refute our preferred IV estimates. Moreover, our IV estimates are *not* sensitive to whether we impose a balanced panel,[1] offering additional confidence that our preferred IV estimates in the main text are more reflective of the true underlying causal effect in our context.

[1]For example, our estimated effect of VI on physician inpatient spending among a balanced panel of physicians is -$97,052, with a 95% confidence interval of -$152,400 to -$41,700. This compares to an overall estimate of -$100,000 without imposing any balance.

References

Callaway, Brantly, & Sant'Anna, Pedro HC. 2020. Difference-in-differences with multiple time periods. *Journal of Econometrics*.

Carlin, Caroline S, Dowd, Bryan, & Feldman, Roger. 2015. Changes in quality of health care delivery after vertical integration. *Health services research*, **50**(4), 1043–1068. Publisher: Wiley Online Library.

Koch, Thomas G, Wendling, Brett W, & Wilson, Nathan E. 2018. The Effects of Physician and Hospital Integration on Medicare Beneficiaries' Health Outcomes. *Review of Economics and Statistics*, 1–38. Publisher: MIT Press.

Tables and Figures

Table App.1: **First-stage IV Estimates**[a]

	Physician-Hospital Integration
PPIS Price Shock (100s)	0.025***
	(0.001)
Any Hospital Integration	0.061***
	(0.005)
Hospital Characteristics	
Nurse FTEs (100s)	0.008***
	(0.001)
Other FTEs (100s)	0.003***
	(0.000)
Beds (100s)	-0.013***
	(0.003)
For-profit	-0.004
	(0.032)
System Affiliation	-0.012
	(0.009)
Major Teaching	-0.028**
	(0.014)
N	773,092

[a]Results from ordinary least squares regression of the integration indicator against our instrument and all other variables discussed in the main text. Sample sizes differ slightly from results in the main text due to missing or excluded values for episode-outcomes (e.g., episode spending in the top or bottom one-percent). Standard errors are in parenthesis, clustered by physician. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table App.2: **Initial OLS Estimates**[a]

	Log Payments	Number of Claims
Integrated with Hospital k	0.004	-1.895***
	(0.003)	(0.355)
Any Hospital Integration	-0.004	0.553*
	(0.003)	(0.300)
Nurse FTEs	-0.000	-0.003***
	(0.000)	(0.001)
Other FTEs	0.000	0.000
	(0.000)	(0.000)
Beds (100s)	0.001	0.513**
	(0.002)	(0.228)
For-profit	-0.004	-2.563
	(0.021)	(2.135)
System Affiliation	0.003	-0.514
	(0.005)	(0.515)
Major Teaching	0.004	-1.083
	(0.008)	(0.923)
Observations	812,843	796,384

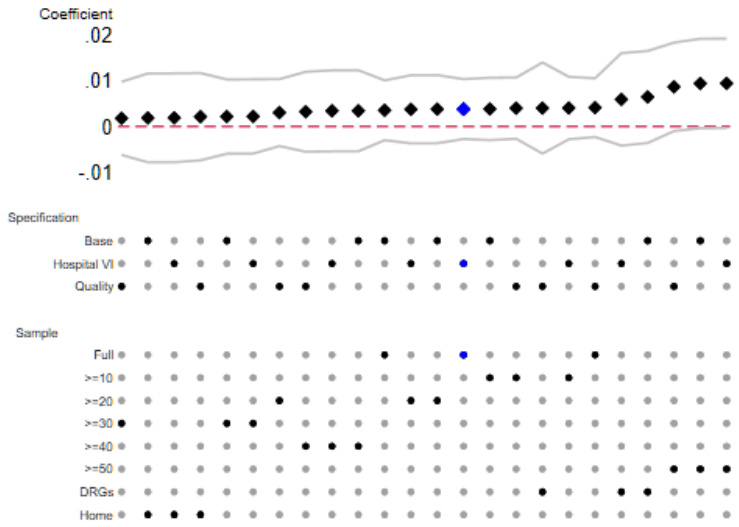
[a]Results from ordinary least squares regression with physician-hospital, year, and month fixed effects. Sample sizes differ slightly from results in the main text due to missing values in the instrument. Standard errors are in parenthesis, clustered by physician. All covariates match those of the main IV results in the text. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table App.3: **Estimated Effects on Quality of Care**[a]

