Airline Hub Airports and Local Economic Outcomes

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Disclaimer

This work is the result of the author's independent research while at Middlebury College and the University of California, Berkeley, and does not necessarily represent the views of the Consumer Financial Protection Bureau or the United States. All errors are my own.

BIG QUESTION

How does the availability and quality of infrastructure affect economic outcomes at the local level?

This paper: **How does the INTENSITY/QUALITY of a transportation investment, as proxied by an airlines' investment in its hub airports, affect local economic outcomes?**



Dulles International Airport, Washington, DC. Courtesy Wikimedia Commons.

Atlanta vs. Birmingham

Example: Atlanta, GA vs. Birmingham, AL



Atlanta vs. Birmingham

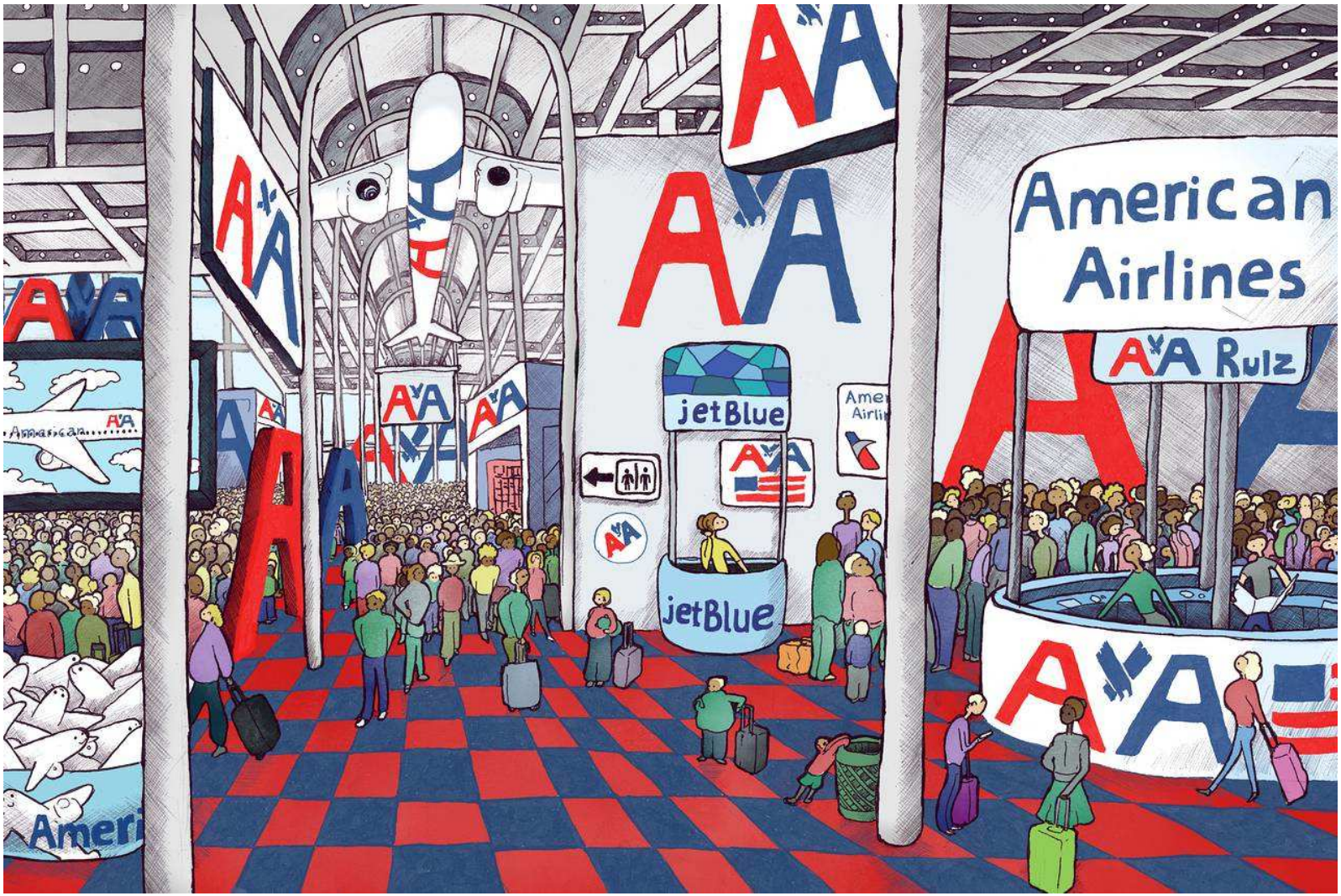
Example: Atlanta, GA vs. Birmingham, AL

"Natural" experiment:

- Two major southern cities located within 150 miles of each other with otherwise similar fundamentals
- Post-Civil-War, Birmingham had natural resource advantage (iron ore, coal and limestone) and faster population growth pre-1930. Populations roughly equal in 1930
- Delta 1940 agreement with CAB - If Delta serves destitute communities in rural south, can fly more and longer routes from Atlanta
- Eastern Air Lines establishes Birmingham mini-hub around 1950; but did not overcome Delta early advantage
- Atlanta now has a population four times that of Birmingham; this massive growth started in 1950s

Charlotte, NC

American Airlines Hub Operating Continuously Since Deregulation



Source: McCartney, Scott."Why an American Airlines Monopoly Works for Charlotte." Wall Street Journal, 2/21/18

Charlotte-Douglas Intl. (CLT) NC

History

- Charlotte, NC: "The city deregulation built"
- Piedmont Airlines established a hub in 1979
- 1989 - Piedmont merged into US Air. Remains a hub through 2005 acquisition of America West, and its 2013 US Airways merger

Outcome

- Establishment of a hub airport, especially early on, could be hugely transformative
- Likely to remain important, even after being acquired by American (banking sector, lucrative business passengers, low operational costs)
- Recent WSJ article notes higher-than-average fares as a trade-off for convenience, but airport management fears adding more competition could encourage American to abandon hub.
    - Corporate contracts, loyalty programs, high proportion of business travelers all salient features of the hub

This Study

- Changes in air traffic provide an avenue for understanding how air traffic, and the quality of air service, might impact economic development
- Use hub opening and hub closing events as source of variation for identification of airport size/intensity of operations on local economic outcomes
  - IO activity - mergers, acquisitions, bankruptcies leading to hub closures;
  - Examine sector-specific employment, payroll, wage outcomes
- Define "Hub" as referred to by airlines in public-facing documentation - financial documents, websites, newspaper articles, etc.
- Estimate effects using OLS panel diff-in-diff; extension of event study framework using synthetic controls

Preview of Findings

- Hypothesis: Hub airports are a "productive amenity", from which firms benefit more than consumers;
  - If true, expect higher wages, higher output measures, higher rents
- Main findings - Hub airports increase:
  - Per-worker wages by average amounts of 1.1 to 1.8 percent
  - Mixed findings on economic output measures - where increases are observed, average amounts 1.7 to 4.3 percent.
    - Outcomes substantiated more for hub openings than for hub closings
    - Hub closings appear to have large effects on employment in amusements and recreation; tourism may be particularly sensitive to hub closings

Outline of Talk

1. Introduction
   - Background
   - Literature
2. Data and Methods
   - Data
   - Methods
3. Results
   - Panel Regression Results
   - Synthetic Control Event Study Results
4. Conclusion
   - Conclusion

Related Literature

Airport Hubs as Centers of Regional Activity

- Magnets for high-tech / innovative activity: Button and Lall (1999), Button and Stough (2000)
- Network effects: Neal (2010; 2011a; 2011b)
- "The Aerotropolis": Kasarda and Lindsay (2011)
- Airport Location and Corporate Headquarters: Bel and Fageda (2008)
- Airports and Local Economic Development: Brueckner (2003), Green (2007), Button et. al (2010), Blonigen and Cristea (2012), Sheard (2014), Cristea (2015), Sheard (2015)

Hubs and Hub "Shocks"

- Focus is on traditional hub-and-spoke mainline carriers
  - Southwest has "focus cities", I control for the presence of these in my estimations, as well as for whether an airport is considered a "cargo hub" by UPS or FedEx;
  - Estimate for all carriers, and "major" carriers, predecessor airlines of American, Delta or United;
- Database of airline hub openings and closures constructed by examining airline web sites, annual financial reports, newspaper articles, aviation trade publications and other historical sources
- Events affecting hubs, e.g. airline mergers, bankruptcies, and acquisitions - follow list compiled by Airlines for America, airline trade group

