More Ado about Nothing?

Questioning the Short and Long-term Effects of Data Breaches on Hospital Finances

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Definition

"A breach is ... an impermissible use or disclosure under the Privacy Rule that compromises the security or privacy of the protected health information." – Health and Human Services

NIH

"The frequency of healthcare data breaches, magnitude of exposed records, and financial losses due to breached records are increasing rapidly." – National Institute for Health 2020

News & Law

News:

- 112 million patients records breached in 2023 (Health IT Security.com)
- "Fifty-eight [data breach] lawsuits were filed in 2021, with 43 of them filed against healthcare organizations, the largest percentage among all industries." (HealthcareFinanceNews.com 2022)
- Johnson Memorial ransomware attack 2021 (NPR.org)
- OPM Hack of 21 million people included health data (OPM.gov)
- HCA Healthcare hack of 11 million patients (hcahealthcare.com)

Law:

- ARRA (American Recovery and Reinvestment Act of 2009)
- HITECH (Health Information Technology for Economic and Clinical Health Act of 2009)
- HIPAA (Health Insurance Portability and Accountability Act of 1996)
- ACA (Affordable Care Act of 2010)
- State Law (Mass 2006, Texas TDPSA 2023)

Literature

Majority of Papers:

- Trends: Rate ↑, Cost ↑
- Calls for accounting, reckoning, punishment
- Set optimal IT spending (Huang et al. 2014)
- Call for government action (Seh et al. 2020)

Causal Papers:

- 26% ↑ in hospital IT spending in the year after a breach (Choi & Johnson 2020)
- No change to hospital productivity (Choi et al. 2020)
- "Much Ado about Nothing: The (Lack of) Economic Impact of Data Privacy Breaches" found: "less than -0.3% cumulative abnormal financial returns" (Richardson et al. 2019)

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  - – Productivity
  - \+ or – Revenue, net income
  - \+ or – Wage index

Data Sources

Y

Healthcare Cost Report Information System (HCRIS)

- Yearly cost report
- 2009-2017
- 7,515 hospitals (90% of all US hospitals)
- Claims (Medicare & private)

X

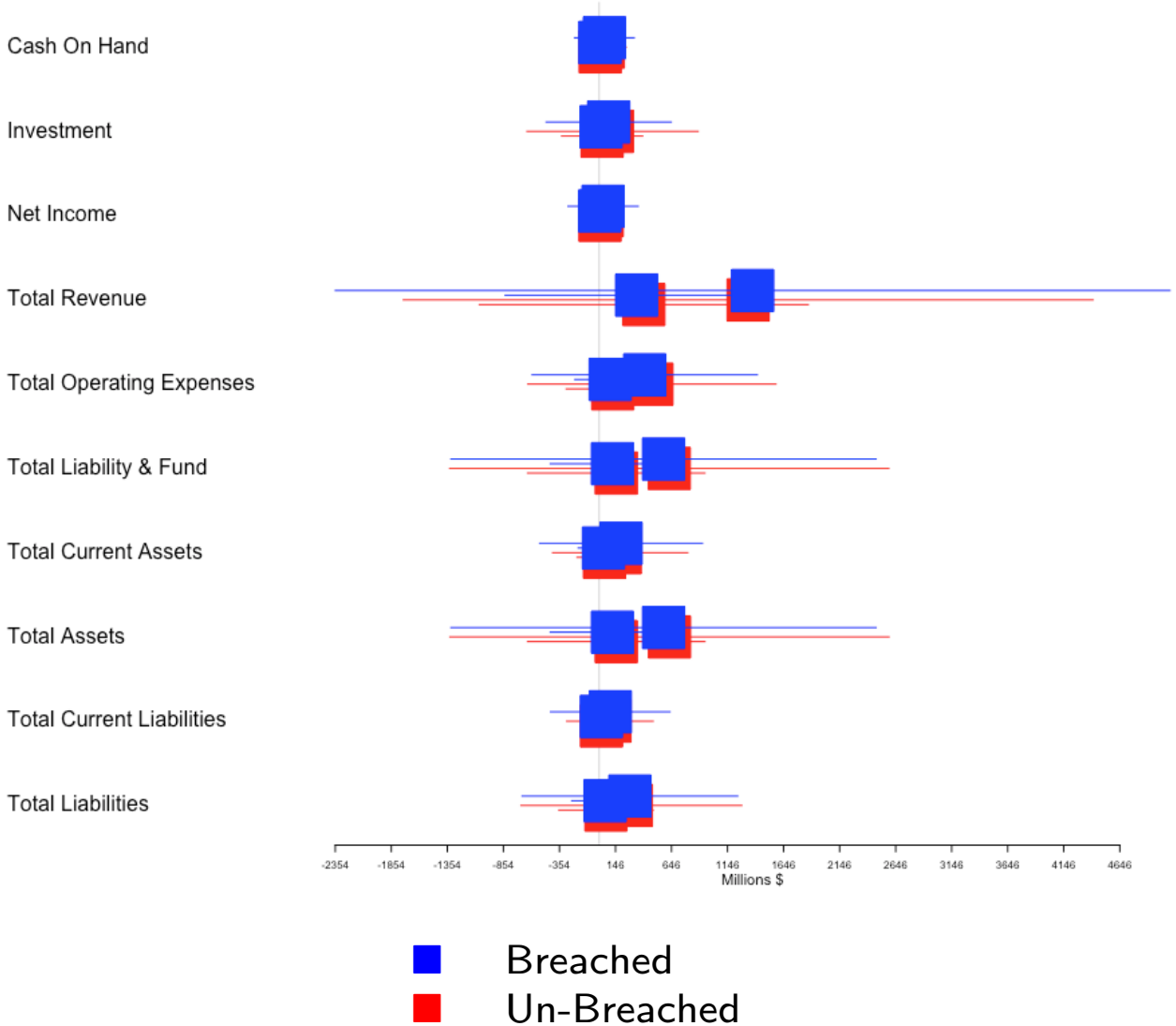
Health and Human Services (HHS)