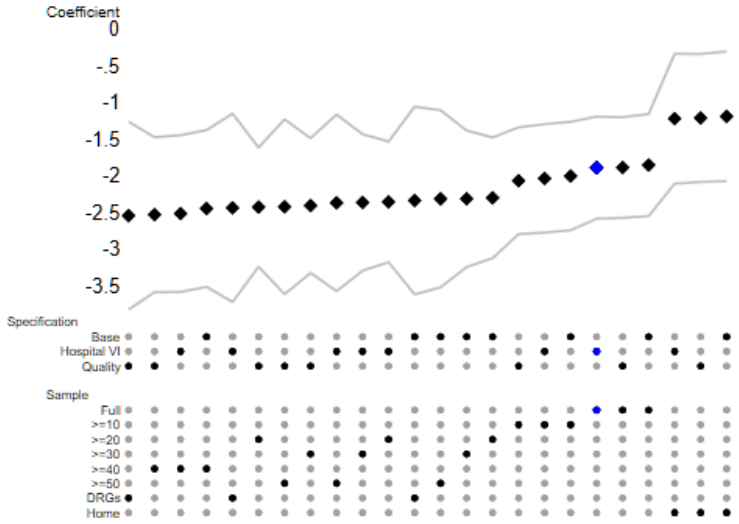
	OLS Estimates			*IV Estimates*		
	Mortality	Readmissions	Complications	Mortality	Readmissions	Complications
Integrated with Hospital k	-0.001	-0.000	0.001	-0.002	0.002	0.013
	(0.001)	(0.002)	(0.001)	(0.009)	(0.019)	(0.010)
Any Hospital Integration	0.001	-0.001	0.000	0.001	-0.001	-0.000
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Nurse FTEs	0.000	0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Other FTEs	0.000	-0.000	-0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Beds (100s)	0.001	-0.001	-0.000	0.001	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
For-profit	-0.007	-0.006	-0.001	-0.012*	-0.001	0.001
	(0.007)	(0.013)	(0.006)	(0.007)	(0.013)	(0.006)
System Affiliation	-0.001	-0.000	-0.001	-0.001	0.000	-0.000
	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)	(0.002)
Major Teaching	0.001	-0.005	-0.002	0.001	-0.004	-0.003
	(0.002)	(0.005)	(0.003)	(0.002)	(0.006)	(0.003)
Observations	842,016	842,016	842,016	773,092	773,092	773,092

[a]OLS and IV results including year, month and physician-hospital fixed effects. Standard errors are in parenthesis, clustered by physician. All covariates match those of the main IV results in the text. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Figure App.1: **Specification Curves for OLS Estimates**[b]



a. Episode payments

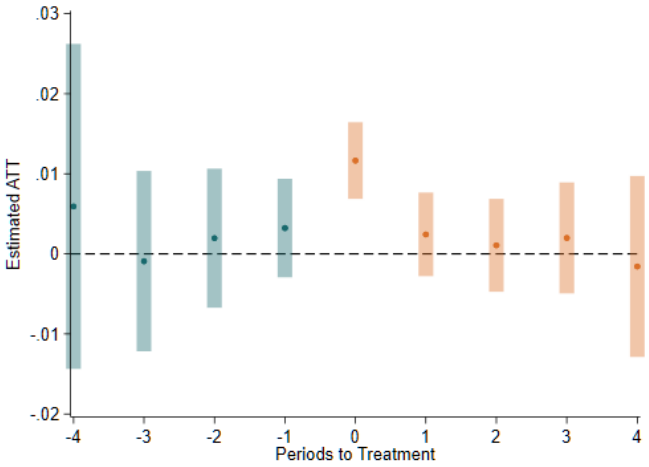


b. Number of claims

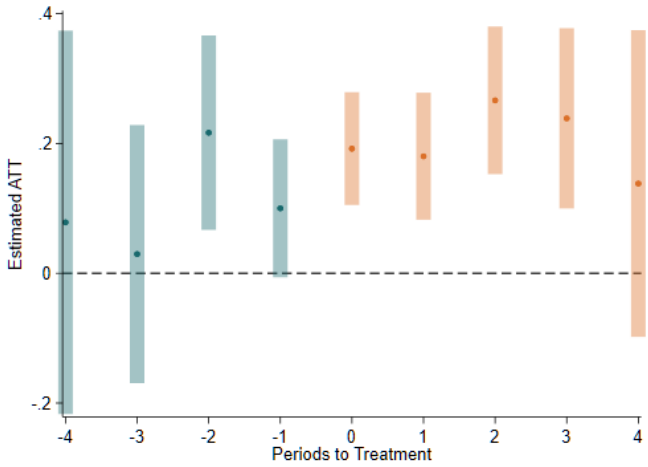
[a]Point estimates and 95% confidence intervals for the coefficient on physician-hospital vertical integration estimated using OLS. "Base" denotes a specification without adjusting for hospital-level vertical integration or quality of care in an episode; "Hospital VI" denotes a specification that includes an indicator for hospital-level vertical integration (the preferred specification presented in the text); and "Quality" denotes a specification that includes an indicator for within-episode mortality as an additional control variable. "Full" denotes the full sample, which is the sample underlying the results in the main text; ">= 10" through ">= 50" denote restrictions on the minimum number of episodes per physician-hospital pair in the estimation sample; "DRGs" denotes the sample that is restricted to orthopedic procedures only; and "Home" denotes a sample that is restricted to patients discharged to home. The code for our specification curves was adapted from Hans S. Sievertson, who kindly made his code available at github.com/hhsievertsen/speccurve.