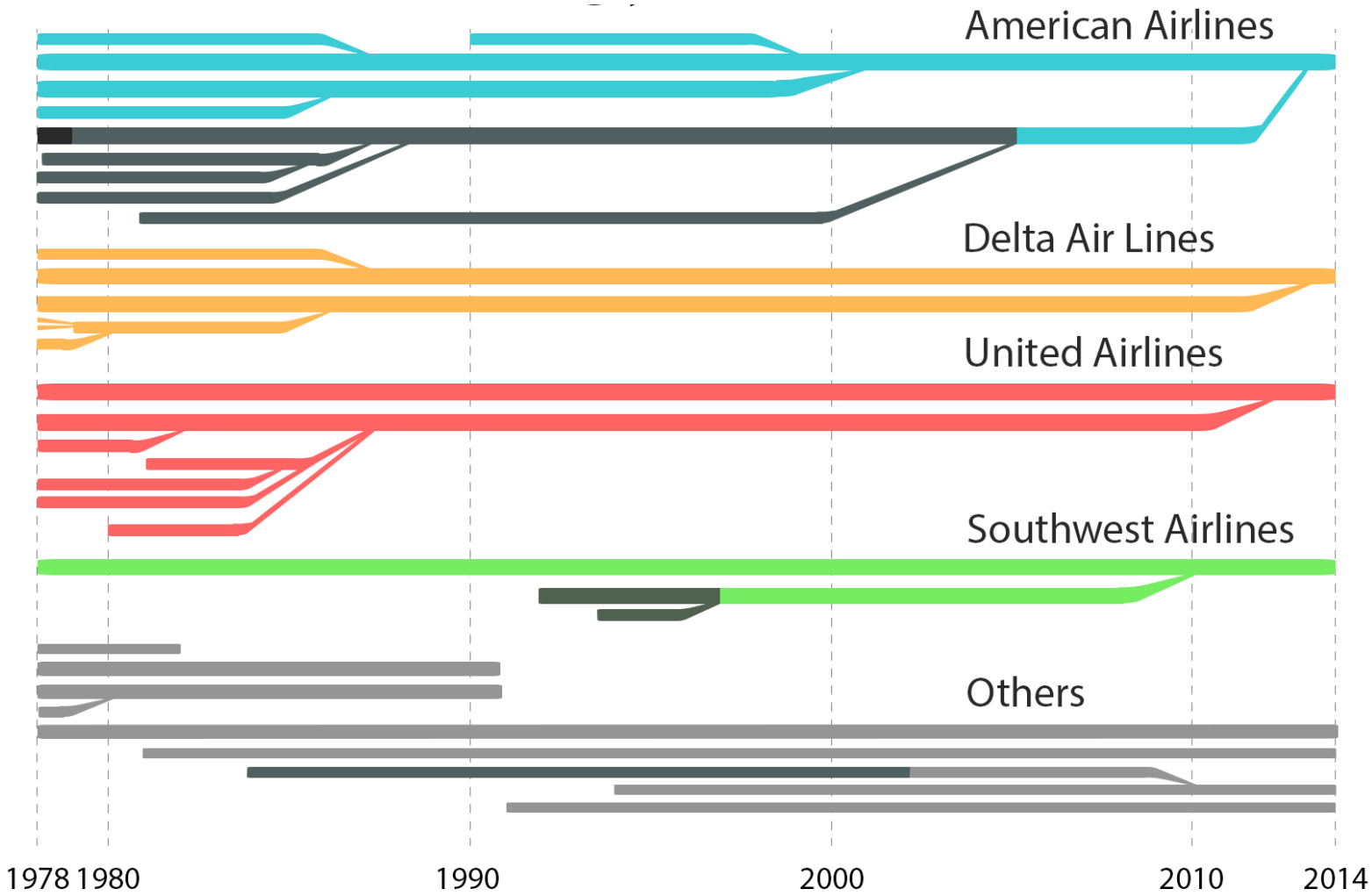
City Outcome Variables

- Panel data set consisting of city's airport hub status (by year), passenger enplanements and operations, market access measures, employment and payroll measures from 1964 to 2012
  - Air traffic data from FAA via Severin Borenstein's Domestic DB1A "Broadened Market Dataset"
  - Dependent variables on employment, etc. from County Business Patterns, 1978 - 2012
  - Population and income measures from Bureau of Economic Analysis, 1978-2012.
  - Unit of observation: CBSA (Metropolitan Statistical Area)

Selection of Hub Airports

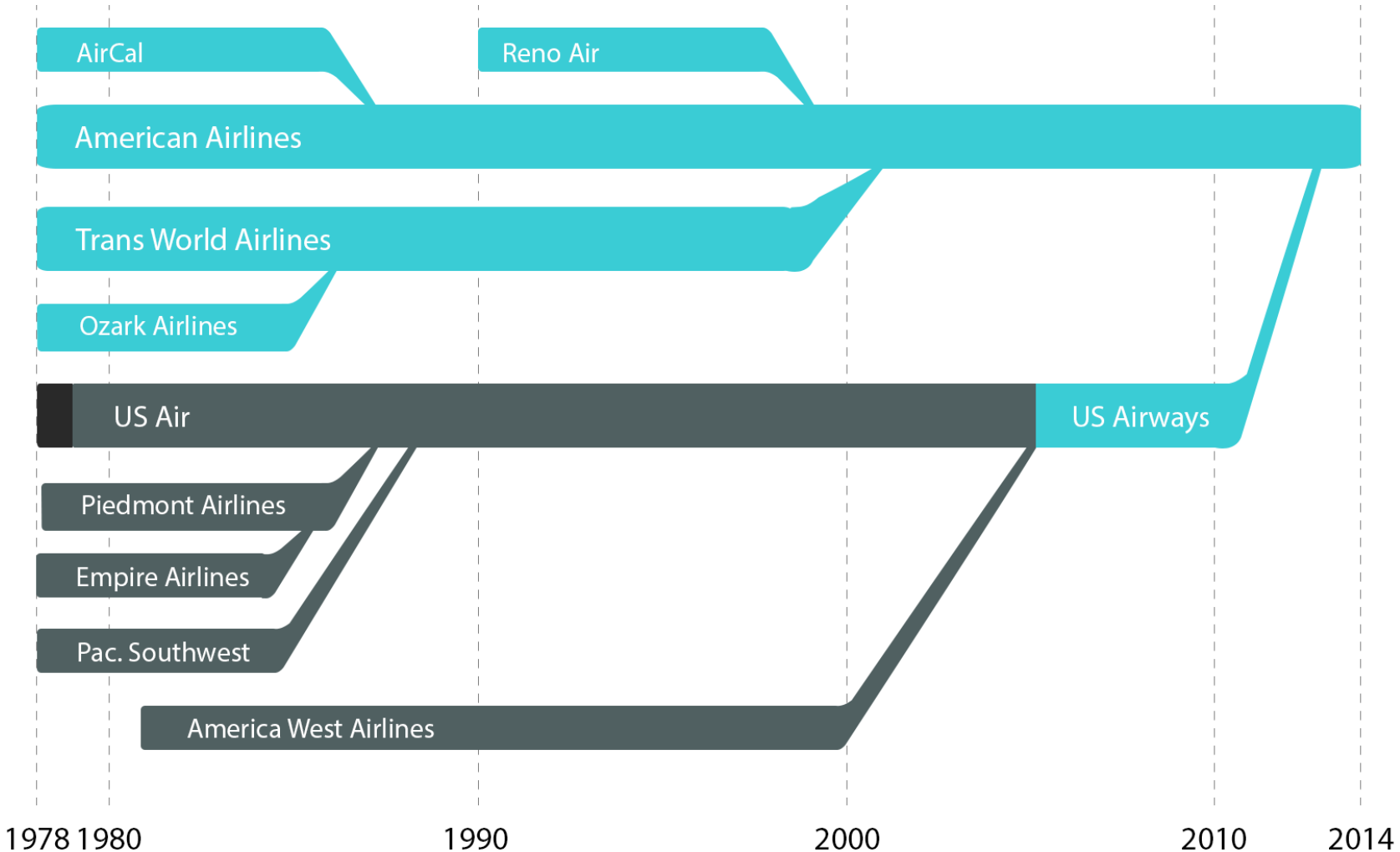
- Airports selected based on passenger traffic
  - Considered all airports that carried at least 0.1 percent of air traffic in 1977
  - Dropped airports in multiple airport cities
- Final sample of 85 airports.
  - 30 were hub airports for some part of their history
  - 21 were "major" hub airports
  - 14 hubs have subsequently closed as of 2012

Airline Genealogy (All)



Color shading corresponds to the eventual major airline individual predecessor airlines would merge into.