- Mandatory report breach affecting 500+ people
- 2009-2018

Financial Indicators - Y (Averages at Hospital-Year level)

	Unbalanced Panel		Balanced Panel	
$ in Millions	Breached	Un-Breached	Breached	Un-Breached
	(1)	*(2)*	*(3)*	*(4)*
Cash On Hand	47.2	7.837	37.7	9.928
	(136)	(58.4)	(104)	(47)
Investment	85.8	17.0	120	27.1
	(285)	(92.1)	(390)	(185)
Total Revenue	1370	335	1330	399
	(1900)	(599)	(1570)	(749)
Total Current Liabilities	100	20.2	96.6	21.3
	(272)	(67.7)	(197)	(89.8)
Wage Index	1.017	0.968	0.980	0.963
	(0.190)	(0.186)	(0.139)	(0.182)
Beds (Average)	269	109	328	122
	(258)	(323)	(304)	(224)
Hospitals (Total)	599	6916	281	3407
Observations (N)	75,150		36,880	

Financial Indicators Plot - Y (Averages at Hospital-Year level)



Empirical Strategy

Difference in Differences:

- Callaway and Sant'anna Specification
- Two-Way Fixed Effects Specification
- Synthetic Difference in Differences Specification

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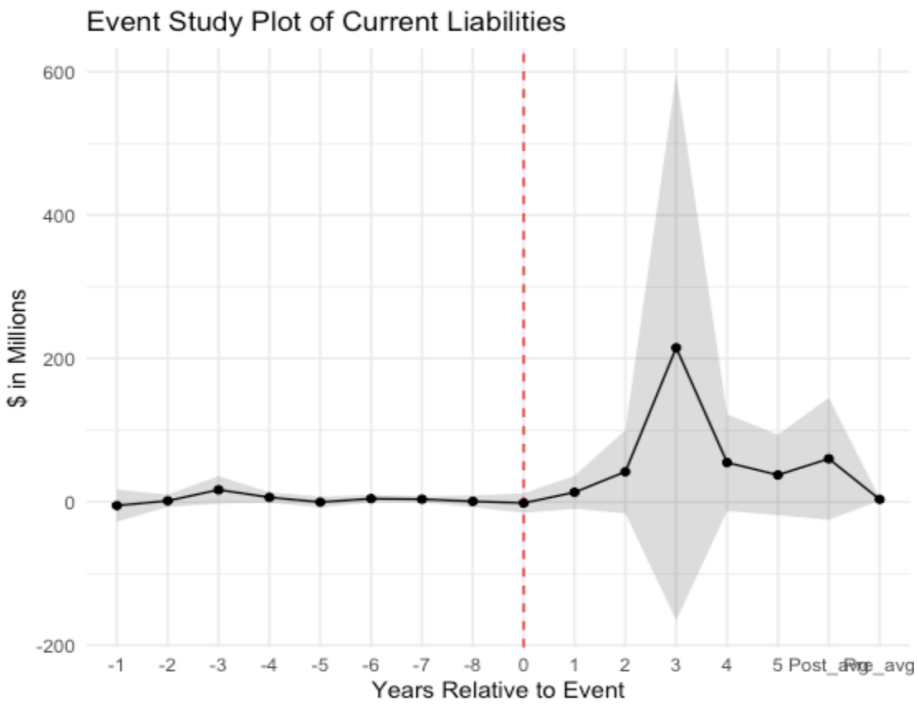
Research Question

What is the impact of a hospital data breach on hospital finances?

DiD with Multiple Time Periods

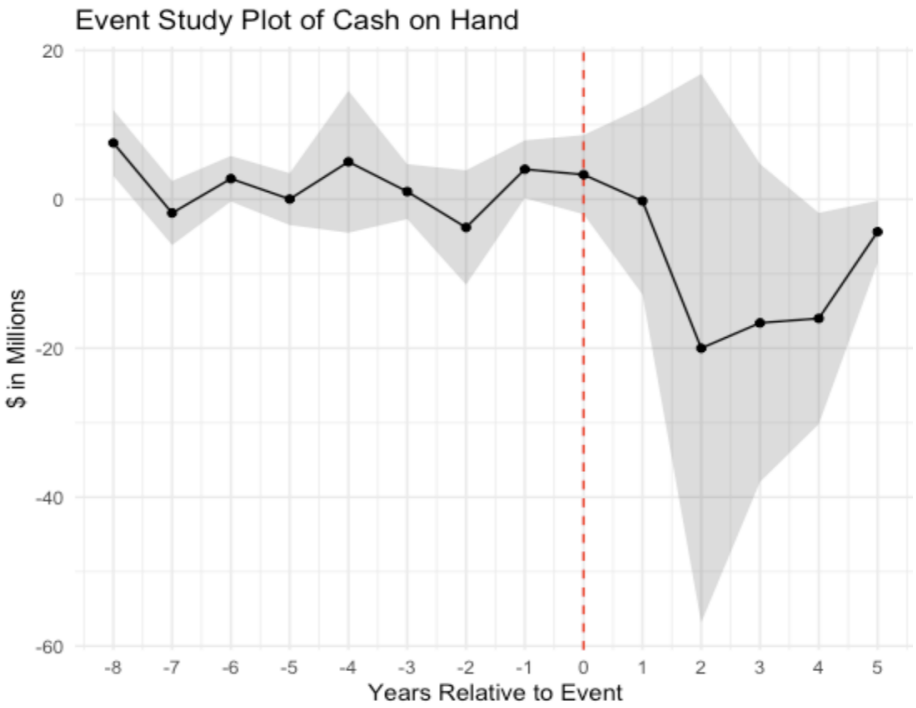
Estimated Effects of a Breach on Wage Index & Current Liabilities

