The Effect of Postsecondary Institutions on Local Economies: A Bird's-Eye View

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Impacts of colleges

- Colleges are vehicles to economic mobility
- They produce …
  - private/individual returns for students (e.g., Bianchi & Giorcelli, 2020; Oreopoulos & Petronijevic, 2013)
  - public/social returns for local communities (e.g., Andrews, 2023; Pfister et al., 2021)
- College expansion is thus a commonly used policy for creating human capital to foster regional economic activity
- We evaluate a large-scale expansion of tertiary education that took place mostly in the early 2000s

Prior work on social returns

- Higher education expansions stimulate regional innovation (e.g., Andrews, 2023; Cowan & Zinovyeva, 2013; Pfister et al., 2021)
- Examples of potential benefits of higher education expansions for individuals:
  - Improved labor market outcomes (e.g., Kyui, 2016)
  - Involvement in innovation activities (e.g., Bianchi & Giorcelli, 2020)
  - Geographic mobility (e.g., Böckerman & Haapanen, 2013)
- Examples of potential benefits of higher education expansions for firms:
  - Increased productivity (e.g., Moretti, 2004)
  - Increased R&D activities (e.g., Lehnert et al., 2020)
  - Increased profits (e.g., Schlegel et al.,2022)

Our contribution

How does the creation of college branch campuses affect local economic activity?

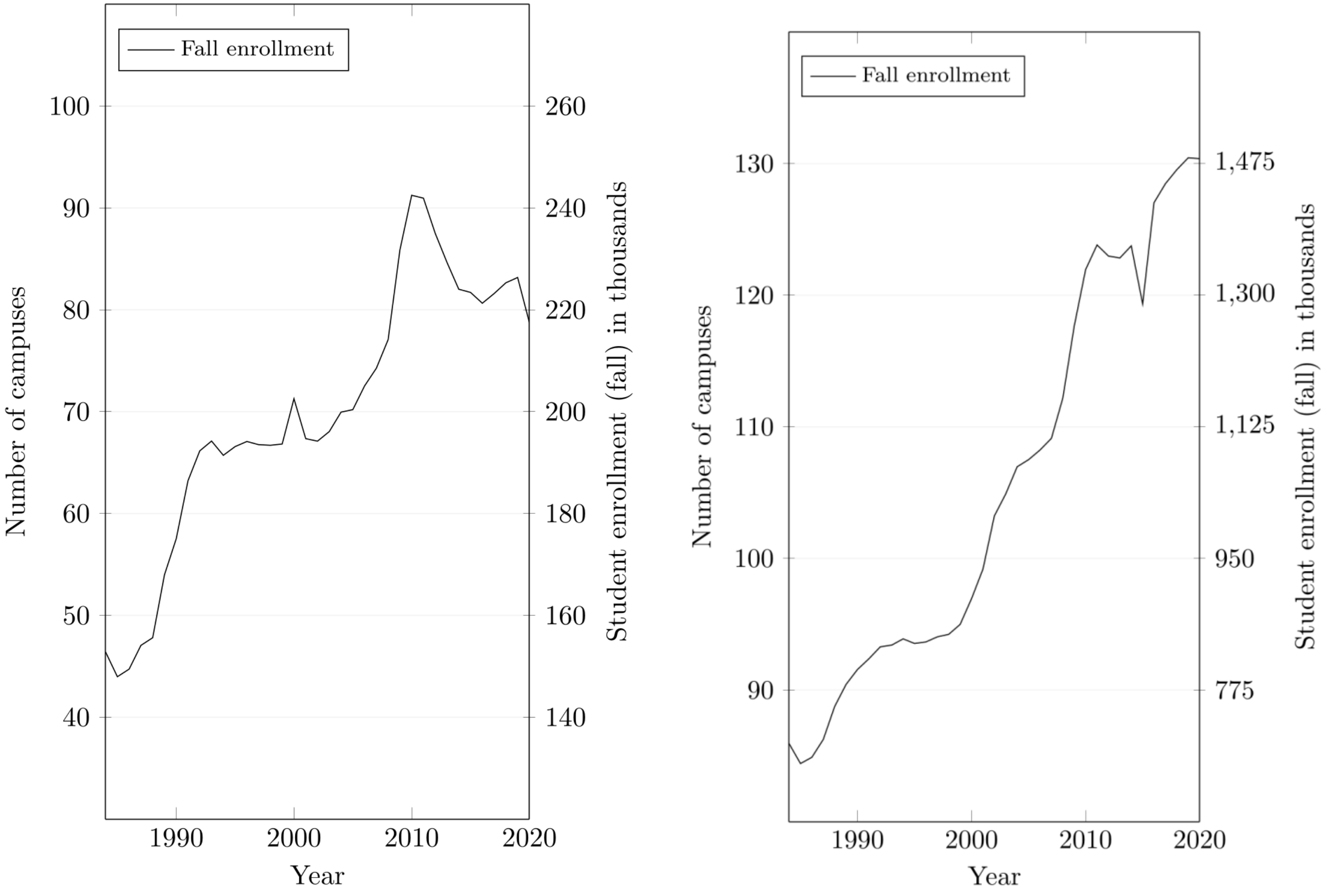
→ Contribution to the literature on the social returns to colleges (e.g., Andrews, 2023; Moretti, 2004; Toivanen & Väänänen, 2016)

→ Contribution to the literature on the identification of regional effects of education expansions (e.g., Cowan & Zinovyeva, 2013; Kamhöfer et al., 2019; Pfister et al., 2021)

→ Contribution to the literature that uses satellite imagery to proxy local economic activity (e.g., Faber & Gaubert, 2019; Lee, 2018; Sutton & Costanza, 2002)

Setting the stage

- U.S. experienced a rapid increase in college attendance, particularly from 2000 to 2010



