Causes and Consequences of Innovation Clusters: Examining the Impact of National Labs

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NBER Place-Based Policies and Entrepreneurship Meeting

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Motivation

- **Question:** Can public institutions focused on applied research create
  - (1) sustained regional innovation?
  - (2) knowledge spillovers beyond the institution?
  - (3) aggregate economic and social impacts in a region?
  - (4) inclusive growth for existing residents?

Like several other programs, the new multi-billion dollar NSF Regional Innovation Engines try to use federal R&D provision to kick-start *"regional innovation ecosystems*" that deliver *"inclusive economic and societal impacts* " in "*regions that have not fully participated in the technology boom."*. Can this work?

What is a National Lab?

- Large literature on public investment in innovation, with recent papers on universities (Andrews AEJ 2023) and contracts to tech leaders (Gross and Sampat AER 2023, Kantor and Whalley AER Forthcoming).
- By contrast, the National Labs are public institutions that translate basic science to innovation. They are funded by the federal government but operated by contractors under long-term agreements.
- Labs vary in size, but often have several thousand staff, budgets in hundreds of millions.
- Most national labs were established 1947-1960. Original goal for 14/17 labs was developing nuclear technology, for weapons and energy.
- Some labs were established with an economic development goal; all now have this mission, and have broadened their research fields.

Map of National Labs founded between 1930-1980

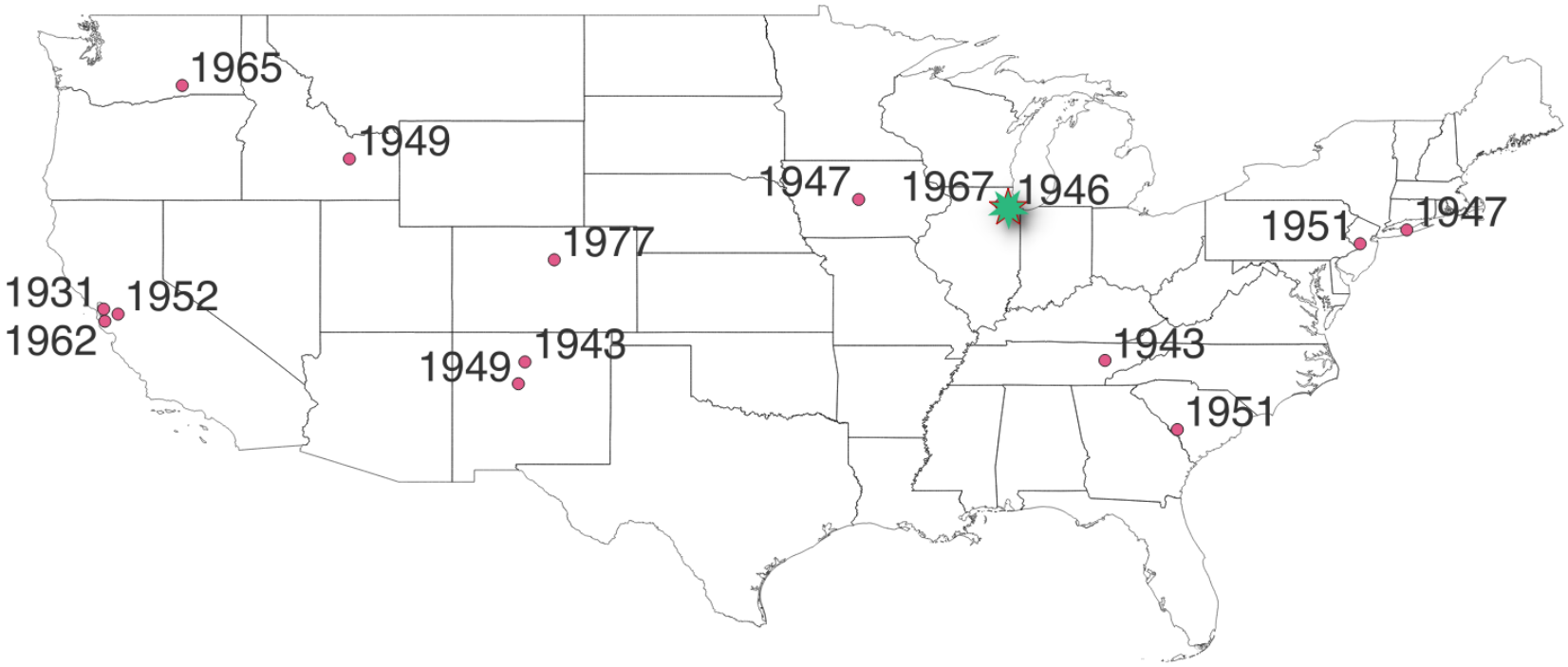


Figure 1: Numbers in parenthesis indicate year of founding

- Focus on **Argonne National Lab** in this talk (marked in green) due to time limitation. Similar results for other labs.