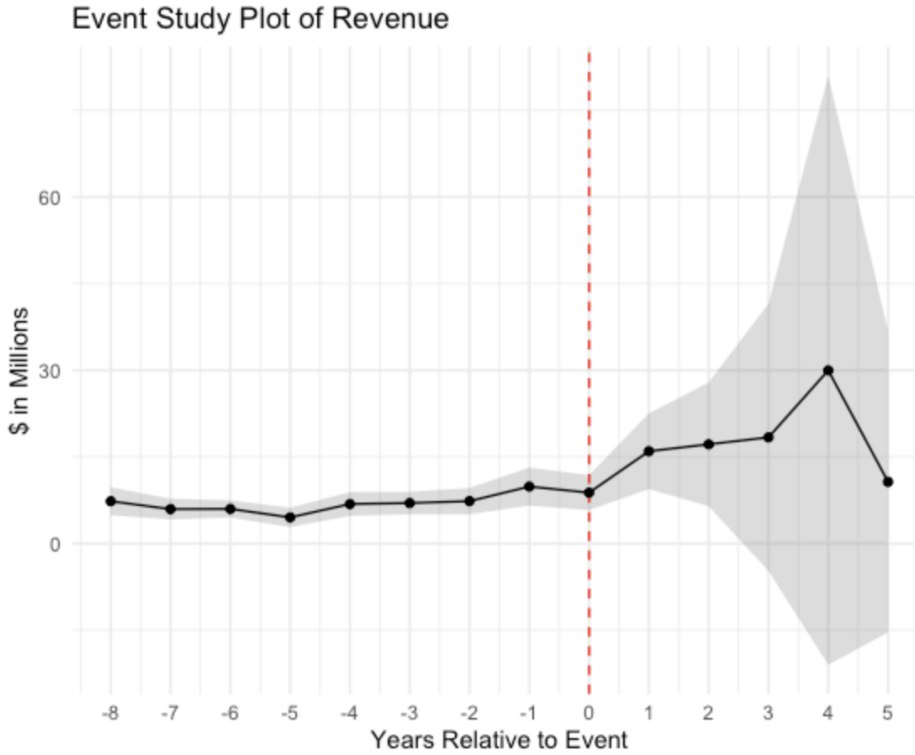


▸ See More Charts

DiD with Multiple Time Periods

Estimated Effects of a Breach on Cash on hand & Revenue





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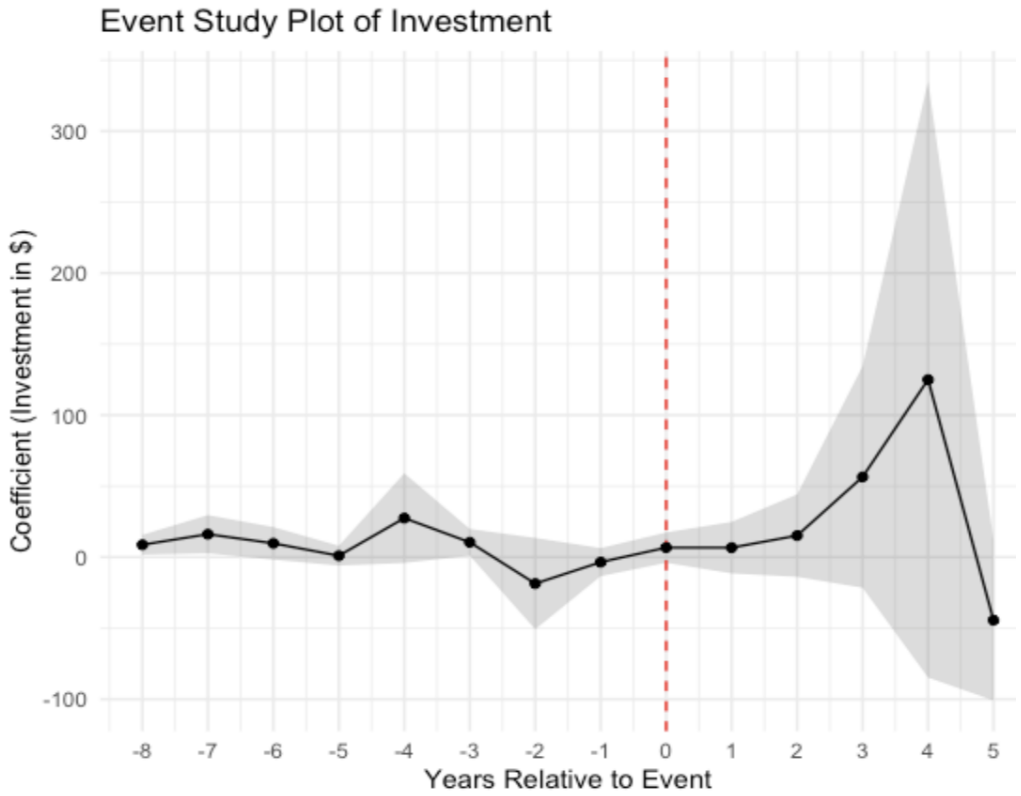
DiD with Multiple Time Periods