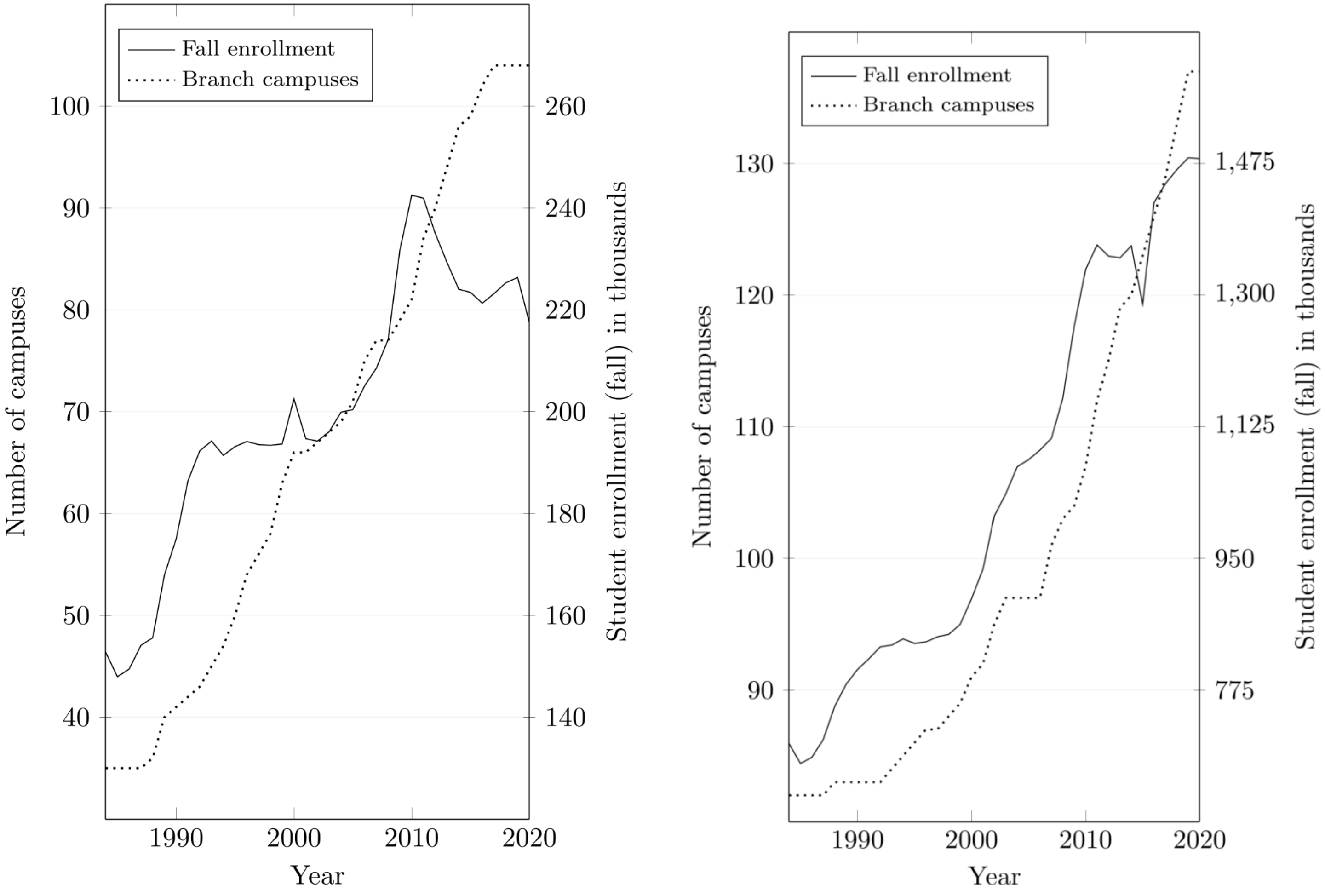
A. Tennessee **B.** Texas

Figure 1. Fall enrollment and number of college branch campuses in Tennessee and Texas, 1984–2020. Source: Digests of Education Statistics (fall enrollment) and own data collection.

Setting the stage

- U.S. experienced a rapid increase in college attendance, particularly from 2000 to 2010
- Most public college systems expanded capacity in two ways:
    1. Increasing capacity at existing colleges
    2. Creating branch campuses
- The creation of branch campuses provides a natural experiment for mesuring social returns

  → Heterogeneous impacts?



A. Tennessee

B. Texas

Figure 1. Fall enrollment and number of college branch campuses in Tennessee and Texas, 1984–2020. Source: Digests of Education Statistics (fall enrollment) and own data collection.

Activities of college branch campuses

- Enable college access for students in remote areas
- Generally teaching-focused institutions, often vocational in nature
- Provide training to develop a skilled workforce
- Few R&D activities

→ Biggest impact is likely the expansion of a skilled labor supply that attracts businesses to the local area or region

→ Additional benefits of improved productivity might accrue to existing businesses

Programs at college branch campuses

- Largest programs at 2-year branch campuses:
  - Health professions and related programs
  - Computer and information science and support programs
  - Liberal arts types of general programs
  - Education programs
- Associate degrees from two-year programs offer direct entry point to the labor market (e.g., work as an early childhoold educator with a degree in education, work as an IT technician with a degree in computer and information science)
- Alternative: continue at 4-year institution to earn a Bachelor degree and work, e.g., as an educational administrator or a software engineer

Problems to solve for answering our research question

1) Acquire data on exact locations and opening years of college branch campuses to exploit both regional and temporal variation
2) Find a measure for economic activity at a level of regional disaggregation that corresponds to the college branch campuses' expected radius of impact
3) Deal with endogeneity in college branch campus locations

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Data on college branch campuses

- Extensive data collection on branch campus openings in Tennessee and Texas (websites, newspapers, etc.)
- Regional and temporal variation through exact locations and opening years
- Differentiation between 2- and 4-year campuses (exclude colleges with programs of less than 2 years)
- Focus on public colleges
- Exclude high school campuses and prison-based branches

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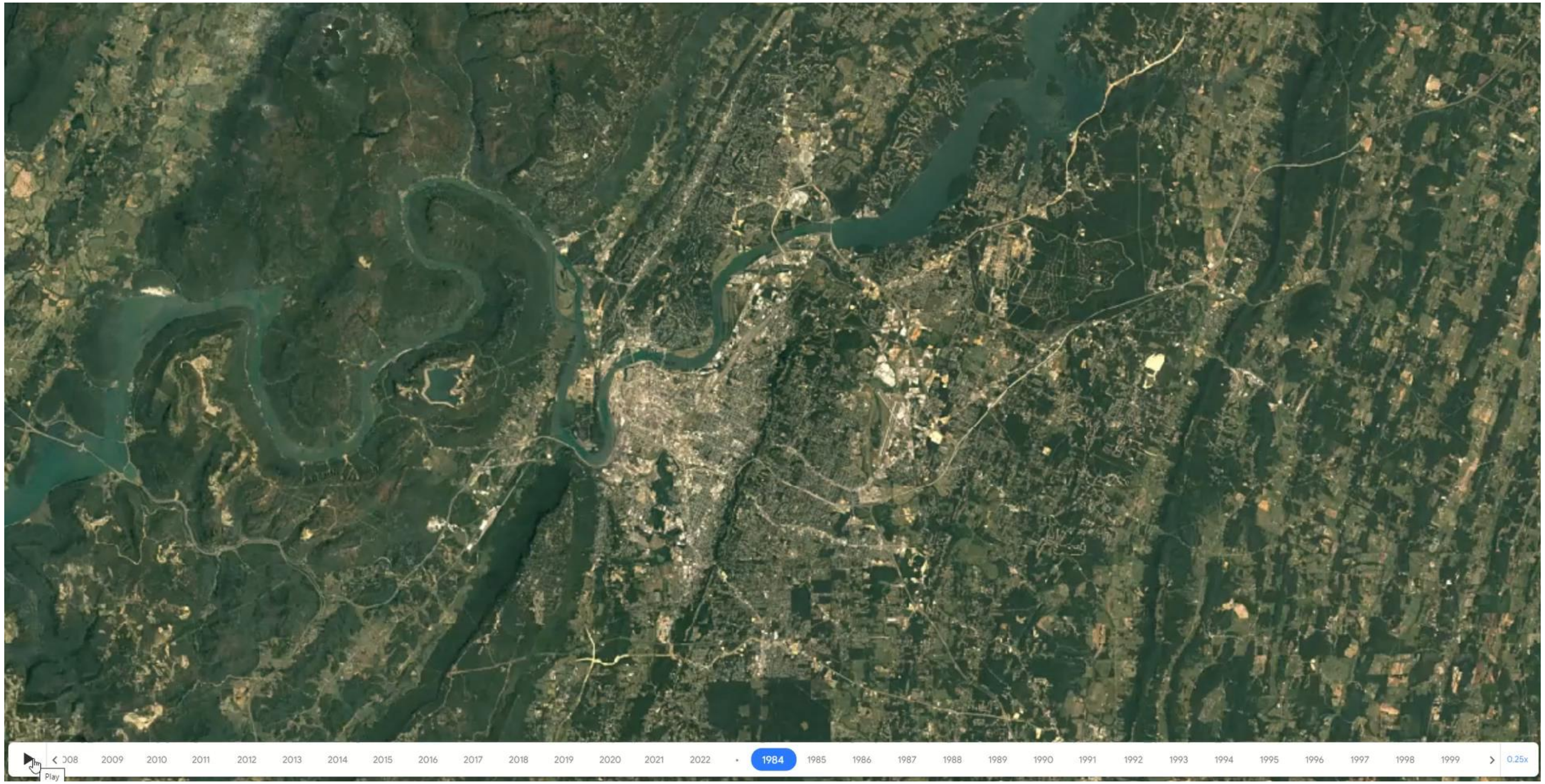
Daytime satellite imagery as an economic proxy



Video 1. Google Timelapse recording of Chattanooga, TN.