Airline Genealogy (American Airlines Family)



Color shading corresponds to the eventual major airline individual predecessor airlines would merge into.

Hubs that Have Closed as of 2012

Airport Code	Airport Name	City	State	Opened	Closed	Psgr	Flights
BNA	Nashville Intl	Nashville	TN	1987	1995	2.72	91
BOI	Boise Air Terminal/Gowen Fld	Boise	ID	1983	2003	0.62	28
BWI	Baltimore/Washington Intl	Baltimore	MD	1983	2003	5.34	147
CMH	Port Columbus Intl	Columbus	OH	1991	2003	1.88	59
COS	City Of Colorado Springs Muni	Colorado Springs	CO	1995	1997	0.63	22
DAY	James M Cox Dayton Intl	Dayton	OH	1982	1992	1	55
LAS	Mc Carran Intl	Las Vegas	NV	1986	2008	10.8	230
MCI	Kansas City Intl	Kansas City	MO	1985	2009	3.81	120
OMA	Eppley Airfield	Omaha	NE	1994	2002	1.17	42
PIT	Pittsburgh Intl	Pittsburgh	PA	1979	2004	5.88	187
RDU	Raleigh-Durham Intl	Raleigh/Durham	NC	1987	2003	2.56	79
RNO	Reno/Tahoe Intl	Reno	NV	1992	1999	1.74	50
SAN	San Diego Intl	San Diego	CA	1978	1988	5.34	119
SJC	Norman Y. Mineta San Jose Intl	San Jose	CA	1988	2012	3.24	92
STL	Lambert-St Louis Intl	St Louis	MO	1980	2003	7.85	230
SYR	Syracuse Hancock Intl	Syracuse	NY	1983	1991	0.8	37

Hubs that Remain Open as of 2012

Airport Code	Airport Name	City	State	Opened	Psgr	Flights
ATL	Hartsfield - Jackson Atlanta Intl	Atlanta	GA	1978	23.82	600
BOS	General Edward Lawrence Logan Intl	Boston	MA	2005	8.64	214
CLE	Cleveland-Hopkins Intl	Cleveland	OH	1978	3.33	118
CLT	Charlotte/Douglas Intl	Charlotte	NC	1979	6.67	203
CVG	Cincinnati/Northern Kentucky Intl	Covington	KY	1986	3.52	132
DTW	Detroit Metropolitan Wayne County	Detroit	MI	1984	9.18	249
JFK	John F Kennedy Intl	New York	NY	1992	8.19	242
LAX	Los Angeles Intl	Los Angeles	CA	1999	17.07	415
MCO	Orlando Intl	Orlando	FL	2008	8.49	182
MEM	Memphis Intl	Memphis	TN	1985	3.06	174
MKE	General Mitchell Intl	Milwaukee	WI	1985	1.91	72
MSP	Minneapolis-St Paul Intl	Minneapolis	MN	1978	9.14	240
ORD	Chicago O'Hare Intl	Chicago	IL	1979	25.53	604
PDX	Portland Intl	Portland	OR	1980	3.49	106
PHL	Philadelphia Intl	Philadelphia	PA	1985	6.93	205
PHX	Phoenix Sky Harbor Intl	Phoenix	AZ	1983	10.62	271
SEA	Seattle-Tacoma Intl	Seattle	WA	1980	7.86	194
SFO	San Francisco Intl	San Francisco	CA	1978	11.66	272
SLC	Salt Lake City Intl	Salt Lake City	UT	1982	5.34	136

Top Control Non-Hub Airports, By Traffic

Airport Code	Airport Name	City	State	Psgr	Flights
SMF	Sacramento Intl	Sacramento	CA	2.58	67
SAT	San Antonio Intl	San Antonio	TX	2.47	74
IND	Indianapolis Intl	Indianapolis	IN	2.32	91
AUS	Austin-Bergstrom Intl	Austin	TX	2.18	66
BDL	Bradley Intl	Windsor Locks	CT	2.09	61
BUF	Buffalo Niagara Intl	Buffalo	NY	1.6	57
JAX	Jacksonville Intl	Jacksonville	FL	1.53	48
ELP	El Paso Intl	El Paso	TX	1.29	45
OKC	Will Rogers World	Oklahoma City	OK	1.25	44
TUS	Tucson Intl	Tucson	AZ	1.24	39
PVD	Theodore Francis Green State	Providence	RI	1.21	35
TUL	Tulsa Intl	Tulsa	OK	1.13	43
SDF	Louisville Intl-Standiford Field	Louisville	KY	1.07	79
BHM	Birmingham-Shuttlesworth Intl	Birmingham	AL	0.92	35
ROC	Greater Rochester Intl	Rochester	NY	0.88	38
GEG	Spokane Intl	Spokane	WA	0.84	34
ALB	Albany Intl	Albany	NY	0.75	26
GSO	Piedmont Triad Intl	Greensboro	NC	0.75	36
LIT	Bill And Hillary Clinton National/Adams Fi	Little Rock	AR	0.74	27
SRQ	Sarasota/Bradenton Intl	Sarasota/Bradenton	FL	0.6	17
DSM	Des Moines Intl	Des Moines	IA	0.52	27
CHS	Charleston Afb/Intl	Charleston	SC	0.51	21
GRR	Gerald R. Ford Intl	Grand Rapids	MI	0.51	22

Baseline: OLS Fixed Effects Regression

- Panel FE, city-specific linear trends, controls for industrial mix (employment shares), Southwest Airlines and cargo airline activity included
  - Inclusion of city-specific time trends allows identification of effects based only on sharp deviations in the data from trend
- May not necessarily resolve all endogeneity concerns, even with full set of controls
- Attenuation bias a major concern as panel methods particularly susceptible

Baseline: OLS Fixed Effects Regression

- Identifying Assumption: Hub openings and closures due to changes in the network structure resulting from industrial organization-related activity.
- Specification (with CBSA/airport as unit of observation):

$$Y_{it} = \alpha + \beta(H_{it} = 1) + \zeta E_{it} + \nu S_{it} + \kappa C_{it} + \gamma_i + \tau_t + \eta_i \cdot (time) + \varepsilon_{it}$$

where β identifies the (log) change in the employment, payroll, population or aviation-related outcome of interest Y_{it}; γ_i is a city fixed effect and τ_t is a year fixed effect. E_{it} is a vector of employment shares in key industries. S_{it} and C_{it} are indicators for a Southwest Airlines focus city and cargo hub, respectively. η_i identifies city-specific time trends.

Synthetic Control Event Study Analysis

- Synthetic units created individually based on technique in Abadie and Gardeazabal (2003), Abadie et. al (2010)
- Matches made such that treated and synthetic control unit have similar outcomes and trend five years before hub opening (3 years before hub closing)
- Incorporates much of same information as panel OLS, e.g. city-specific trends, industrial mix
- Unable to incorporate information on Southwest Airlines or cargo activity due to nature of estimator and limited variability over short time horizons considered
  - Rather, use historical airport information (whether city had an airport in 1926, whether city had an air mail stop in 1938) to fine-tune matches

More on Synthetic Controls

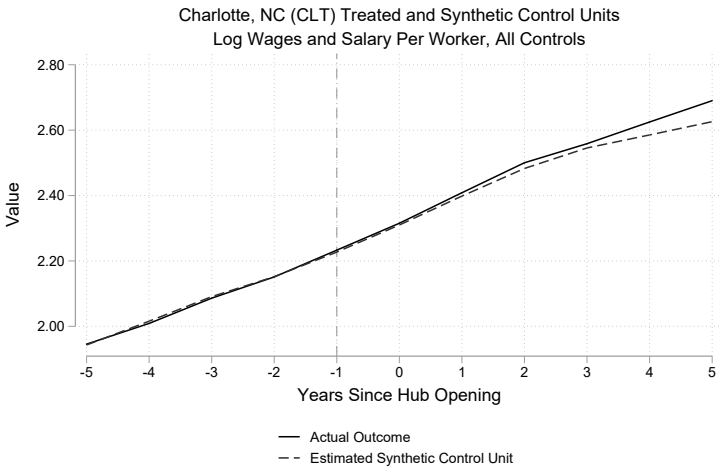
- Goal: Estimate a "counterfactual" outcome for each airline-hub-airport CBSA that could then be used to estimate treatment effect
- Find a set of weights on control CBSAs (W) (based on the given covariates, V) such that the synthetic unit replicates the observed unit in the pre-period
- Algorithm chooses optimal weights W^* that minimizes the mean square prediction error (MSPE) given by