Estimated Effects of a Breach on Investment



Results Comparison

	CS	TWFE		
	Avg. Effect	Avg. Effect	Std. Er.	P-Value
Cash on Hand	-10.83	4.30	5.63	0.445
Investments	21.24	19.20	14.90	0.197
Total Revenue	99.30	344.00	47.10	0.001
Total Current Liabilities	56.64	21.20	9.00	0.018
Wage Index	0.000034	-0.0032	0.0022	0.150

Conclusion – More Ado about Nothing?

- Calls into question the (nearly) unanimous interpretation of descriptive and TWFE-based papers
- Breach effects are heterogeneous
- Costs diverge from and regress to "steady state"
- Existing financial mechanisms mitigate mid-term financial impacts.
- CS estimate $\rightarrow$ Hospital data breaches caused an 8.7% increase in average yearly revenue ($115.8 million increase from a baseline of $1.332 billion).
- Policy implications
- Future opportunities:
  - Estimate effects of breach size
  - Use pre-HITECH Act data to isolate the effect of the law
  - Heterogeneity
  - CMS data

Discussion

Questions?

Thank you!

Multi-time period difference in differences

Callaway and Sant'anna (CS)

$$\text{ATT}(g,t) = E\left[\left(\frac{G_g}{E[G_g]} - \frac{\frac{\hat{p}(X)}{C}}{1-\hat{p}(X)} \cdot \frac{1}{E\left[\frac{\hat{p}(X)}{C} \cdot \frac{1}{1-\hat{p}(X)}\right]}\right)(Y_t - Y_{g-1})\right] \quad (1)$$

- $ATT(g,t)$ is the Average Treatment Effect on the Treated for group g at time t
- G_g is an indicator variable that equals 1 if a hospital belongs to group g and 0 otherwise.
- C is an indicator that equals 1 if a hospital is in the control group at time t.
- $\hat{p}(X)$ represents a propensity score.
- X : Observed hospital characteristics
- Y_t and Y_{g-1} is the outcome variables for time t and the period before the breach for group g

Assumptions:

- ~~Constant treatment effects~~
- Irreversibility of treatment
- Random sampling (iid)
- Limited treatment anticipation
- Conditional parallel trends from "Not-Yet-Treated" or "Never-Treated" Group
- Stable Unit Treatment Value Assumption (SUTVA)

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Two-Way Fixed Effects – TWFE

$$\text{ATT}_{it} = \beta_0 + \beta_1 \text{Breach}_{it} + \alpha_i + \delta_t + \varepsilon_{it} \quad (2)$$

- $ATT(g, t)$ is the Average Treatment Effect on the Treated
- Breach_{it} : Breach indicator
- α_i : Hospital fixed effects
- δ_t : Year fixed effects

Assumptions:

- Parallel trends
- Constant treatment effect over time (else possible negative weights)
- Limited treatment anticipation
- Exogenous treatment timing
- Stable Unit Treatment Value Assumption (SUTVA)

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Synthetic Difference in Differences

Clarke et. al. Synth-DID

$$\hat{\tau}_{\text{sdid}} = \arg\min_{\mu,\alpha,\beta,\tau} \sum_{i=1}^{N}\sum_{t=1}^{T} (Y_{it} - \mu - \alpha_i - \beta_t - W_{it}\tau)^2 \hat{\omega}_{\text{sdid},i}\hat{\lambda}_{\text{sdid},t} \tag{3}$$

- $\hat{\tau}_{\text{sdid}}$: average treatment effect on the treated (ATT)
- arg min: minimizes the sum of squared differences for $(\mu, \alpha, \beta, \tau)$
- μ is the overall intercept
- α_i is the fixed effect for hospital i
- β_t represents fixed effect for time period t
- W_{it} is the treatment indicator for hospital i at time t
- τ is the parameter of interest
- Y_{it} is the outcome variable for hospital i at time t
- $\hat{\omega}_{\text{sdid},i}$ and $\hat{\lambda}_{\text{sdid},t}$ weights for hospital i time t

Assumptions:

- ~~Parallel trends~~
- ~~Constant treatment effects~~
- Limited treatment anticipation
- Exogenous treatment timing
- Stable Unit Treatment Value Assumption (SUTVA)