Daytime satellite imagery as an economic proxy

Existing economic measures do not …

… allow studying highly localized regions at which we expect effects to occur (e.g., county-level GDP statistics, night lights with much coarser spatial resolution)

… cover a long enough time series to study the branch campus openings (e.g., easily accessible county GDP statistics start in 2001)

→ Use a proxy developed from daytime satellite imagery with these properties (Lehnert et al., 2023)

→ Regional panel between 1984 and 2020 allowing us to exploit time series for the identification of causal effects

Daytime satellite imagery as an economic proxy

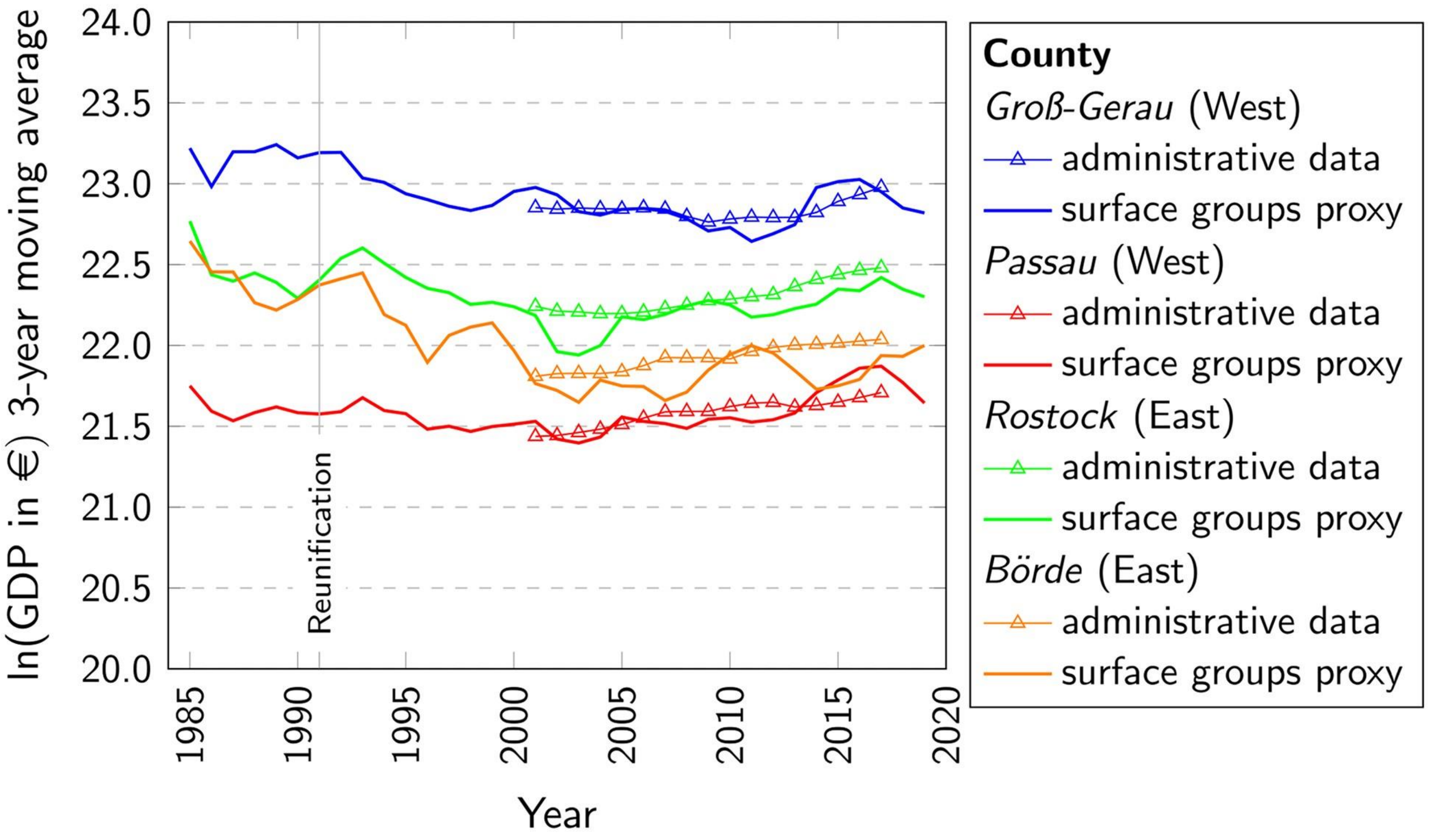


Figure 2. Administrative and predicted GDP in four German counties. Source: Lehnert et al. (2023).

Daytime satellite imagery as an economic proxy: land-cover classification

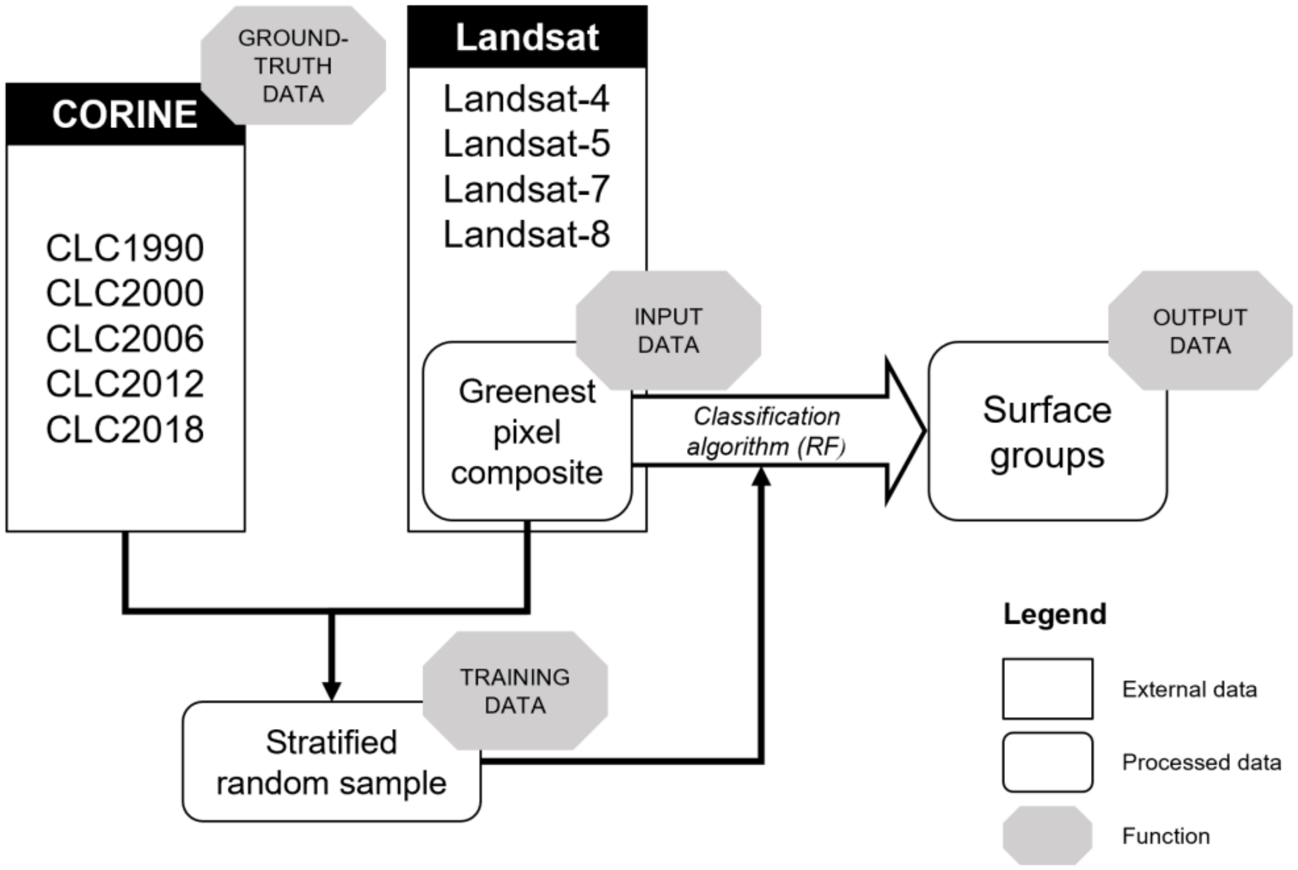


Figure 3. Machine-learning procedure for land-cover classification. Source: Lehnert et al. (2023).