Figure App.2: **Event Studies for Components of Episodes**[a]

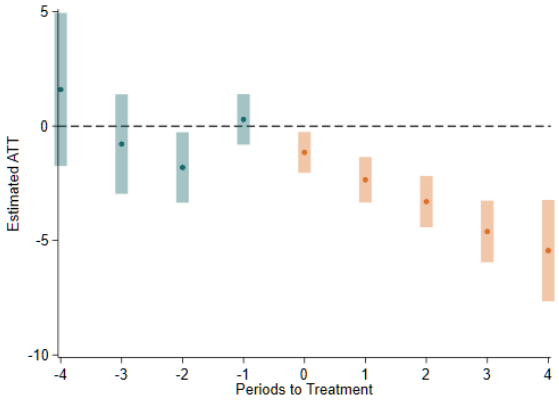
Number of Claims



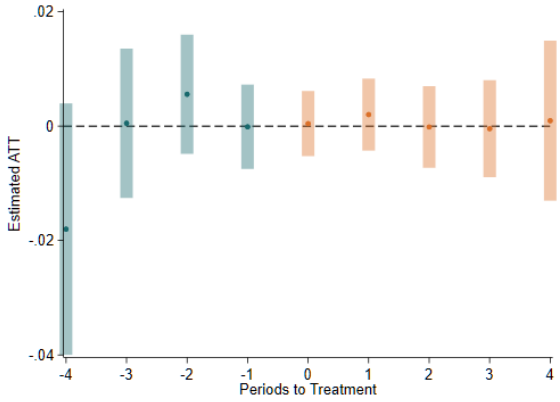
a. Inpatient



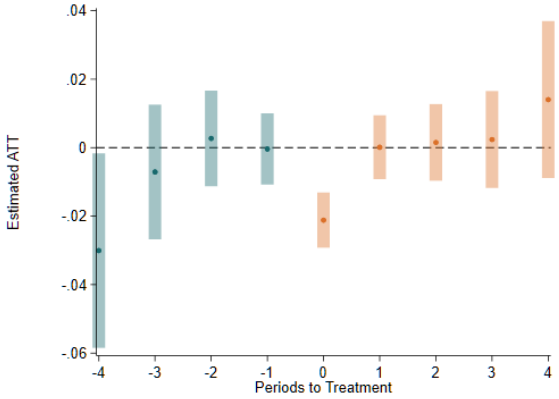
b. Outpatient



c. Professional Services



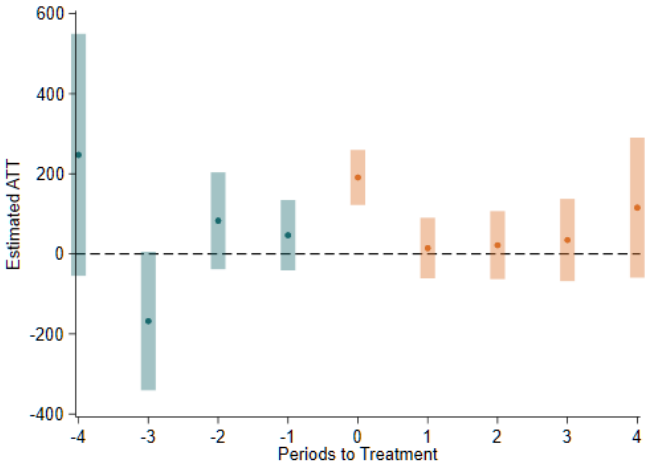
d. SNF



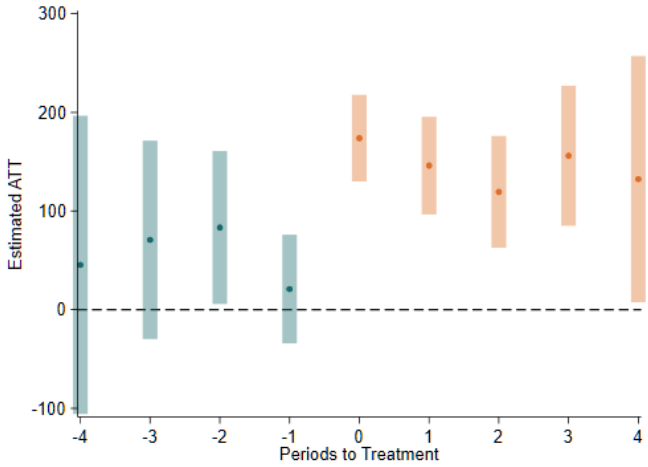
e. HHA

[a]Figures present the results of yearly ATTs based on the repeated cross-section version of Callaway & Sant'Anna (2020), without adjustment for any covariates. Outcomes are the number of claims associated with each component of the episode, as described in the captions. We exclude, separately for each outcome, observations in the upper 1% of values.