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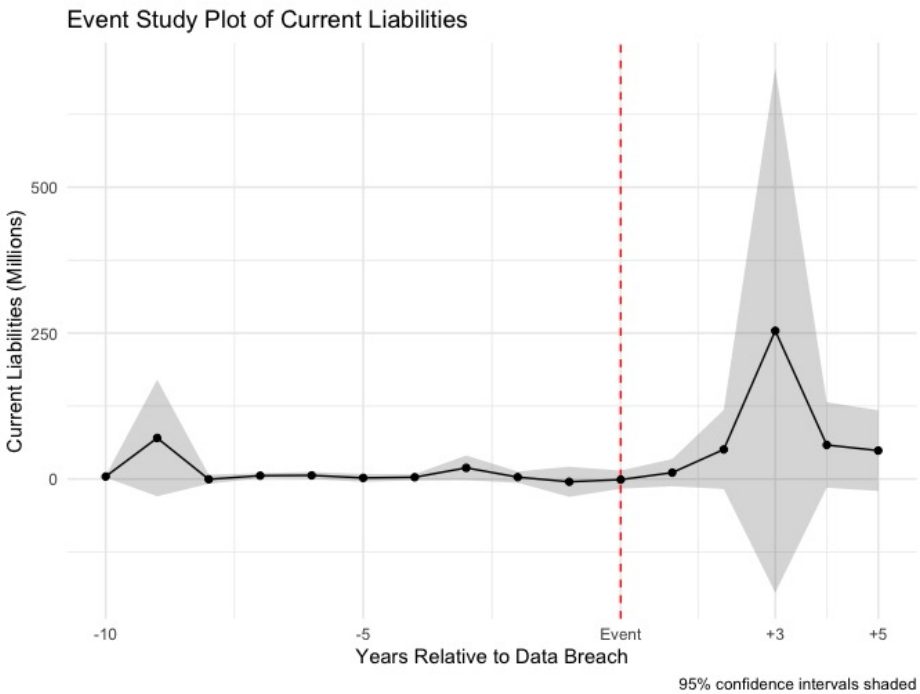
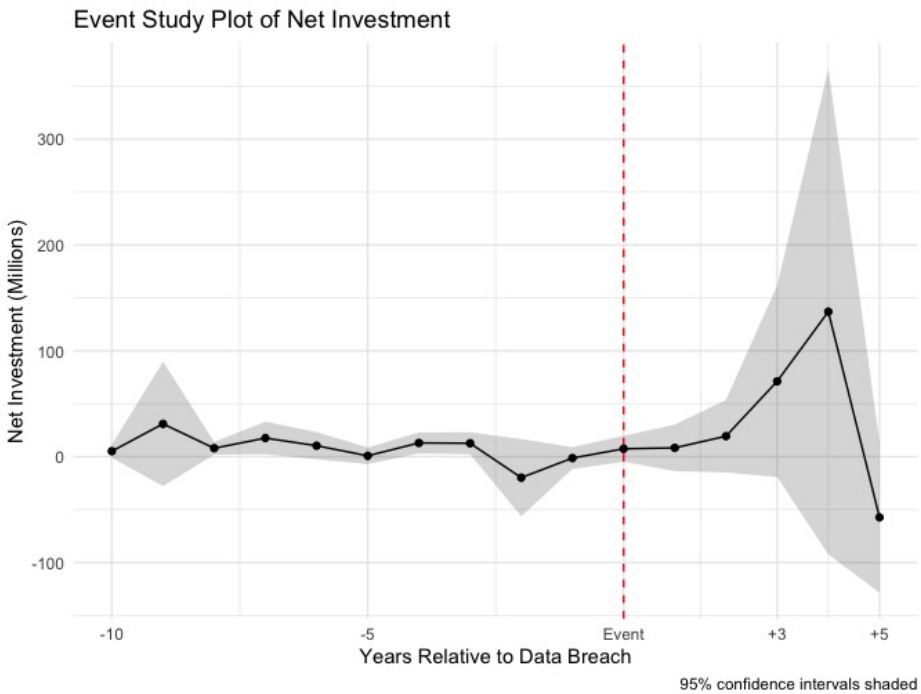
DiD with Multiple Time Periods - Detailed Charts 1/4