Daytime satellite imagery as an economic proxy: land-cover classification

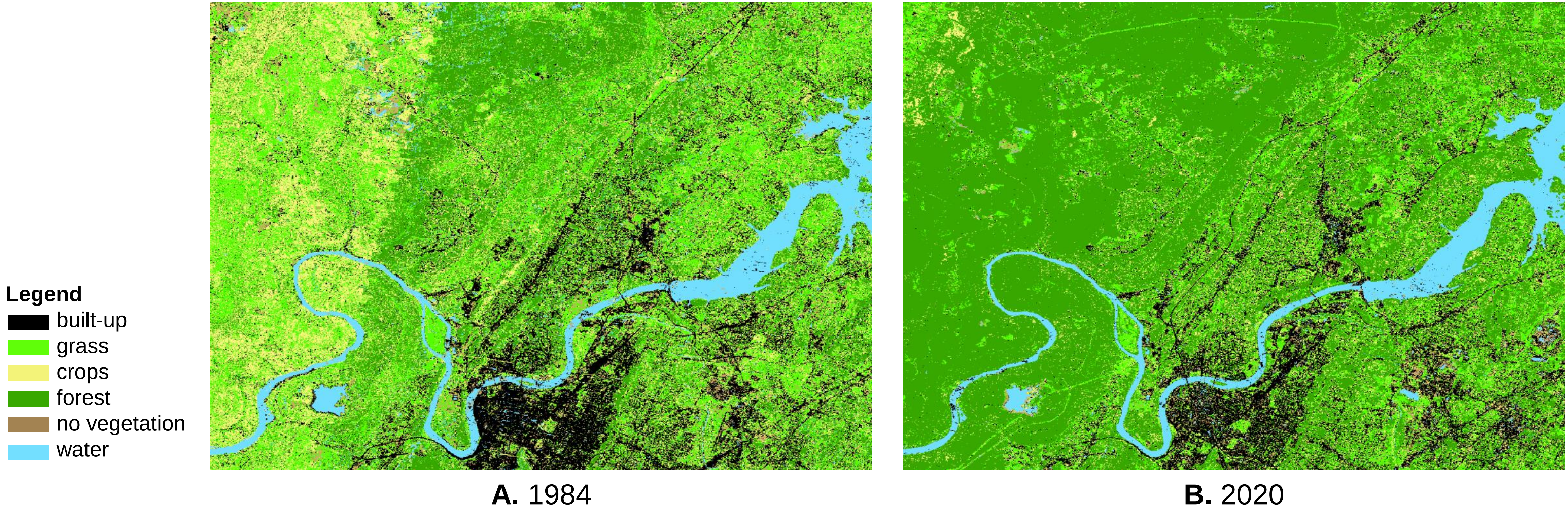


Figure 4. Land-cover classification for Chattanooga, TN.

Daytime satellite imagery as an economic proxy: GDP prediction

- Associate land cover with economic indicators at lowest possible disaggregation: county-level GDP, 2001–2020 (Source: Bureau of Economic Analysis)
- Standardize all variables in the prediction model to obtain an economic measure at a higher disaggregation level (census tracts)
- Obtain prediction of standardized log GDP at the census tract level, 1984–2020

Daytime satellite imagery as an economic proxy: GDP prediction

Estimation model for GDP prediction:

$$Y_{jt} = \lambda + \kappa LC_{jt} + v_{s[j]} + \tau_t + \mu_{jt}$$

where

Y: standardized log GDP for county j in year t

LC: vector including the six standardized log pixel counts per land-cover category

v_s: set of state dummies

$\tau_{t:}$ set of year dummies

μ: error term

Counties vs. census tracts

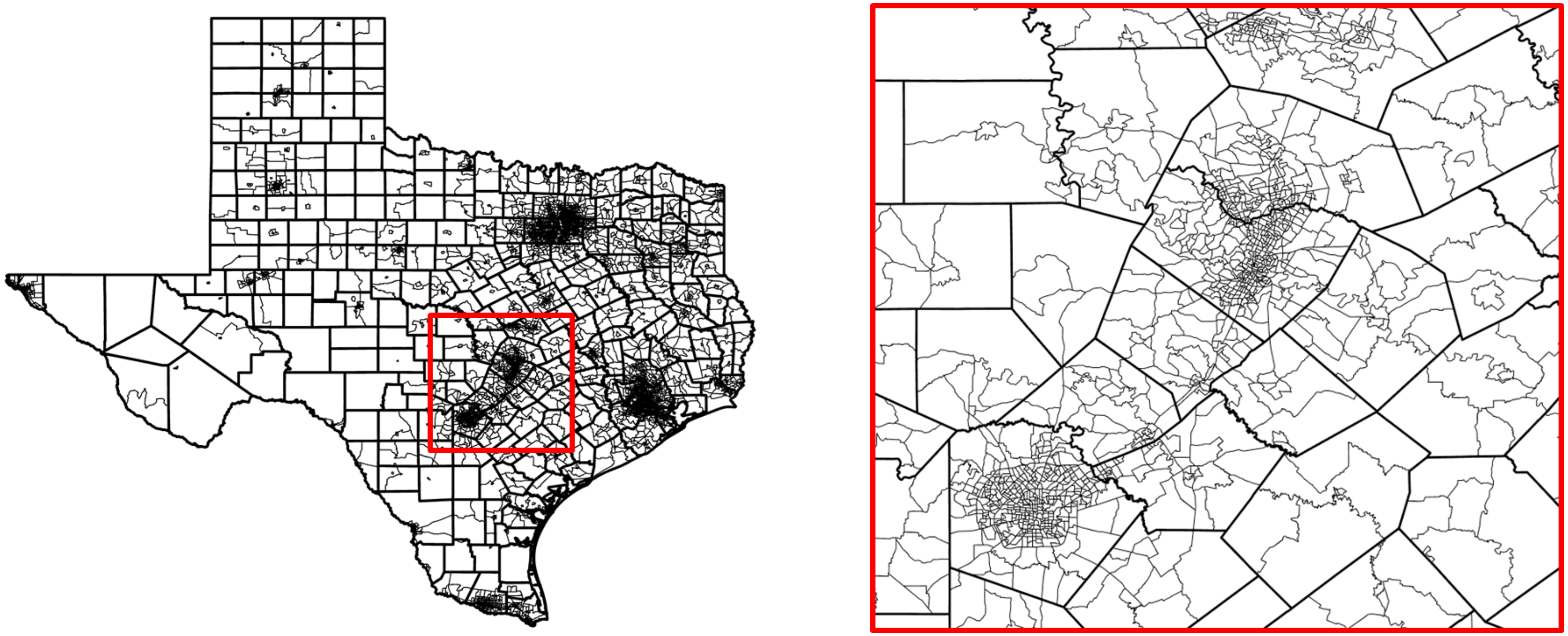
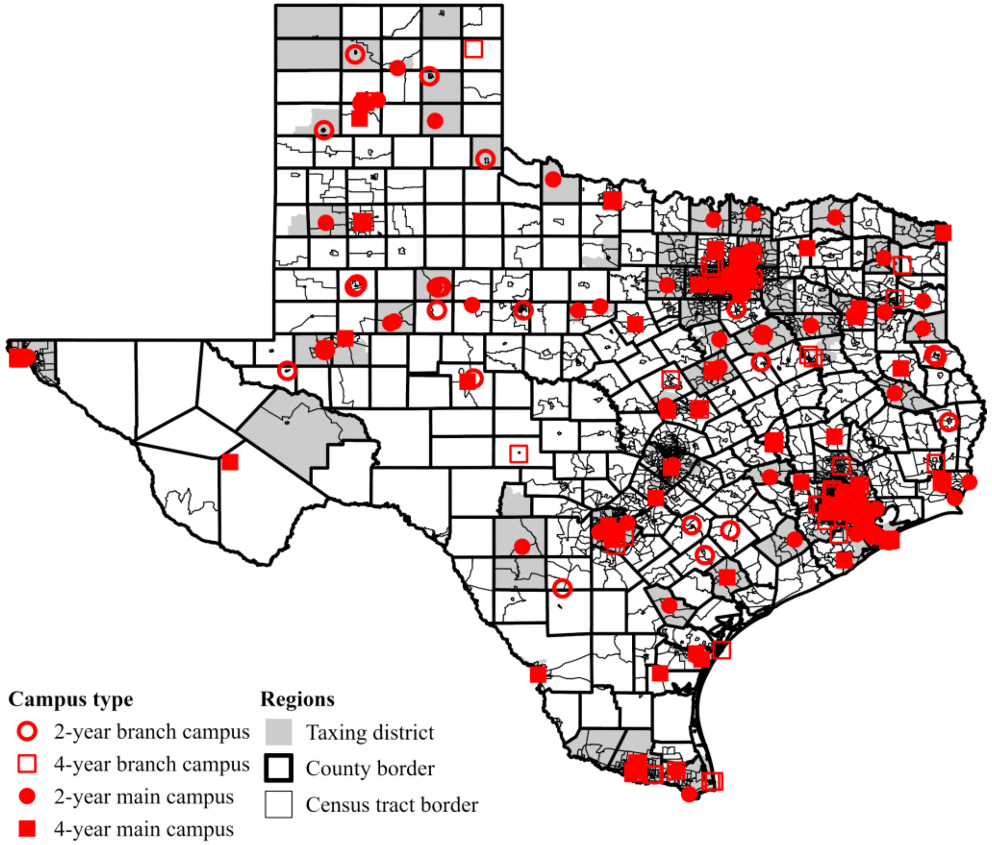
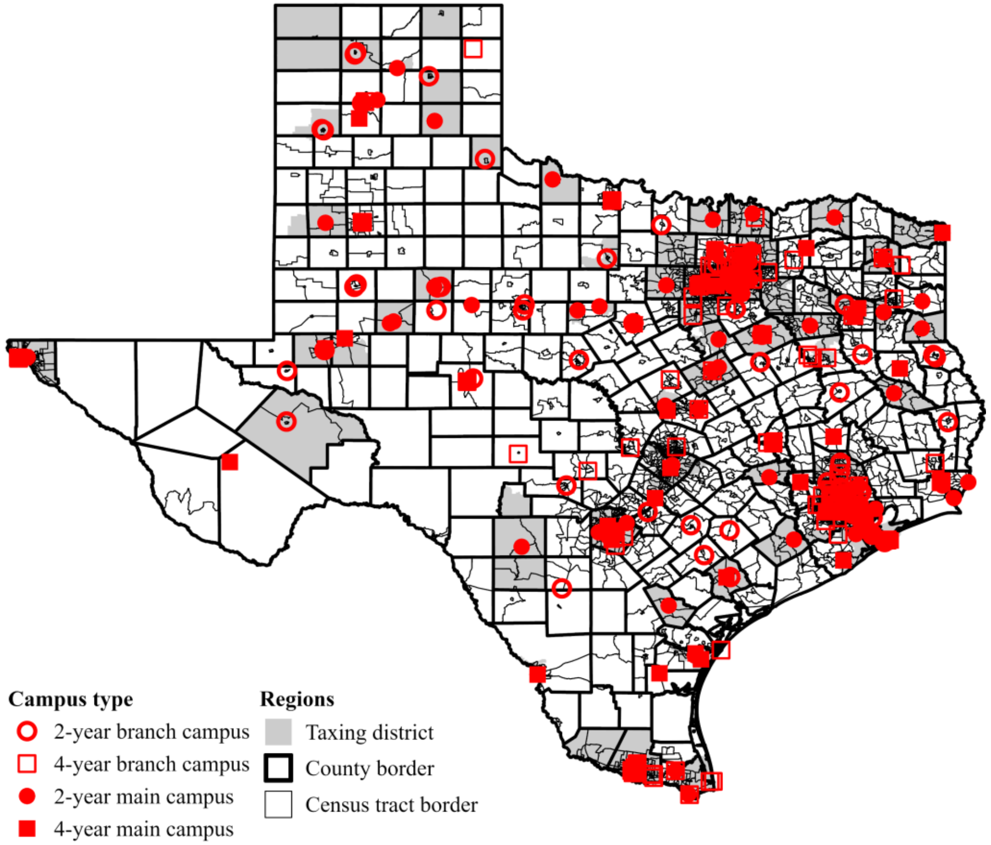