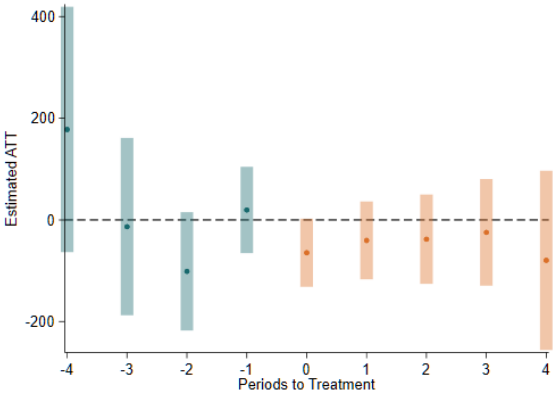
Figure App.3: **Event Studies for Components of Episodes**[a]
Medicare Payments



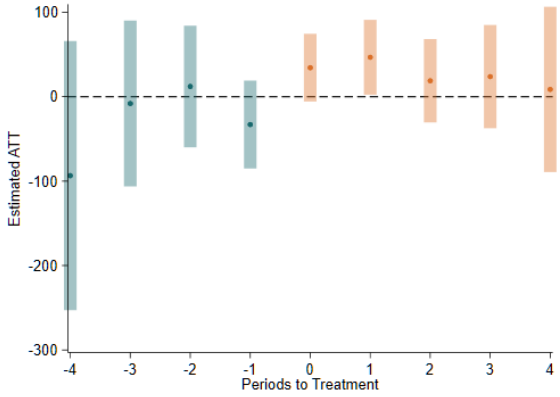
a. Inpatient



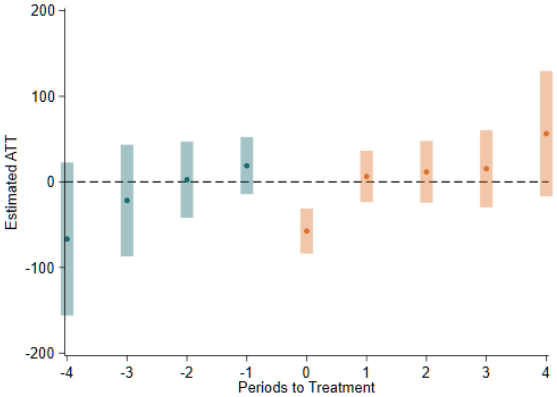
b. Outpatient



c. Professional Services



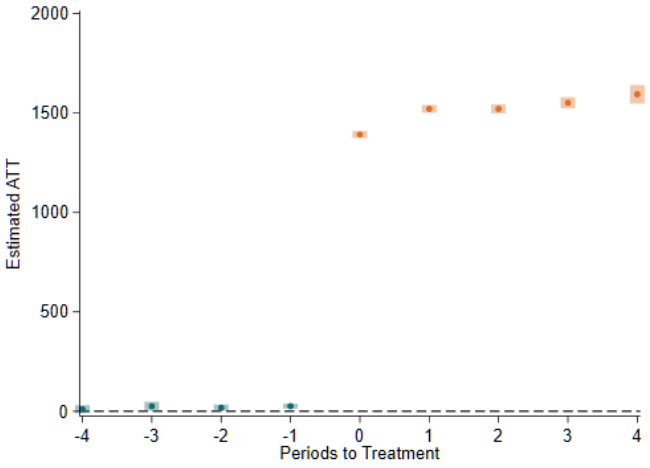
d. SNF



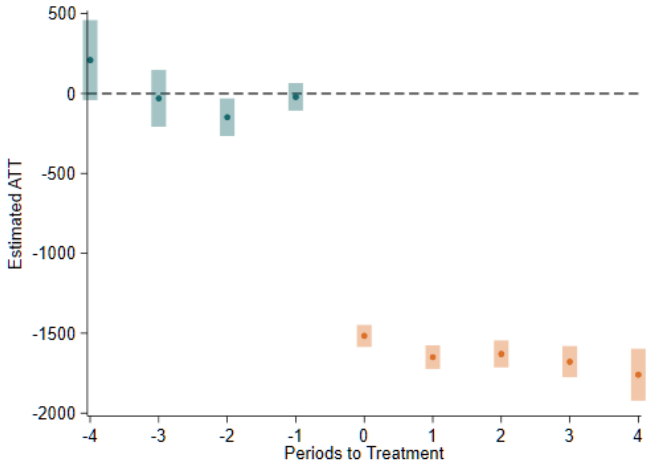
e. HHA

[a]Figures present the results of yearly ATTs based on the repeated cross-section version of Callaway & Sant'Anna (2020), without adjustment for any covariates. Outcomes are the total Medicare payments associated with each component of the episode, as described in the captions. We exclude, separately for each outcome, observations in the upper 1% of values.