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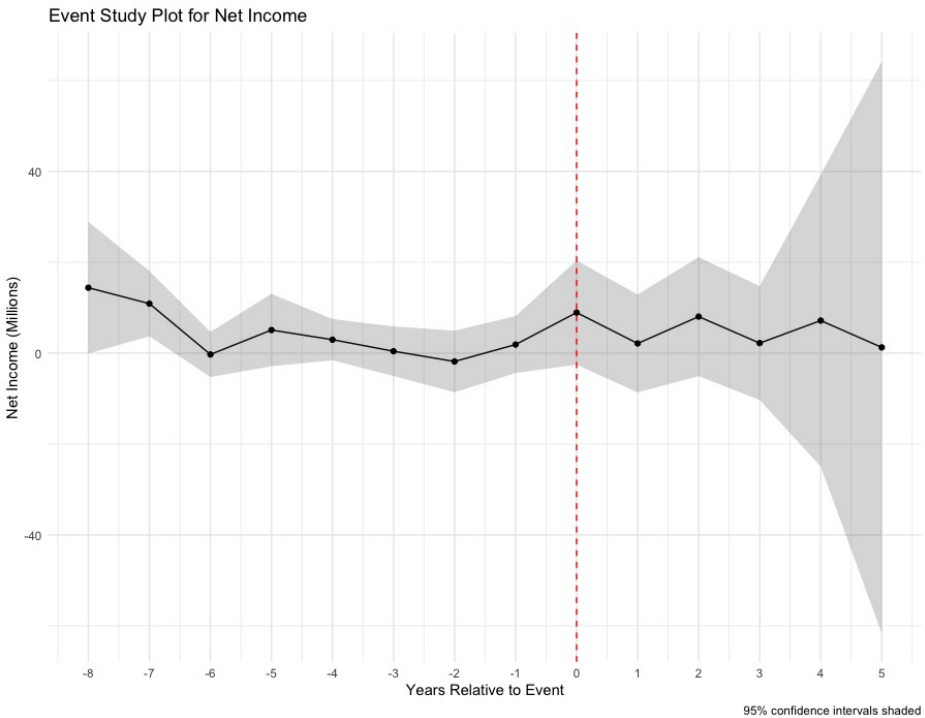
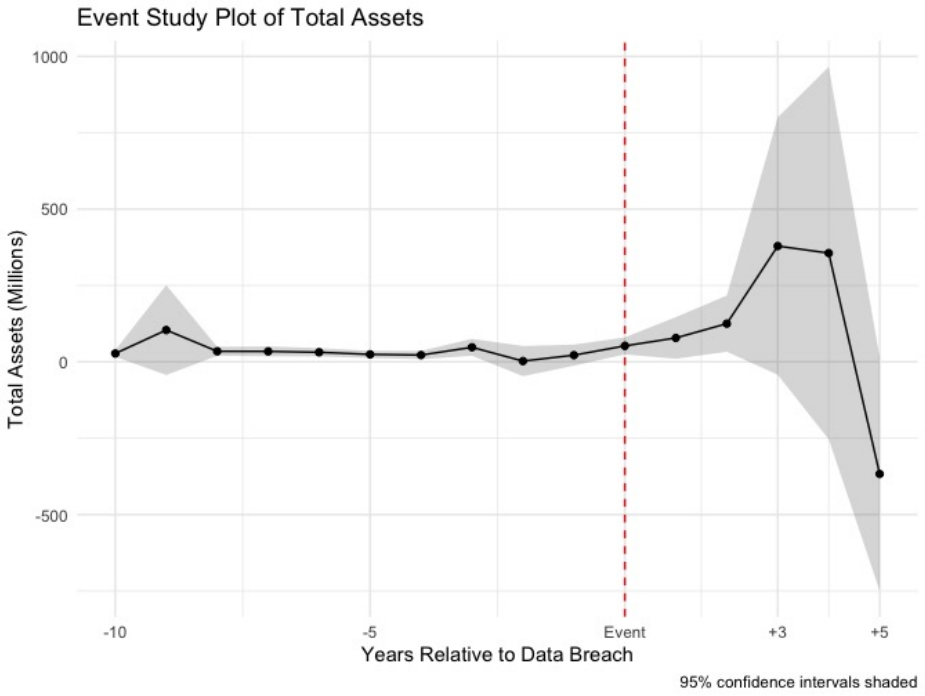
DiD with Multiple Time Periods - Detailed Charts 2/4





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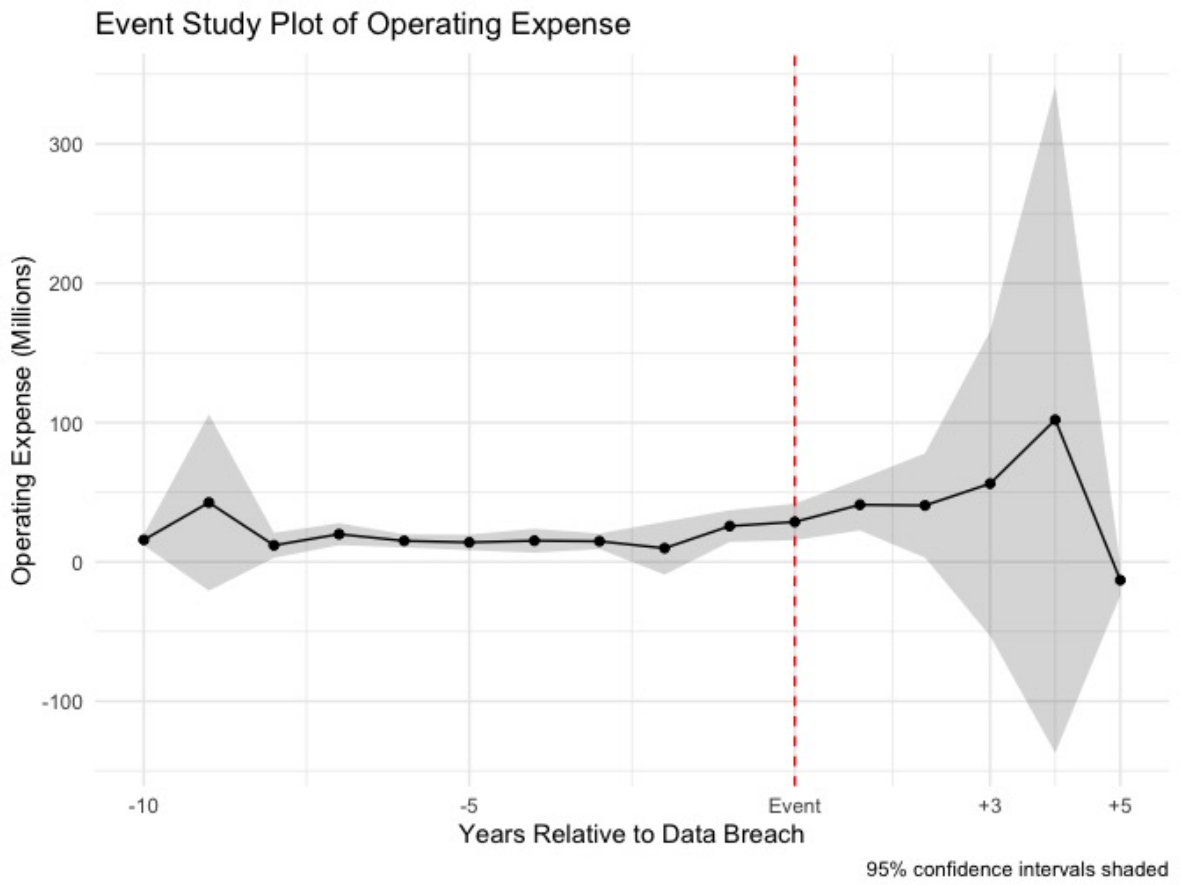
DiD with Multiple Time Periods - Detailed Charts 3/4