Figure 5. County and census-tract boundaries in Texas.

College branch campus locations



A. 1984



B. 2020

Figure 6. College branch campus locations in Texas, 1984 and 2020.

Problems to solve for answering our research question

1) Acquire data on exact locations and opening years of college branch campuses to exploit both regional and temporal variation
2) Find a measure for economic activity at a level of regional disaggregation that corresponds to the college branch campuses’ expected radius of impact
3) Deal with endogeneity in college branch campus locations

Taxing districts in Texas

- Granted taxing authority by collection of supporting school districts
- Have existed for 50+ years
- In-district tuition < Out-of-district tuition
- Incentives to locate near district borders

- Non-taxing districts only get branch campuses if Texas Coordinating Board organizes it or “service area” builds it
  - Tuition is uniform across state at these

Taxing districts in Texas

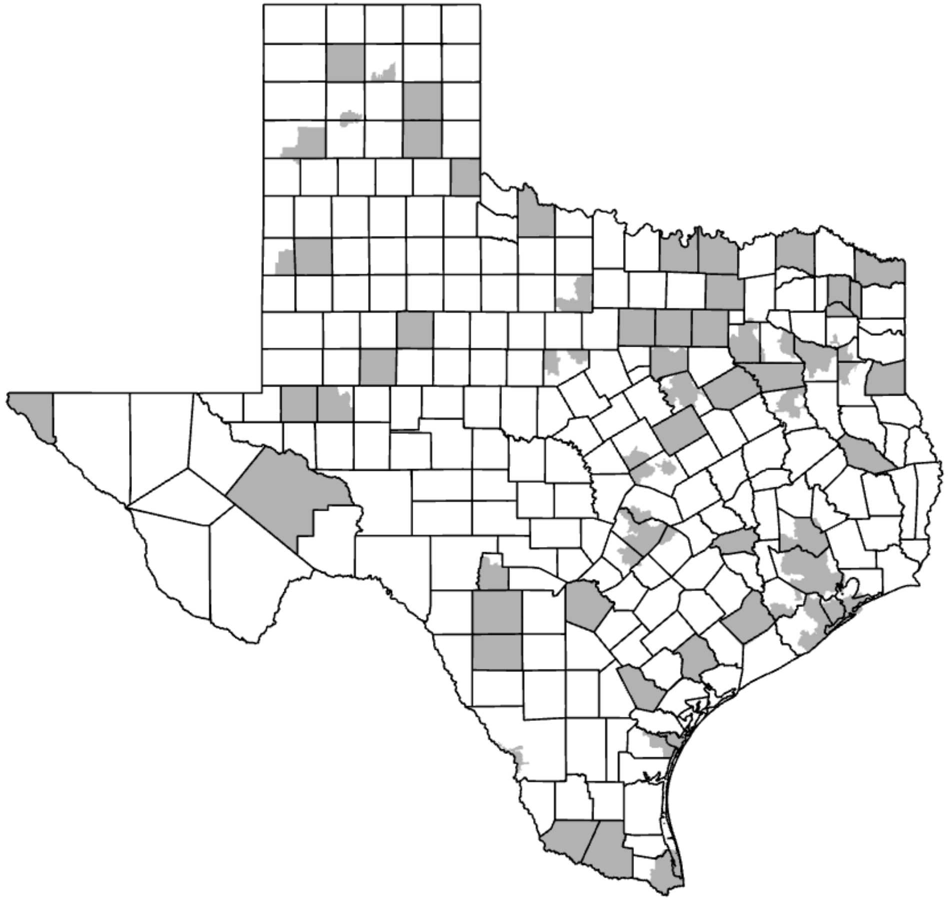


Figure 8. Map of Texas community college taxing districts.