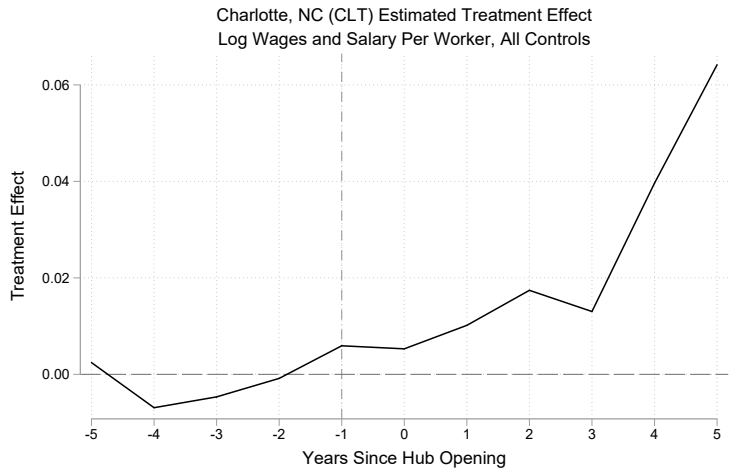
$$\|X_1 - X_0 W\|_V = \sqrt{(X_1 - X_0 W)^T V (X_1 - X_0 W)}$$

where:

- $W = (w_2, ..., w_{C+1})^T$ is a $(C \times 1)$ vector of positive weights that sum to 1.
- X_1 is a $(k \times 1)$ vector containing a set of pre-intervention characteristic values
- X_0 is a $(k \times C)$ matrix collecting the values of the same variables for the non-airline-hub airport CBSAs in donor pool

Sample Synthetic Unit: Charlotte





Top-Weighted Components of Synthetic Unit (with "W" weights)

0.758 Charleston-North Charleston-Summerville, SC Metro Area

0.151 Sioux Falls, SD Metro Area

0.091 Harrisburg-Carlisle, PA Metro Area

Pooled Synthetic Control Estimation

Estimation Process:

- Step 1: Compute the synthetic unit for each airport CBSA
- Step 2: Pool treated and estimated synthetic control units
- Step 3: Run an event-time specification as follows to obtain treatment effects:

$$y_{it} = \alpha + \theta_i + \gamma_t + \sum_{k=-j}^{5} \lambda_k \delta_{k,it} + \varepsilon_{it} \quad (1)$$

$$y_{it} = \alpha + \theta_i + \gamma_t + \sum_{k=-j}^{0} \lambda_k \delta_{k,it} + \psi(H_{it} = 1) + \nu(t > 0) + \eta(H_{it} = 1)(t > 0) + \varepsilon_{it}$$

where α is a constant, θ_i is a CBSA fixed effect, and γ_t is a time fixed effect. $\delta_{k,it}$ is an indicator variable equal to 1 if the CBSA is in year k of its hub opening/closure event. n the regressions, $k = -1$ is left out as the reference year. MSPE minimized over 5 years prior to hub opening and 3 years prior to hub closing, i.e $j = 5$ for hub opening events and $j = 3$ for hub closing events. $H = 1$ indicates hub open at time t. Eq (1) results shown graphically. Values of η based on Equation (2) referenced in tables that follow.

Results: OLS Airport Outcomes, All Hubs

	(1)	(2)	(3)	(4)
Passengers	0.317***	0.252***	0.139**	0.122**
	(0.078)	(0.093)	(0.061)	(0.058)
Flights	0.292***	0.238***	0.140***	0.131***
	(0.067)	(0.077)	(0.051)	(0.047)
Air Travel Employment	0.238***	0.174**	0.228***	0.174***
	(0.085)	(0.083)	(0.066)	(0.056)
Hotel Employment	0.096***	0.090**	0.070**	0.055**
	(0.036)	(0.037)	(0.027)	(0.025)
Amusements and Rec Emp	-0.013	0.003	-0.025	-0.018
	(0.031)	(0.028)	(0.024)	(0.024)
CBSA/Year FE	Y	Y	Y	Y
Share/SWA/Cargo Controls	N	Y	N	Y
CBSA-Specific Trend	N	N	Y	Y

30 hubs and 55 non-hubs included in regressions. Standard errors clustered on CBSA level.

*$p < 0.1, **p < 0.05, ***p < 0.01$

Results: OLS Output Measures

	(1)	(2)	(3)	(4)
Personal Income	0.039	0.025	0.012	-0.004
	(0.027)	(0.024)	(0.013)	(0.009)
Total Payroll	0.054*	0.030	0.012	-0.011
	(0.028)	(0.024)	(0.016)	(0.011)
Total Earnings	0.050*	0.029	0.012	-0.010
	(0.028)	(0.024)	(0.015)	(0.010)
Total Wage and Salary Income	0.049*	0.026	0.009	-0.011
	(0.027)	(0.024)	(0.014)	(0.011)
Total Employment	0.023	0.009	0.010	-0.005
	(0.028)	(0.022)	(0.012)	(0.009)
CBSA/Year FE	Y	Y	Y	Y
Share/SWA/Cargo Controls	N	Y	N	Y
CBSA-Specific Trend	N	N	Y	Y

30 hubs and 55 non-hubs included in regressions. Standard errors clustered on CBSA level.

*$p < 0.1, **p < 0.05, ***p < 0.01$

Results: OLS Wage Measures

	(1)	(2)	(3)	(4)
Per-Capita Personal Income	0.019*	0.011	0.013	0.001
	(0.010)	(0.009)	(0.011)	(0.008)
Payroll Per Worker	0.033***	0.023*	0.002	-0.006
	(0.011)	(0.011)	(0.007)	(0.006)
Earnings Per Worker	0.024**	0.014	0.004	-0.006
	(0.009)	(0.009)	(0.008)	(0.006)
Wages and Salary Per Worker	0.023***	0.012	0.001	-0.007
	(0.008)	(0.009)	(0.008)	(0.006)
CBSA/Year FE	Y	Y	Y	Y
Share/SWA/Cargo Controls	N	Y	N	Y
CBSA-Specific Trend	N	N	Y	Y

30 hubs and 55 non-hubs included in regressions. Standard errors clustered on CBSA level.

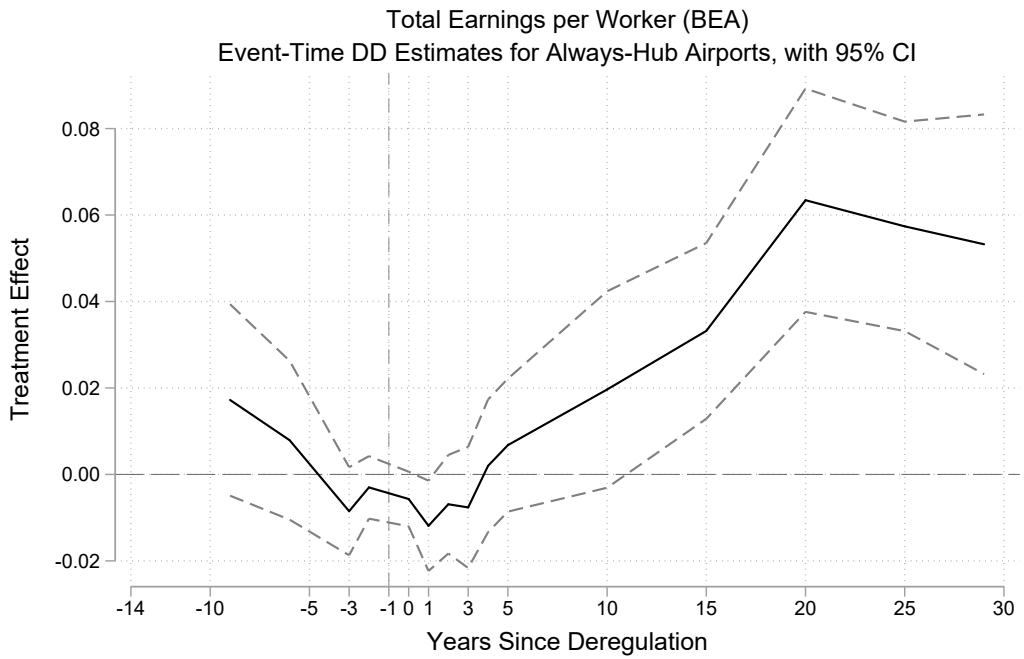
*$p < 0.1, **p < 0.05, ***p < 0.01$

Concern: Attenuated Estimates

Alternative experiment:

- Fix time of treatment at year = 1978
- Run standard difference-in-differences specification, with all controls, for airports that are hubs and that have never closed
  - 9 years before deregulation, 30 years after
- Compare to event-time difference in differences outcome
  - Differing outcomes could suggest overfitting and/or attenuation bias, both of which would lead to the near-zero outcomes above even if the estimate is nonzero

Concern: Attenuated Estimates



- Estimated effect from standard DD specification: -0.006 (SE 0.006)
- Based on graph/ET-DD, treatment effect should be roughly 0.03
  - Implication: Evidence from OLS may be unreliable, especially when controls for CBSA trends are added

Synthetic Control Event Study

- Separate identification of effects for hub openings and closings
- Synthetic units incorporate city-specific changes, in both level and trend
- Mitigates other forms of endogeneity as well such as simultaneous causality
- Outcomes reported here are average treatment effects based on pooled SC event study

Results: SC ES Airport Outcomes, All Hubs

	Hub Openings		Hub Closings	
	(1)	(2)	(3)	(4)
Passengers	0.266***	0.299***	-0.332***	-0.256**
	(0.057) [21]	(0.062) [19]	(0.099) [12]	(0.096) [12]
Flights	0.299***	0.263***	-0.210**	-0.291**
	(0.074) [21]	(0.063) [20]	(0.084) [12]	(0.092) [9]
Air Travel Employment	0.310***	0.243***	-0.092	-0.129
	(0.085) [27]	(0.072) [26]	(0.125) [14]	(0.118) [11]
Hotel Employment	0.093***	0.053	-0.049	-0.056
	(0.030) [26]	(0.034) [23]	(0.064) [13]	(0.061) [13]
Amusements and Recr. Emp.	-0.034	-0.048	-0.109**	-0.087**
	(0.040) [27]	(0.035) [25]	(0.036) [14]	(0.032) [14]
Full Set of Emp. Share/Loc. ctrls	N	Y	N	Y

Brackets indicate number of units considered. Standard errors clustered on CBSA level.

*$p < 0.1, **p < 0.05, ***p < 0.01$

Results: SC ES Output Measures, All Hubs

	Hub Openings		Hub Closings	
	(1)	(2)	(3)	(4)
Personal Income	0.025**	0.017*	-0.001	0.013
	(0.010) [26]	(0.009) [26]	(0.016) [14]	(0.012) [14]
Total Payroll	0.043***	0.036***	0.020	0.003
	(0.014) [25]	(0.009) [25]	(0.019) [14]	(0.015) [14]
Total Earnings	0.034***	0.019*	0.007	0.003
	(0.011) [26]	(0.010) [26]	(0.016) [14]	(0.015) [14]
Total Wage and Salary Income	0.033***	0.018	0.006	-0.002
	(0.011) [26]	(0.010) [24]	(0.016) [14]	(0.014) [13]
Total Employment	0.034***	0.009	0.011	0.007
	(0.012) [27]	(0.011) [27]	(0.017) [14]	(0.010) [14]
Full Set of Emp. Share/Loc. ctrls	N	Y	N	Y

Brackets indicate number of units considered. Standard errors clustered on CBSA level.

*$p < 0.1, **p < 0.05, ***p < 0.01$

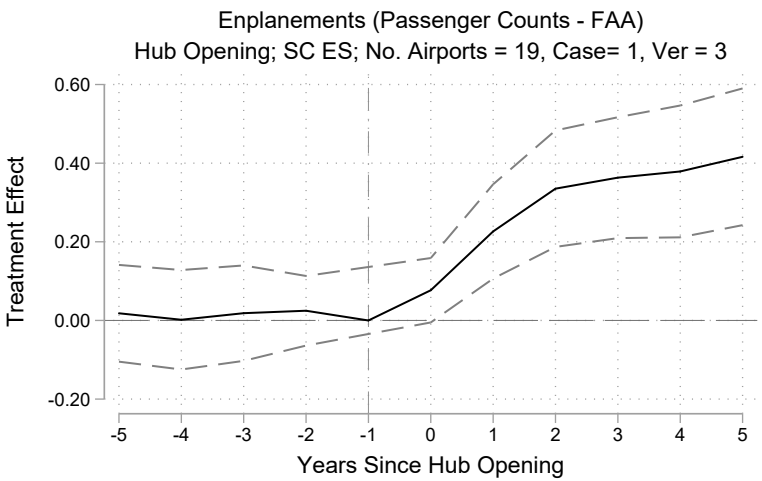
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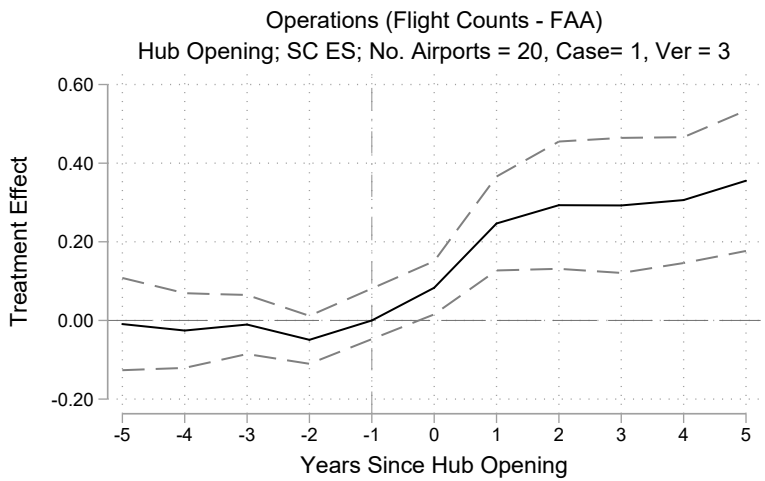
	Hub Openings		Hub Closings	
	(1)	(2)	(3)	(4)
Per-Capita Personal Income	0.023***	0.012***	-0.019	-0.012
	(0.007) [26]	(0.004) [26]	(0.014) [14]	(0.010) [14]
Payroll Per Worker	0.020***	0.016***	-0.004	-0.001
	(0.006) [25]	(0.004) [25]	(0.008) [14]	(0.007) [14]
Earnings Per Worker	0.030***	0.015***	-0.004	0.001
	(0.006) [26]	(0.004) [26]	(0.009) [14]	(0.008) [14]
Wages and Salaries Per Worker	0.029***	0.011**	-0.004	-0.003
	(0.006) [26]	(0.005) [24]	(0.007) [14]	(0.007) [14]
Full Set of Emp. Share/Loc. ctrls	N	Y	N	Y

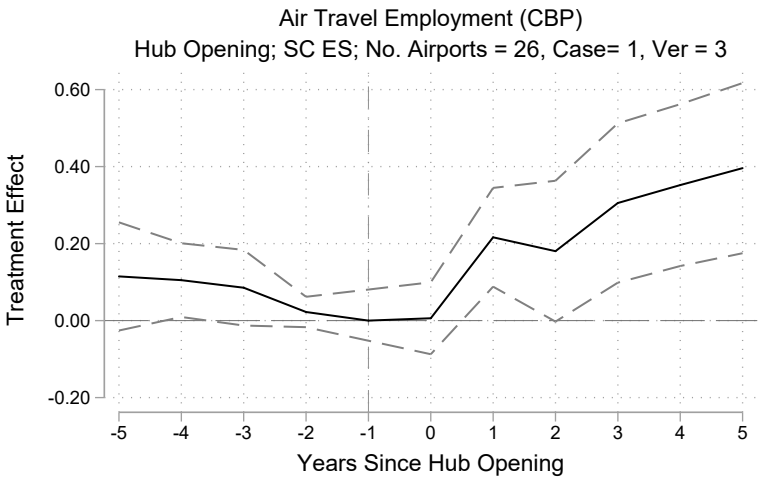
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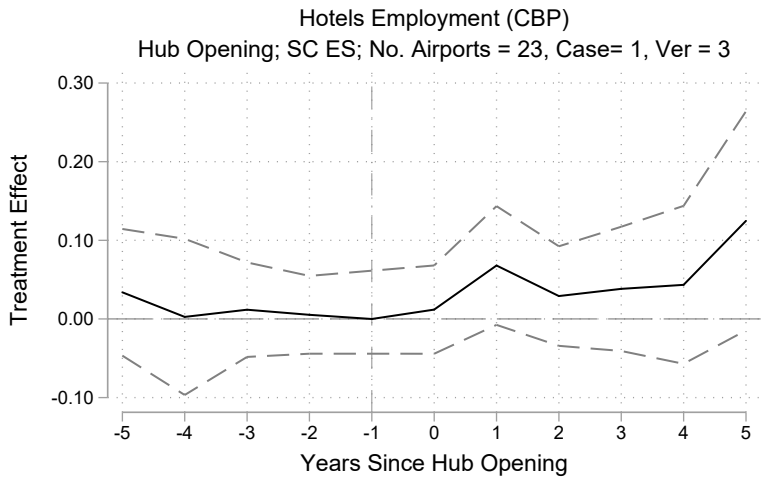
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Hub Opening SC Event Study: Airport Effects