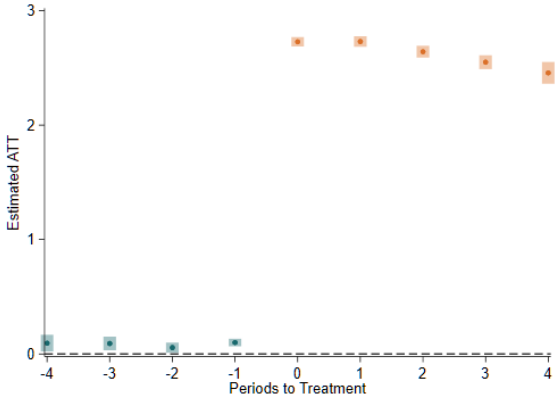
Figure App.4: **Event Studies for Referral Patterns**[a]



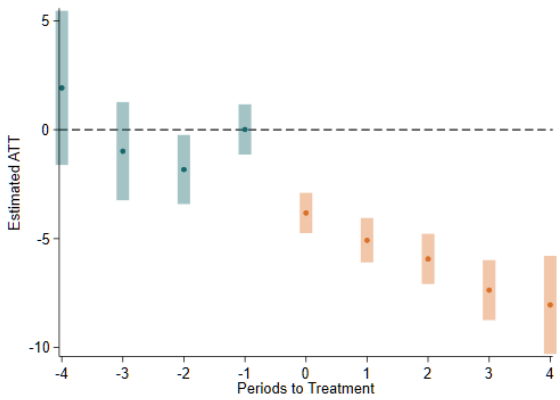
a. Payments to Integrated Providers



b. Payments to Non-integrated Providers



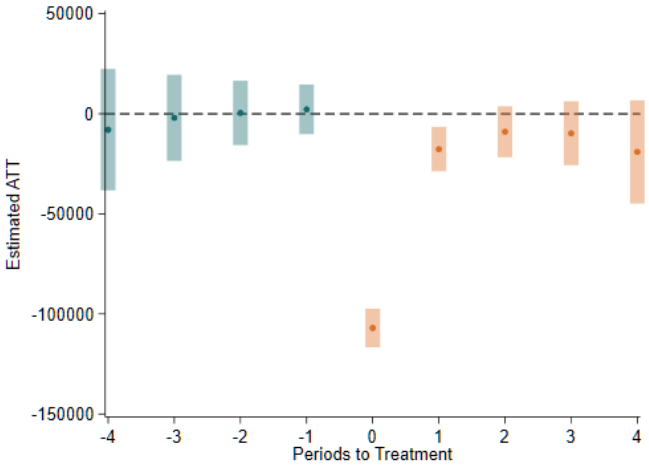
c. Claims to Integrated Providers



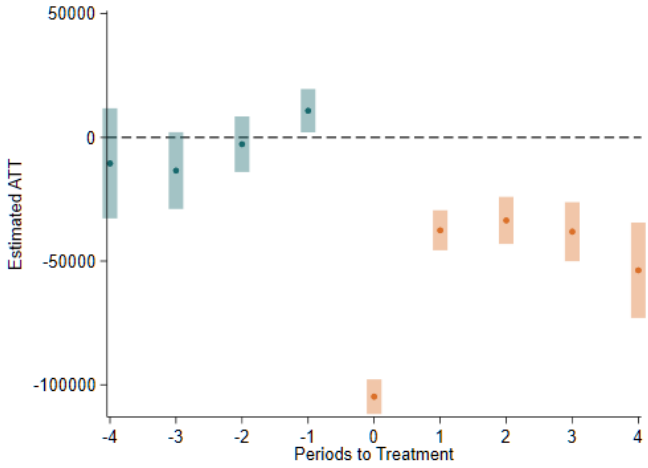
d. Claims to Non-integrated Providers

[a]Figures present the results of yearly ATTs based on the repeated cross-section version of Callaway & Sant'Anna (2020), without adjustment for any covariates. Outcomes are total claims and payments to integrated or non-integrated providers within each episode, as described in the captions. We exclude, separately for each outcome, observations in the upper 1% of values.