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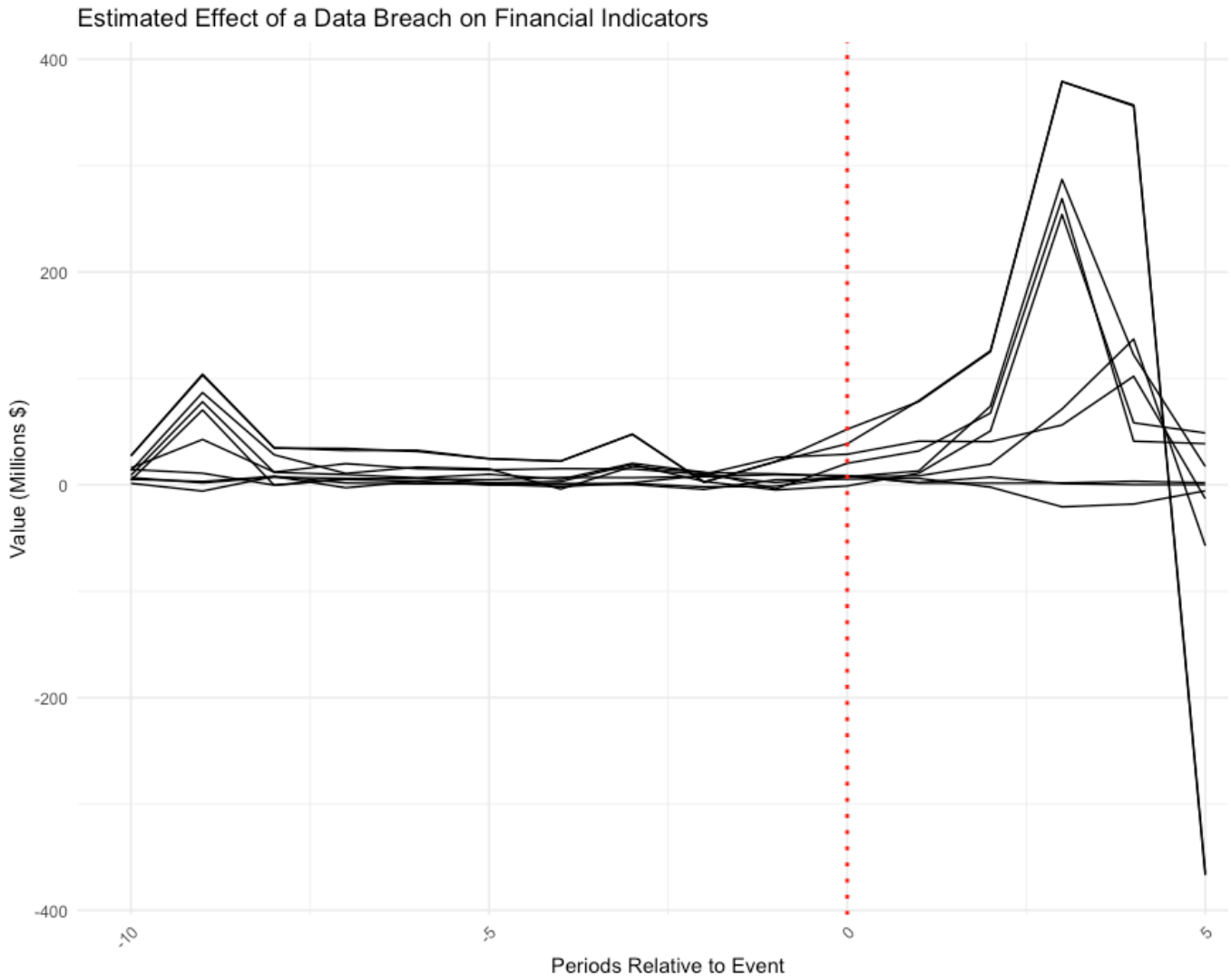
DiD with Multiple Time Periods - All Detailed Charts 4/4