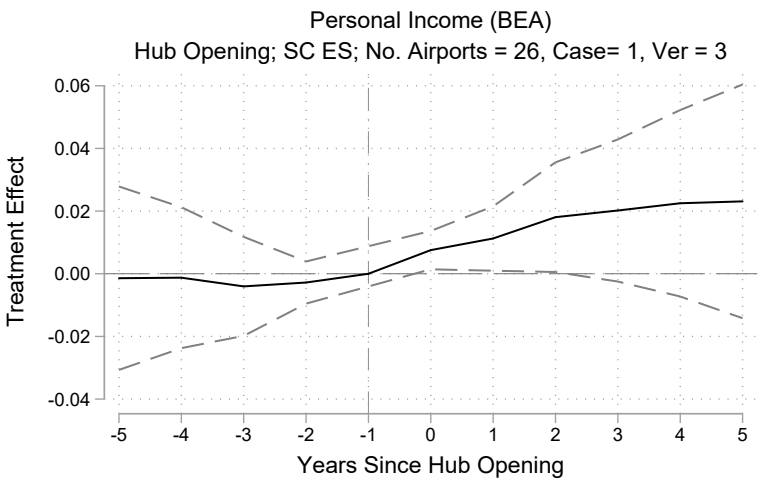


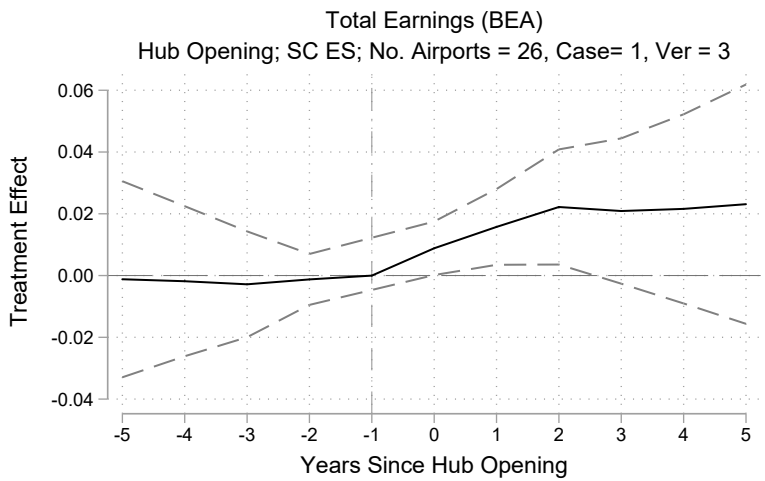


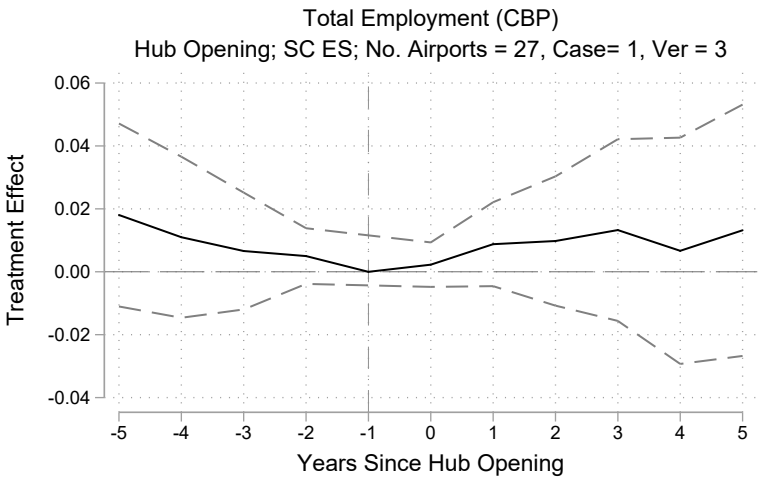


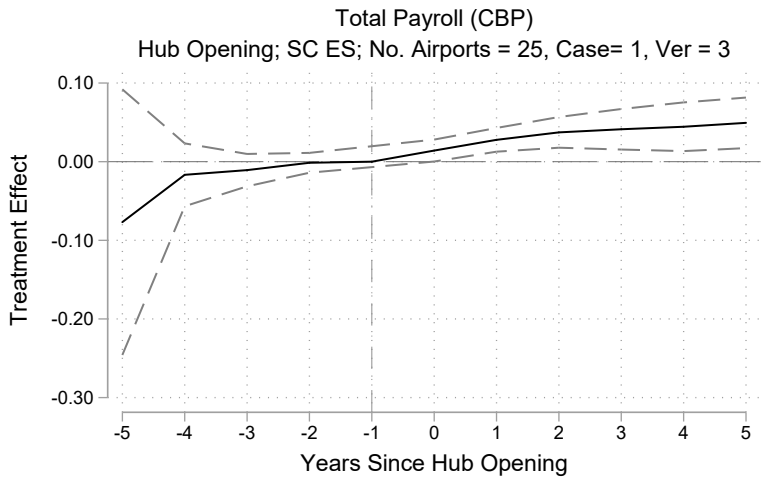
All available estimated synthetic counterfactuals were used in the estimation of this event study, regardless of goodness of fit. All relevant and available control variables were used in constructing the counterfactual synthetic units. Dotted lines indicate 95 percent confidence intervals.