College branch campus locations

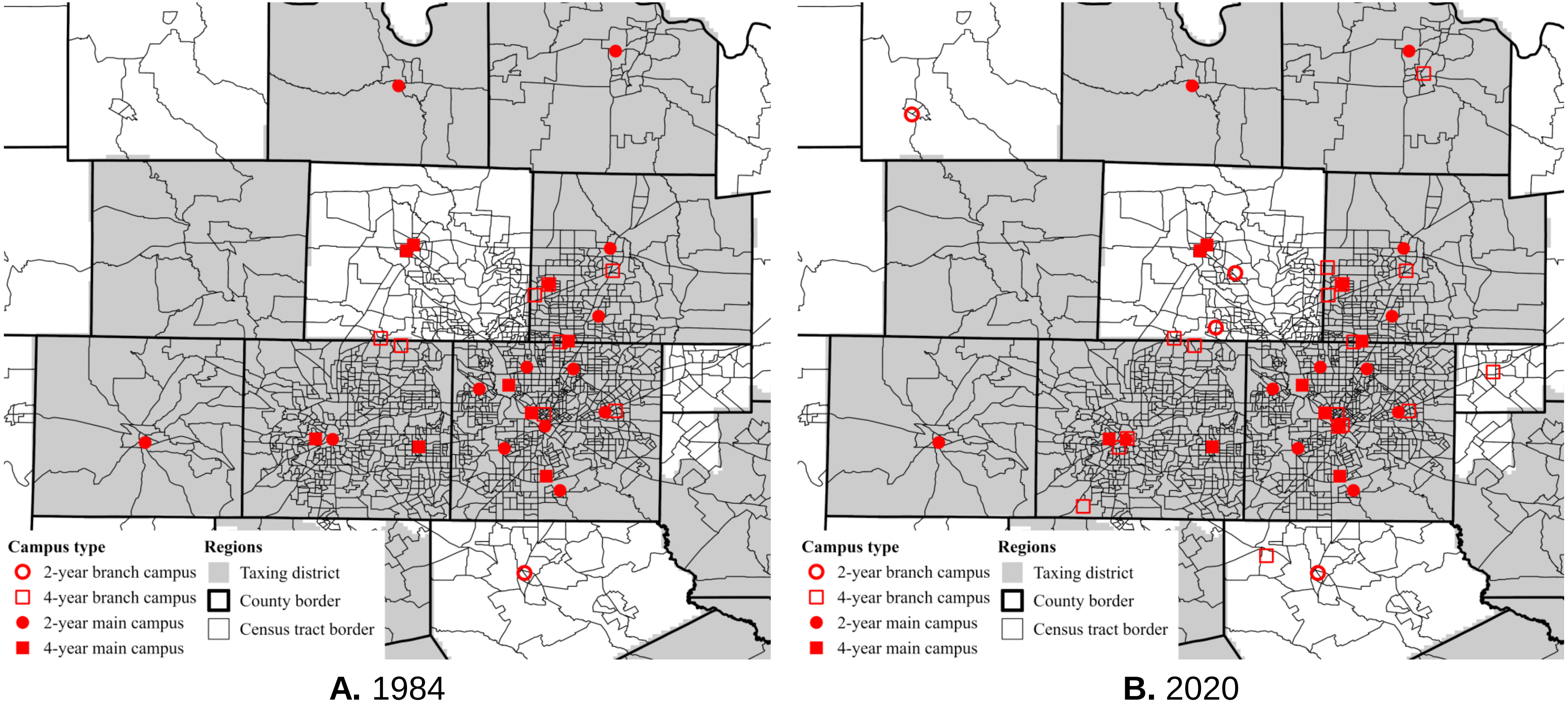


Figure 7. College branch campus locations in the greater Dallas area, 1984 and 2020.

Identification strategy: conventional DD

Conventional difference-in-differences (DD) model:

$$\widehat{Y_{it+4}} = \alpha + \beta BranchCampusOpen_{it} + \gamma_i + \delta_t + \varepsilon_{it}$$

where
$\widehat{Y_{it+4}}$: proxy for GDP in tract *i* in year *t+4*
BranchCampusOpen: =1 for tracts within treatment radius (25 miles)
γ_i: set of census tract dummies
δ_t: set of year dummies
ε: error term

Identification strategy: heterogeneity-robust DD

Heterogeneity-robust DD model (Callaway & Sant'Anna, 2021):

$$\widehat{Y_{it+4}} = \alpha + \sum_{\theta=-20}^{20} \beta_\theta (I_\theta \times BranchCampusOpen_{it}) + \gamma_i + \delta_t + \varepsilon_{it}$$

where

$\widehat{Y_{it+4}}$: proxy for GDP in tract *i* in year *t+4*

I_θ: =1 in the specified number of years before (-θ) or after (θ) treatment

BranchCampusOpen: =1 for tracts within treatment radius (25 miles)

γ_i: set of census tract dummies

δ_t: set of year dummies

ε: error term

Identification strategy: IV approach

- Instrumental variable (IV) approach for Texas exploiting taxing regulations and distance from other campuses as instruments
- Second stage similar to conventional DD model
- First stage:

$$BranchCampusOpen_{it} = \eta + \zeta DistCampus_{it-5} + \xi Tax_i \times DistCampus_{it-5} + \gamma_i + \delta_t + \varepsilon_{it}$$

where
BranchCampusOpen: =1 for tracts within treatment radius (25 miles)
DistCampus: average travel distance to five closest branch campuses
Tax: =1 if tract located within taxing district
γ_i: set of census tract dummies
δ_t: set of year dummies
ε: error term

Conventional DD results

Table 1. DD estimates of branch campus effect on economic activity within 25-mile radius of impact in Tennessee and Texas

	Tennessee		Texas	
	(1)	(2)	(3)	(4)
Any Branch Campus	0.039***		0.165***	
	(0.008)		(0.008)	
Two-Year Branch Campus		0.049***		0.065***
		(0.008)		(0.010)
Four-Year Branch Campus		-0.003		0.142***
		(0.011)		(0.009)
Observations	62,630	62,630	251,680	251,680
Number of tracts	1,701	1,701	6,875	6,875
Within-R^2	0.207	0.208	0.192	0.189

Notes: The dependent variable is the predicted standardized natural logarithm of GDP. The treatment variables are lagged four years so that we estimate the economic impact of a branch campus four years after its opening date. All models include constant, census tract FE, and year FE. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Heterogeneity-robust DD results

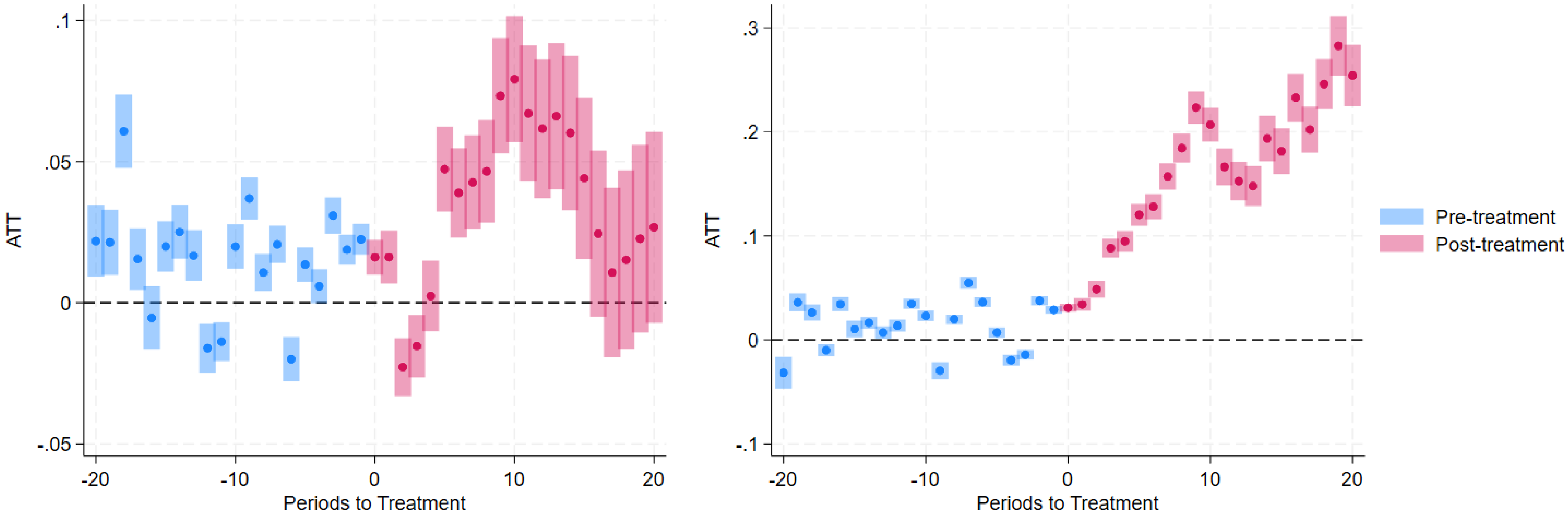


Figure 9. Heterogeneity-robust DD estimates of effects within 25-mile radius of impact in Tennessee and Texas.