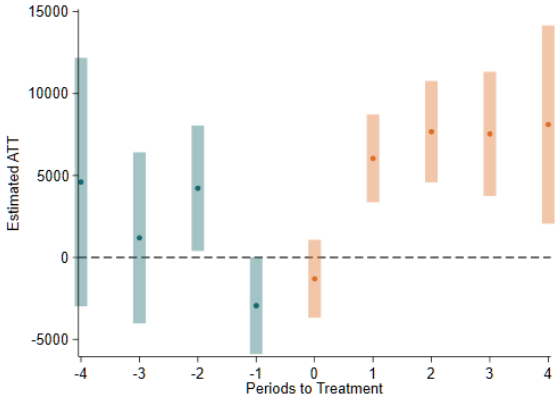
Figure App.5: **Event Studies for Total Payments**[a]
Unbalanced Panel and No Fixed Effects



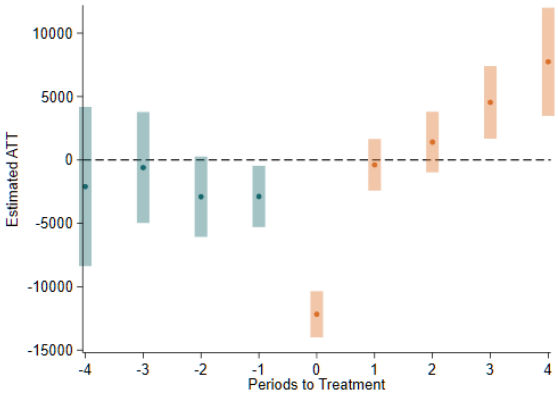
a. All Payments



b. Inpatient



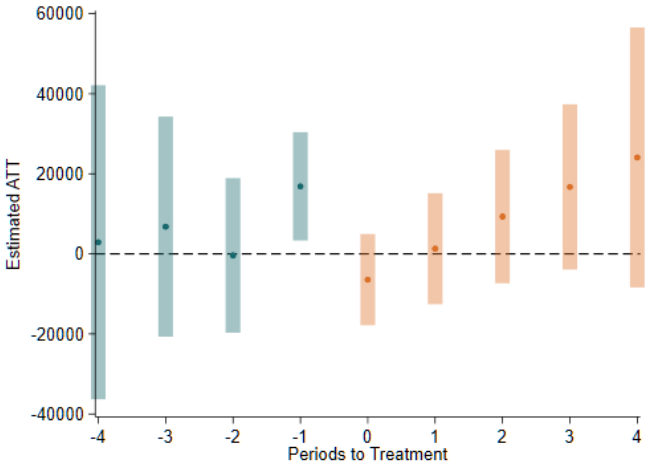
c. Outpatient



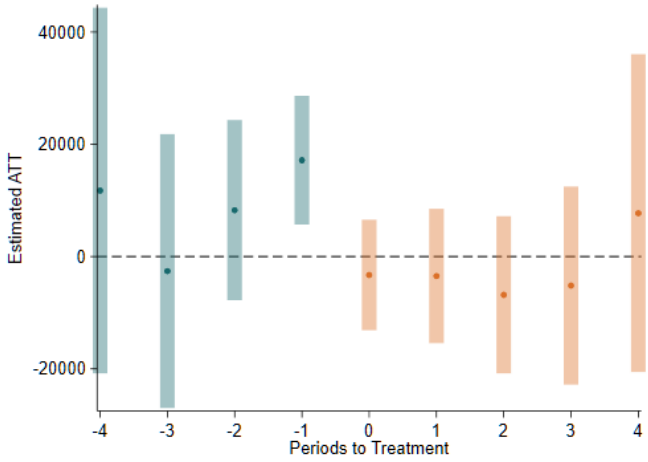
d. Professional Services

[a]Figures present the results of yearly ATTs based on the repeated cross-section version of Callaway & Sant'Anna (2020), without adjustment for physician fixed effects and without imposing balance in the physician-level panel. We exclude, separately for each outcome, observations in the upper and lower 5% of values.

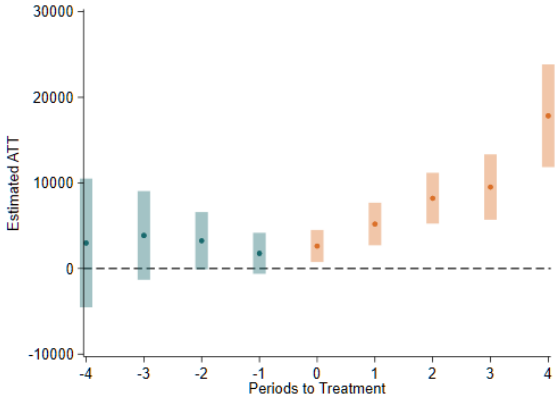
Figure App.6: **Event Studies for Total Payments**[a]
Balanced Panel with Fixed Effects