Hub Opening SC Event Study: Economy Output Effects



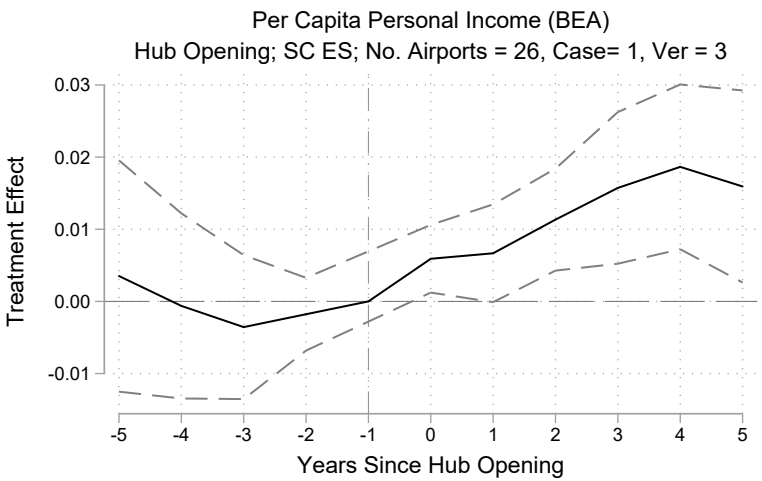


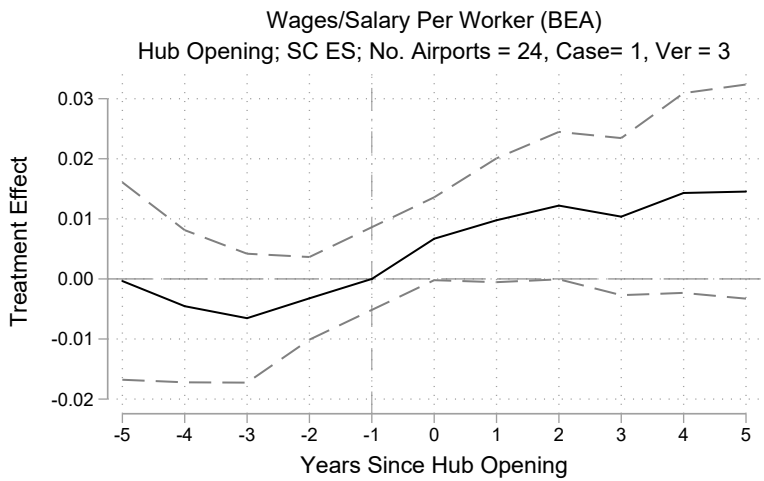


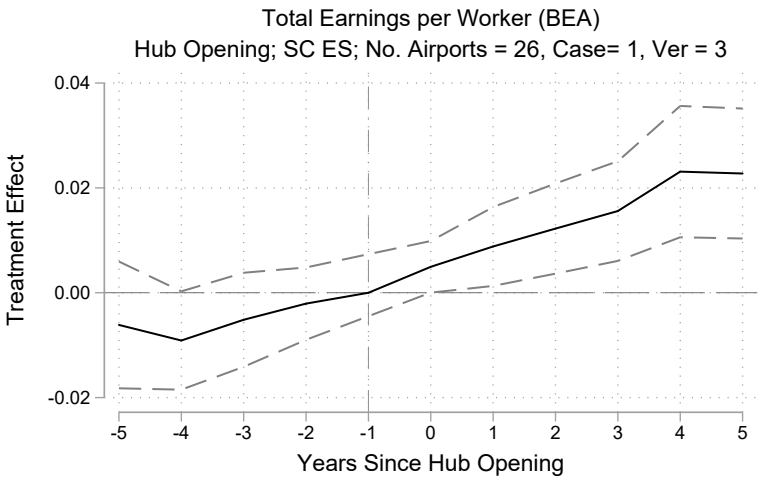


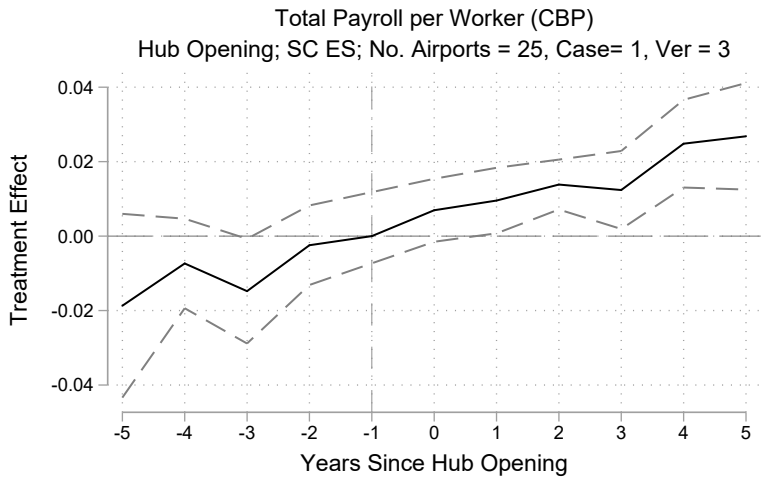
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Hub Opening SC Event Study: Wage Effects



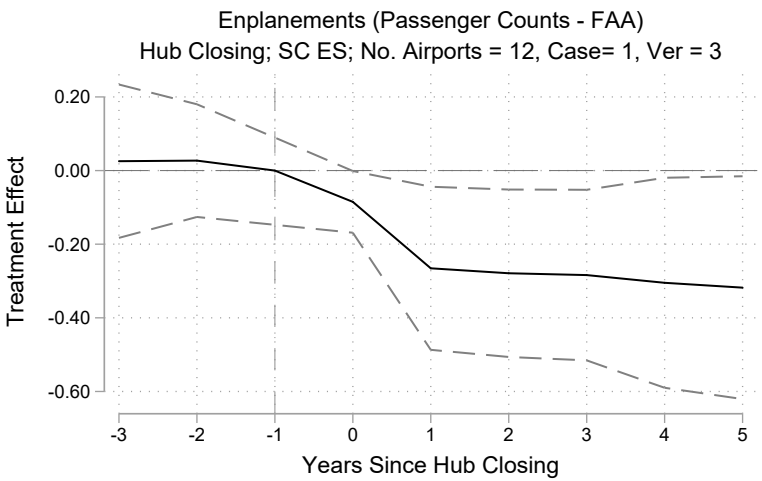


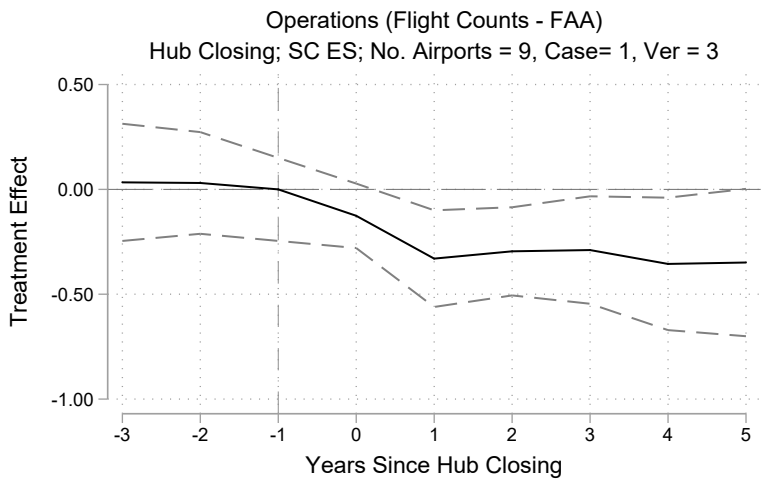




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Hub Closing SC Event Study: Airport Effects