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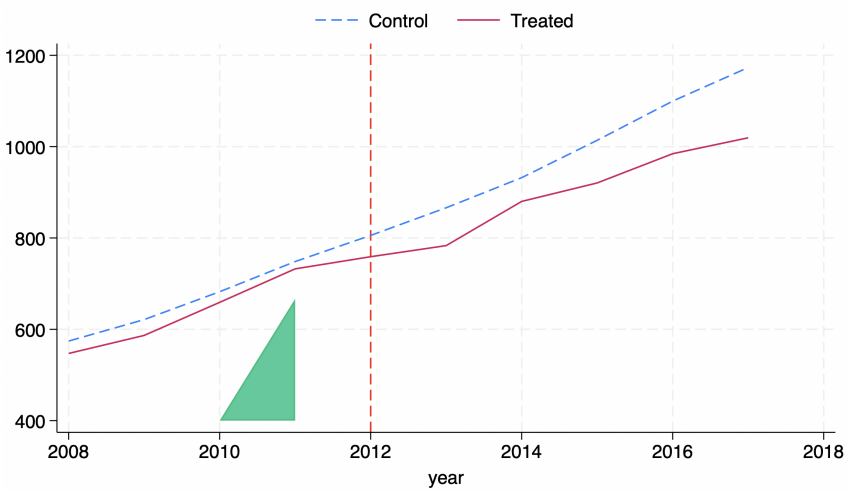
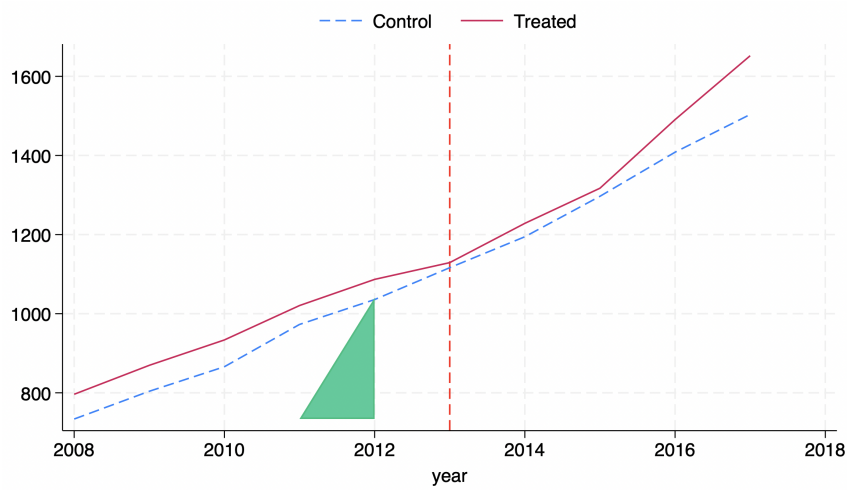
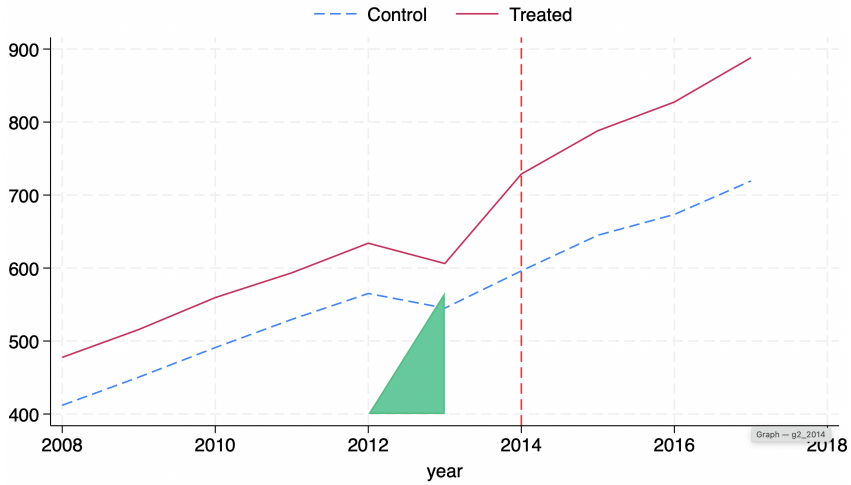
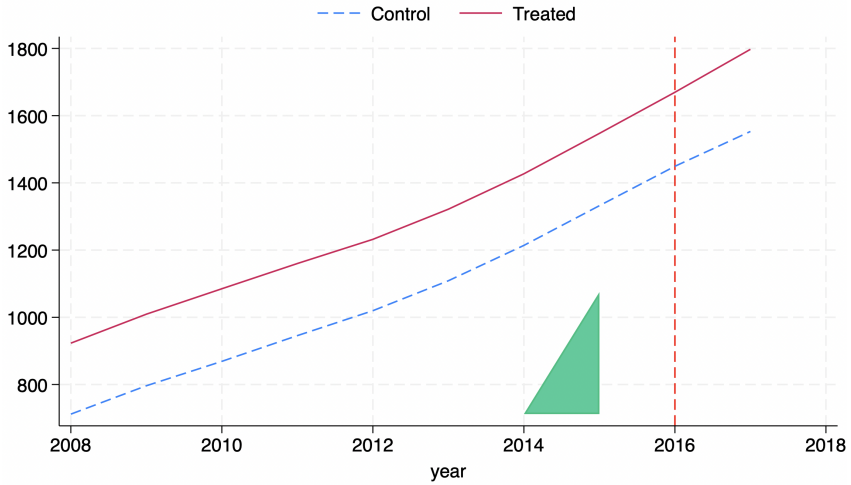
Synthetic DiD

Revenue ($ Millions)









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