A. Tennessee

B. Texas

IV results

Table 2. IV estimates of branch campus effect on economic activity within 25-mile radius of impact in Texas

	(1)	(2)
Any Branch Campus	0.196***	
	(0.039)	
Two-Year Branch Campus		0.108***
		(0.024)
Four-Year Branch Campus		0.197***
		(0.019)
First first-stage F-value of instruments	458.99***	2,183.95***
Second first-stage F-value of instruments		3,268.45***
Observations	251,680	251,680
Number of tracts	6,875	6,875
Within-R^2	0.192	0.186

Notes: The dependent variable is the predicted standardized natural logarithm of GDP. The treatment variables are lagged four years so that we estimate the economic impact of a branch campus four years after its opening date. All models include constant, census tract FE, and year FE. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Magnitude of impact

- Economic Activity
  - Standardized metric of ln(gdp)
  - Necessary since we don’t have the “constant” at the census tract level
- Reversing the standardization
  - Need some estimate of “constant” at census tract level
  - Conservative estimate: county-level constant is uniformly distributed across census tracts
  - Liberal estimate: county-level constant is distributed according to built-up area

Magnitude of the estimates

Table 3. Estimated magnitude of branch campus effect on economic activity within 25-mile radius of impact

Model	State	Specification	Coefficient (std. log GDP)	Conservative Estimate (log GDP)	Liberal Estimate (log GDP)
Conventional DD	TN	pooled	0.039***	0.014	0.033
		2-year campus	0.049***	0.017	0.041
		4-year campus	-0.003	-0.001	-0.002
	TX	pooled	0.165***	0.059	0.146
		2-year campus	0.065***	0.023	0.055
		4-year campus	0.142***	0.051	0.125
IV	TX	pooled	0.196***	0.071	0.176
		2-year campus	0.108***	0.038	0.093
		4-year campus	0.197***	0.071	0.177

Robustness check: variation of treatment radius

- Apply 10-mile and 40-mile treatment radius as a robustness check
- Results hold for the larger radius
- Results hold for smaller radius in Texas but turn insignificant in Tennessee

Coming Attractions…

- Understanding the 2- and 4-year difference
- Moving census tracts to 1990 definition rather than 2020
- Examine census tract changes in educational levels (although the changing nature of these makes this difficult over time)
- Extend database on college branch campus locations

Discussion and conclusion

- Significant impact of college branch campuses on local economic activity
- 2-year branch campuses with somewhat larger impact but positive effects for both types of campuses
- Effect peaks within 10 years of a branch campus opening and then remains at a higher than pre-opening level
- Limitations and avenues for future research
  - Expanding the analysis to include additional states
  - Investigating the role of college branch campuses within the larger higher education system
  - Qualitative investigation of branch campus site selection

Appendix

Conventional DD results: 10-mile radius

Table 4. DD estimates of branch campus effect on economic activity within 10-mile radius of impact in Tennessee and Texas

	Tennessee		Texas	
	(1)	(2)	(3)	(4)
Any Branch Campus	0.003		0.025**	
	(0.011)		(0.010)	
Two-Year Branch Campus		0.016		-0.007
		(0.012)		(0.014)
Four-Year Branch Campus		-0.049**		0.037***
		(0.016)		(0.013)
Observations	62,630	62,630	251,680	251,680
Number of tracts	1,701	1,701	6,875	6,875
Within-R^2	0.204	0.205	0.175	0.175

Notes: The dependent variable is the predicted standardized natural logarithm of GDP. The treatment variables are lagged four years so that we estimate the economic impact of a branch campus four years after its opening date. All models include constant, census tract FE, and year FE. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

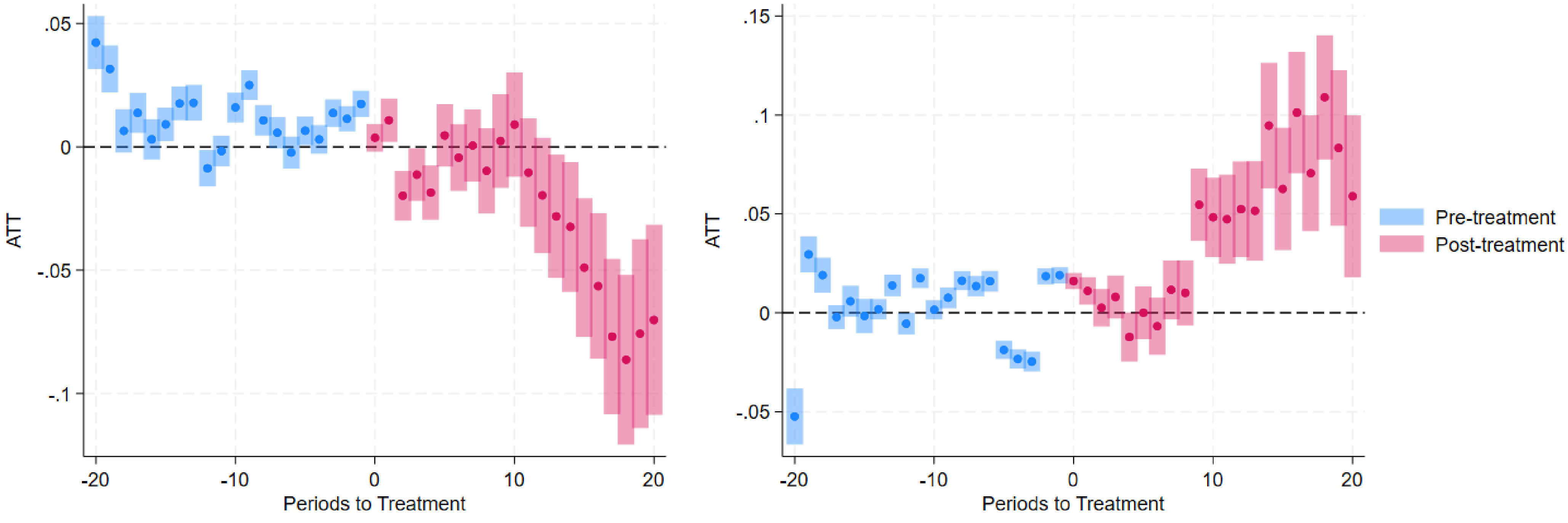
Conventional DD results: 40-mile radius

Table 5. DD estimates of branch campus effect on economic activity within 40-mile radius of impact in Tennessee and Texas

	Tennessee		Texas	
	(1)	(2)	(3)	(4)
Any Branch Campus	0.043***		0.217***	
	(0.006)		(0.007)	
Two-Year Branch Campus		0.047***		0.103***
		(0.006)		(0.008)
Four-Year Branch Campus		-0.002		0.210***
		(0.009)		(0.008)
Observations	62,630	62,630	251,680	251,680
Number of tracts	1,701	1,701	6,875	6,875
Within-R^2	0.207	0.207	0.205	0.210

Notes: The dependent variable is the predicted standardized natural logarithm of GDP. The treatment variables are lagged four years so that we estimate the economic impact of a branch campus four years after its opening date. All models include constant, census tract FE, and year FE. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Heterogeneity-robust DD results: 10-mile radius