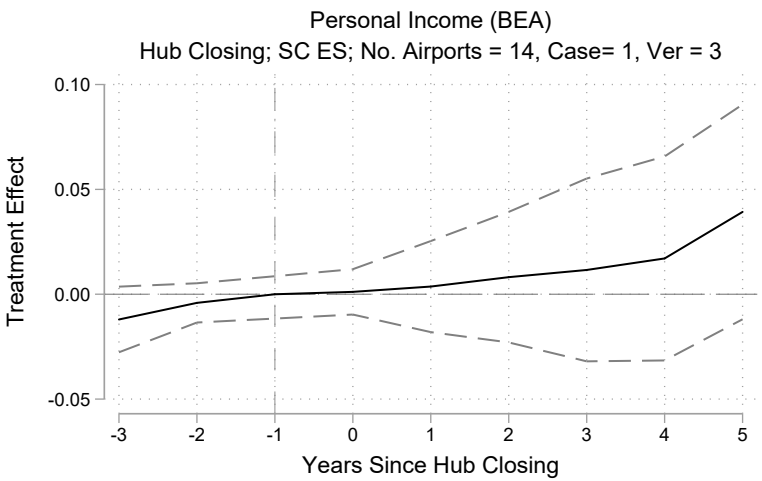


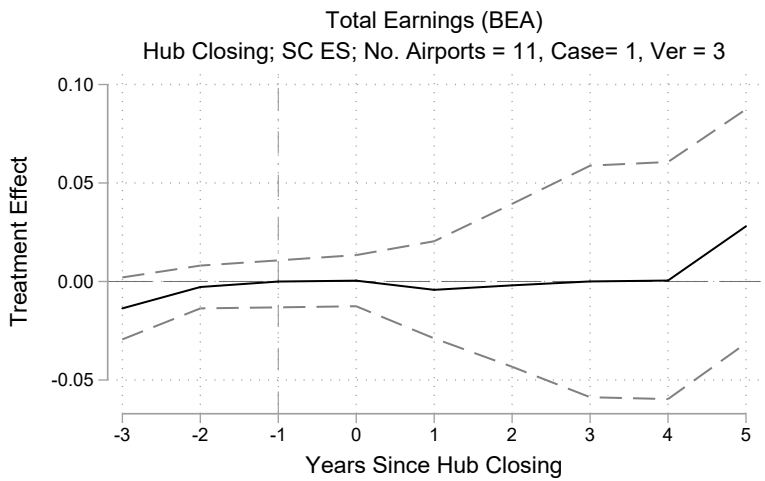


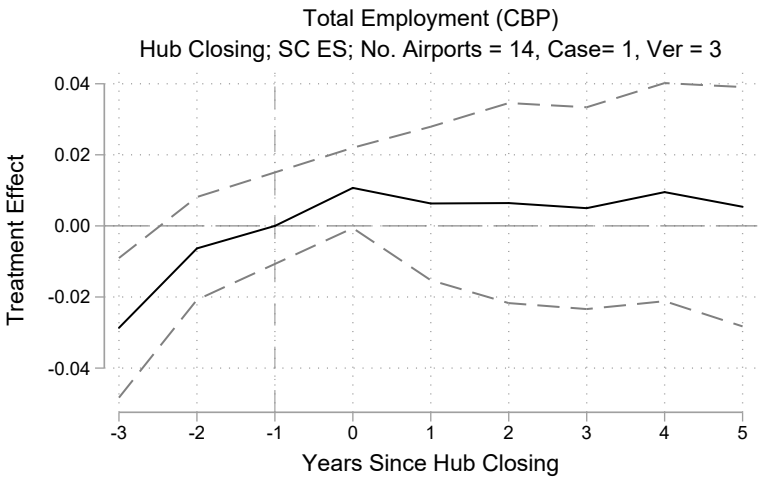


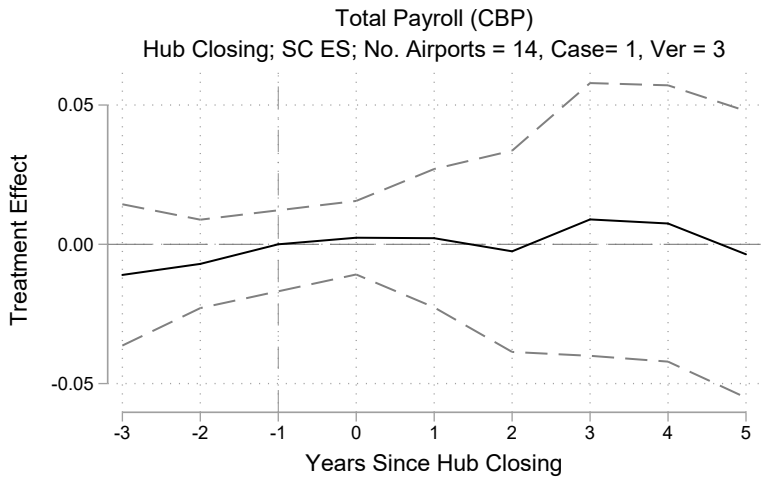
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Hub Closing SC Event Study: Economy Output Effects



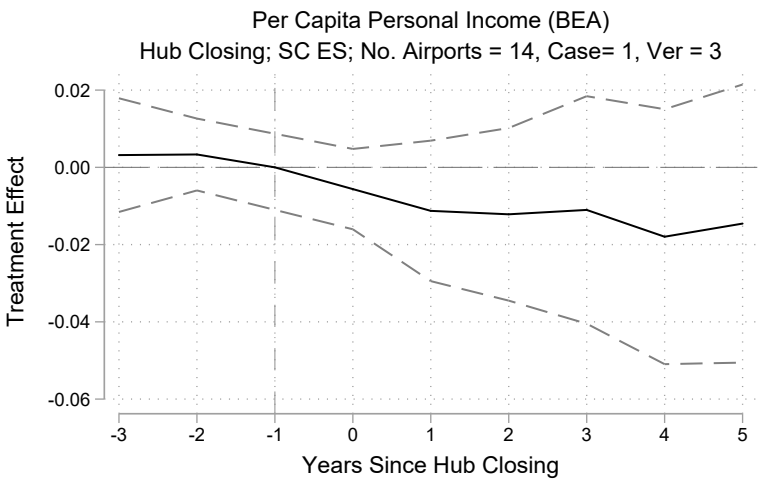


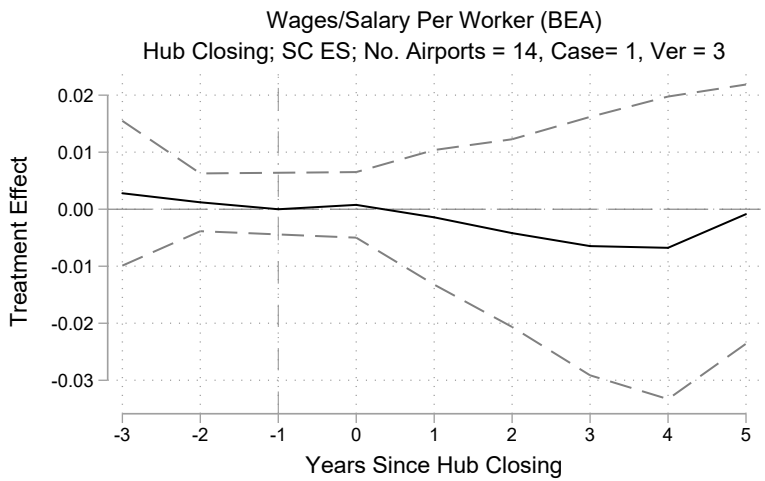


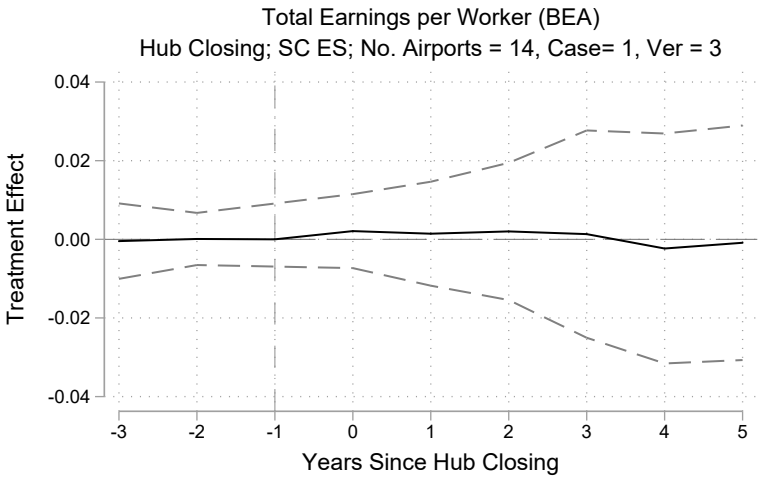


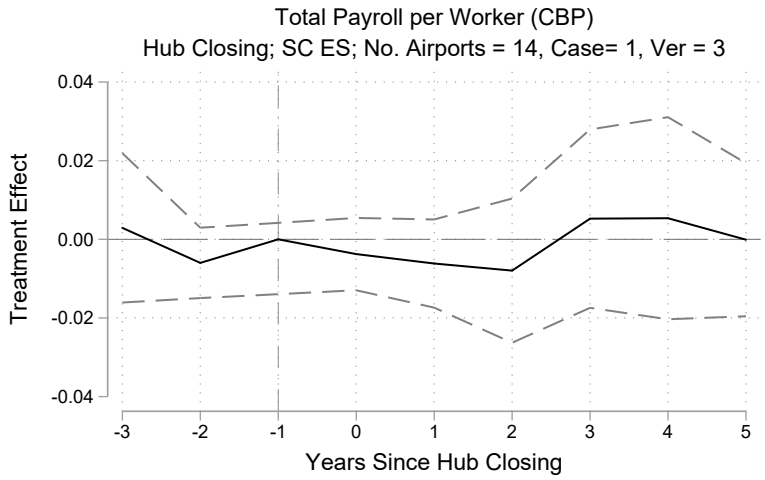
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Hub Closing SC Event Study: Wage Effects









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Comparison to Prior Studies

Are these results reasonable?

- Button et. al (2010): Elasticity between passenger counts and per-capita income approx. 0.04
- Sheard (2015): Elasticity between airport size and GDP approx. 0.035

- This study: elasticity between passenger counts and per-capita income $= 0.012/0.299 = \mathbf{0.040}$

Conclusion

- Evidence suggests that airport hubs may have an effect on the local economy via enhanced productivity effects
- Wage measures (per-capita personal income, earnings per worker, etc.) increase by average amounts of 1.1 to 1.8 percent
  - Robust to use of varying sets of controls in synthetic unit estimation, using wild bootstrap given no. clusters < 50
- Output measures such as personal income and total payroll may increase as well, from averages of 1.7 to 4.3 percent depending on measure
  - Less robust; no significant corresponding changes in employment measured

Conclusion

- Most effects primarily attributable to hub openings
  - Amusements and Recreation employment decreases by 8 percent as a result of hub closings
  - Tourism may be dramatically affected by future hub closures
- Effects may be due to convenience factors for business travelers
  - Increased flight frequency, access to more non-stop flights to more destinations, corporate travel contracts, etc.
  - To be explored in future research

Thank you!

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