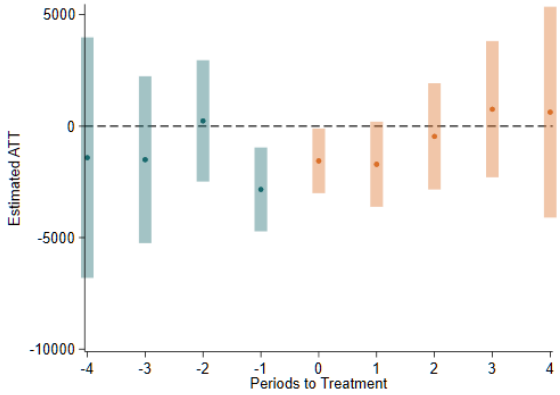
a. All Payments



b. Inpatient



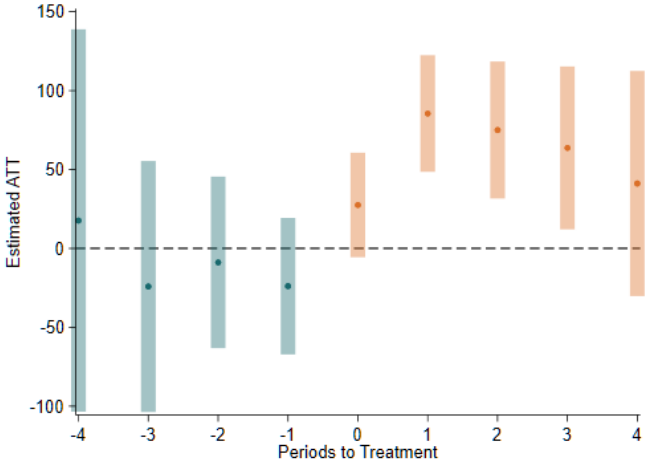
c. Outpatient



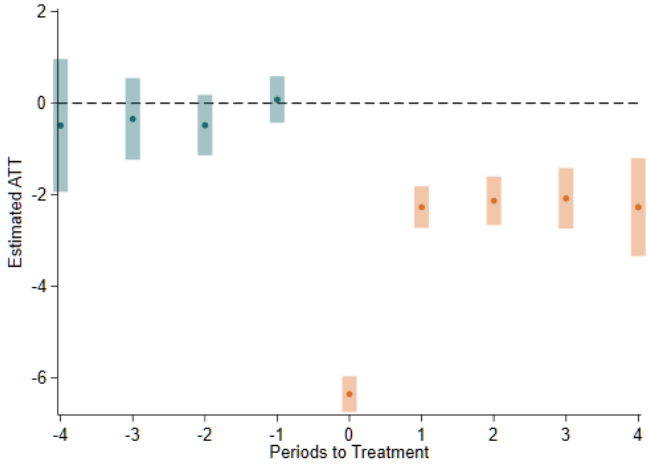
d. Professional Services

[a]Figures present the results of yearly ATTs based on the panel version of Callaway & Sant'Anna (2020), with adjustment for physician fixed effects and imposing pairwise balance in the physician-level panel. We exclude, separately for each outcome, observations in the upper and lower 5% of values.

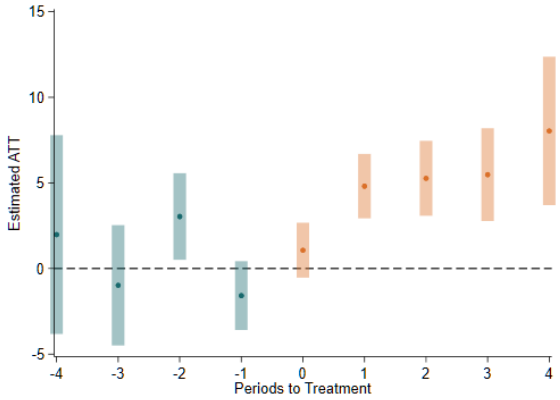
Figure App.7: **Event Studies for Total Claims**[a]
Unbalanced Panel and No Fixed Effects