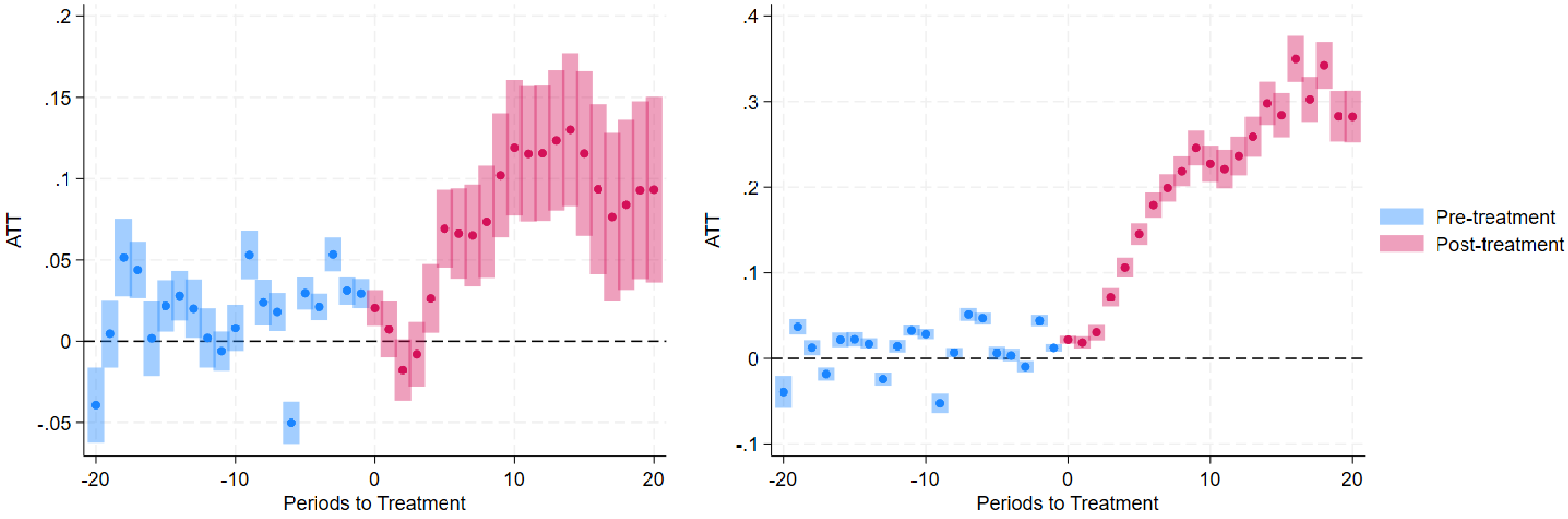


A. Tennessee

B. Texas

Figure 10. Heterogeneity-robust DD estimates of effects within 10-mile radius of impact in Tennessee and Texas.

Heterogeneity-robust DD results: 40-mile radius



A. Tennessee

B. Texas

Figure 11. Heterogeneity-robust DD estimates of effects within 40-mile radius of impact in Tennessee and Texas.

IV results: 10-mile radius

Table 6. IV estimates of branch campus effect on economic activity within 10-mile radius of impact in Texas

	(1)	(2)
Any Branch Campus	0.199***	
	(0.043)	
Two-Year Branch Campus		0.577***
		(0.069)
Four-Year Branch Campus		0.334***
		(0.034)
First first-stage F-value of instruments	432.21***	212.88***
Second first-stage F-value of instruments		497.11***
Observations	251,680	251,680
Number of tracts	6,875	6,875
Within-R^2	0.165	0.098

Notes: The dependent variable is the predicted standardized natural logarithm of GDP. The treatment variables are lagged four years so that we estimate the economic impact of a branch campus four years after its opening date. All models include constant, census tract FE, and year FE. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

IV results: 40-mile radius

Table 7. IV estimates of branch campus effect on economic activity within 40-mile radius of impact in Texas

	(1)	(2)
Any Branch Campus	0.133***	
	(0.034)	
Two-Year Branch Campus		0.104***
		(0.018)
Four-Year Branch Campus		0.254***
		(0.024)
First first-stage F-value of instruments	611.11***	3,708.38***
Second first-stage F-value of instruments		1,526.02***
Observations	251,680	251,680
Number of tracts	6,875	6,875
Within-R^2	0.201	0.209

Notes: The dependent variable is the predicted standardized natural logarithm of GDP. The treatment variables are lagged four years so that we estimate the economic impact of a branch campus four years after its opening date. All models include constant, census tract FE, and year FE. Robust standard errors in parentheses. ****p*<0.01, ***p*<0.05, **p*<0.1.

IV results: first-stage for Table 2

Table 8. First stage IV estimates for Table 2.

	Any Branch Campus (1)	2-Year Branch Campus (2)	4-Year Branch Campus (3)
ln(Avg. Distance to 5 Closest Branch Campuses)	0.056		
	(0.047)		
ln(Avg. Distance to 5 Closest Branch Campuses) × Taxing District	-0.661***		
	(0.047)		
ln(Avg. Distance to 5 Closest 2-Year Branch Campuses)		-0.601***	-0.255***
		(0.015)	(0.018)
ln(Avg. Distance to 5 Closest 2-Year Branch Campuses) × Taxing District		0.100***	-0.251***
		(0.016)	(0.019)
ln(Avg. Distance to 5 Closest 4-Year Branch Campuses)		0.483***	-0.710***
		(0.027)	(0.048)
ln(Avg. Distance to 5 Closest 4-Year Branch Campuses) × Taxing District		-0.100***	-0.240***
		(0.027)	(0.050)
F-value of instruments	458.99***	2,183.95***	3,268.45***
Corresponding second stage in Table 2	(1)	(2)	(2)
Observations	251,680	251,680	251,680
Number of tracts	6,875	6,875	6,875
Within-R^2	0.409	0.393	0.411

Notes: The dependent variable is the binary indicator for a branch campus opening and is lagged 4 years. All models include constant, census tract FE, and year FE. Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

References

Andrews, M. (2023). How do institutions of higher education affect local invention? Evidence from the establishment of U.S. colleges. American Economic Journal: Economic Policy, 15(2), 1-14. https://doi.org/10.1257/pol.20200320

Bianchi, N., & Giorcelli, M. (2020). Scientific education and innovation: From technical diplomas to university STEM degrees. Journal of the European Economic Association, 18(5), 2608-2646. https://doi.org/10.1093/jeea/jvz049

Böckerman, P., & Haapanen, M. (2013). The effect of polytechnic reform on migration. Journal of Population Economics, 26, 593-617. https://doi.org/10.1007/s00148-012-0454-4

Callaway, B., & Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. Journal of Econometrics, 225(2), 200-230. https://doi.org/10.1016/j.jeconom.2020.12.001 Cowan, R., & Zinvovyeva, N. (2013). University effects on regional innovation. Research Policy, 42, 788-800. https://doi.org/10.1016/j.respol.2012.10.001

Faber, B., & Gaubert, C. (2019). Tourism and economic development: Evidence from Mexico's coastline. American Economic Review, 109(6), 2245-2293. https://doi.org/10.1257/aer.20161434

Kamhöfer, D. A., Schmitz, H., & Westphal, M. (2019). Heterogeneity in marginal non-monetary returns to higher education. Journal of the European Economic Association, 17(1), 205-244. https://doi.org/10.1093/jeea/jvx058

Kyui, N. (2016). Expansion of higher education, employment and wages: Evidence from the Russian Transition. Labour Economics, 39, 68-87. https://doi.org/10.1016/j.labeco.2016.01.001

Lee, Y. S. (2018). International isolation and regional inequality: Evidence from sanctions on North Korea. Journal of Urban Economics, 103, 34-51. https://doi.org/10.1016/j.jue.2017.11.002

Lehnert, P., Niederberger, M., Backes-Gellner, U., & Bettinger, E. (2023). Proxying economic activity with daytime satellite imagery: Filling data gaps across time and space. PNAS Nexus, 2023, 1-11. https://doi.org/10.1093/pnasnexus/pgad099

References

Lehnert, P., Pfister, C., & Backes-Gellner, U. (2020). Employment of R&D personnel after an education supply shock: Effects of the introduction of Universities of Applied Sciences in Switzerland. Labour Economics, 66, 101833. https://doi.org/10.1016/j.labeco.2020.101883

Moretti, E. (2004). Estimating the social return to higher education: Evidence from longitudinal and repeated cross-sectional data. Journal of Econometrics, 121(1-2), 175-212. https://doi.org/10.1016/j.jeconom.2003.10.015

Oreopoulos, P., & Petronijevic, U. (2013). Making college worth it: A review of the returns to higher education. The Future of Children, 23(1), 41-65. https://doi.org/10.1353/foc.2013.0001

Pfister, C., Koomen, M., Harhoff, D., & Backes-Gellner, U. (2021). Regional innovation effects of applied research institutions. Research Policy, 50(4), 104197. https://doi.org/10.1016/j.respol.2021.104197

Schlegel, T., Pfister, C., & Backes-Gellner, U. (2022). Tertiary education expansion and regional firm development. Regional Studies, forthcoming. https://doi.org/10.1080/00343404.2021.2010695

Sutton, P. C., & Costanza, R. (2002). Global estimates of market and non-market values derived from nighttime light satellite imagery, land cover, and ecosystem service valuation. Ecological Economics, 41(3), 509-527. https://doi.org/10.1016/S0921-8009(02)00097-6

Toivanen, O., & Väänänen, L. (2016). Education and invention. The Review of Economics and Statistics, 98(2), 382-396. https://doi.org/10.1162/REST_a_00520