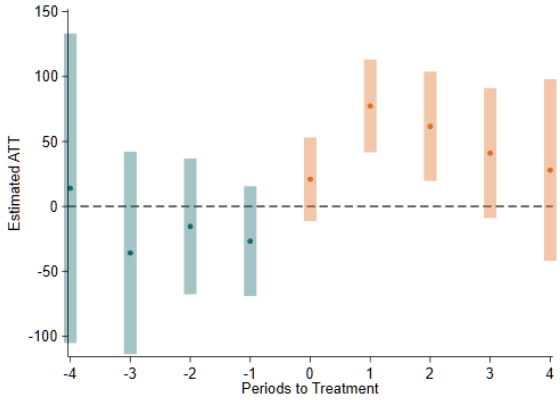
a. All Payments



b. Inpatient



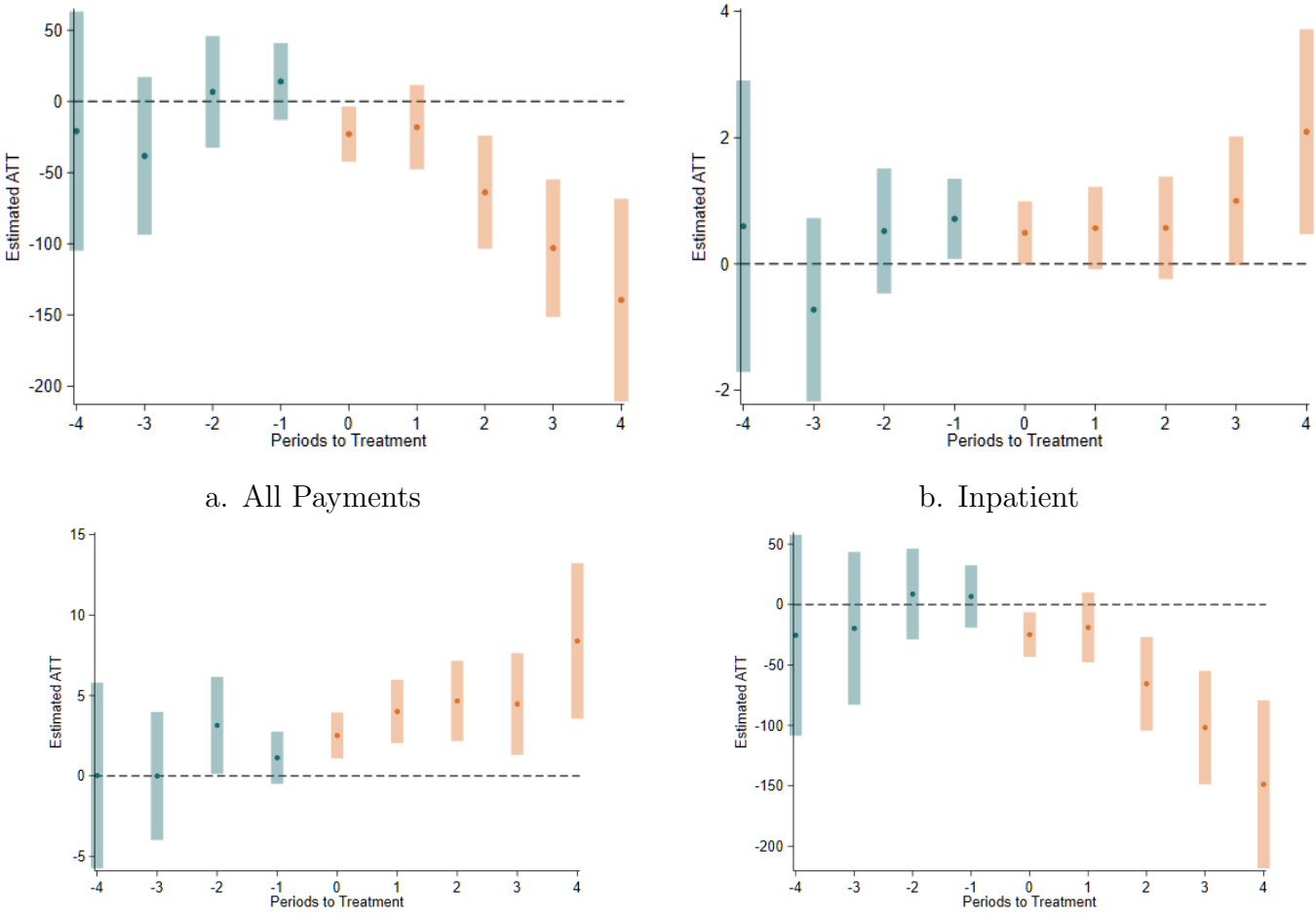
c. Outpatient



d. Professional Services

[a]Figures present the results of yearly ATTs based on the repeated cross-section version of Callaway & Sant'Anna (2020), without adjustment for physician fixed effects and without imposing balance in the physician-level panel. We exclude, separately for each outcome, observations in the upper and lower 5% of values.

Figure App.8: **Event Studies for Total Claims**[a]
Balanced Panel with Fixed Effects



a. All Payments

b. Inpatient

c. Outpatient

d. Professional Services

[a]Figures present the results of yearly ATTs based on the panel version of Callaway & Sant'Anna (2020), with adjustment for physician fixed effects and imposing pairwise balance in the physician-level panel. We exclude, separately for each outcome, observations in the upper and lower 5% of values.