1. Regional Innovation: National Labs Increase Patenting

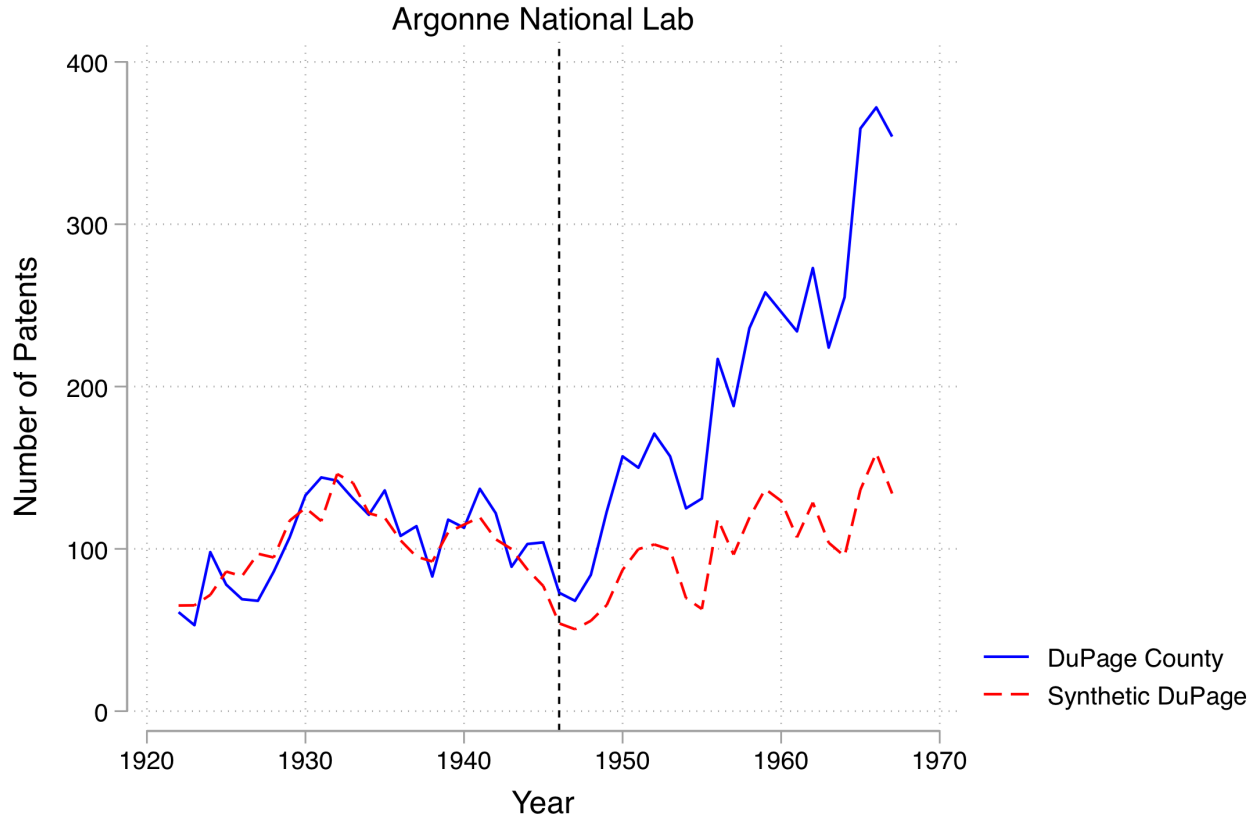


Figure 2: Patents For Argonne National Lab, IL (synthetic control result).

(Click here for more national lab slides.) (Click here for counterfactual locations.)

2. Knowledge Spillovers: Non-Argonne inventors also patent more after lab is established (DuPage county)

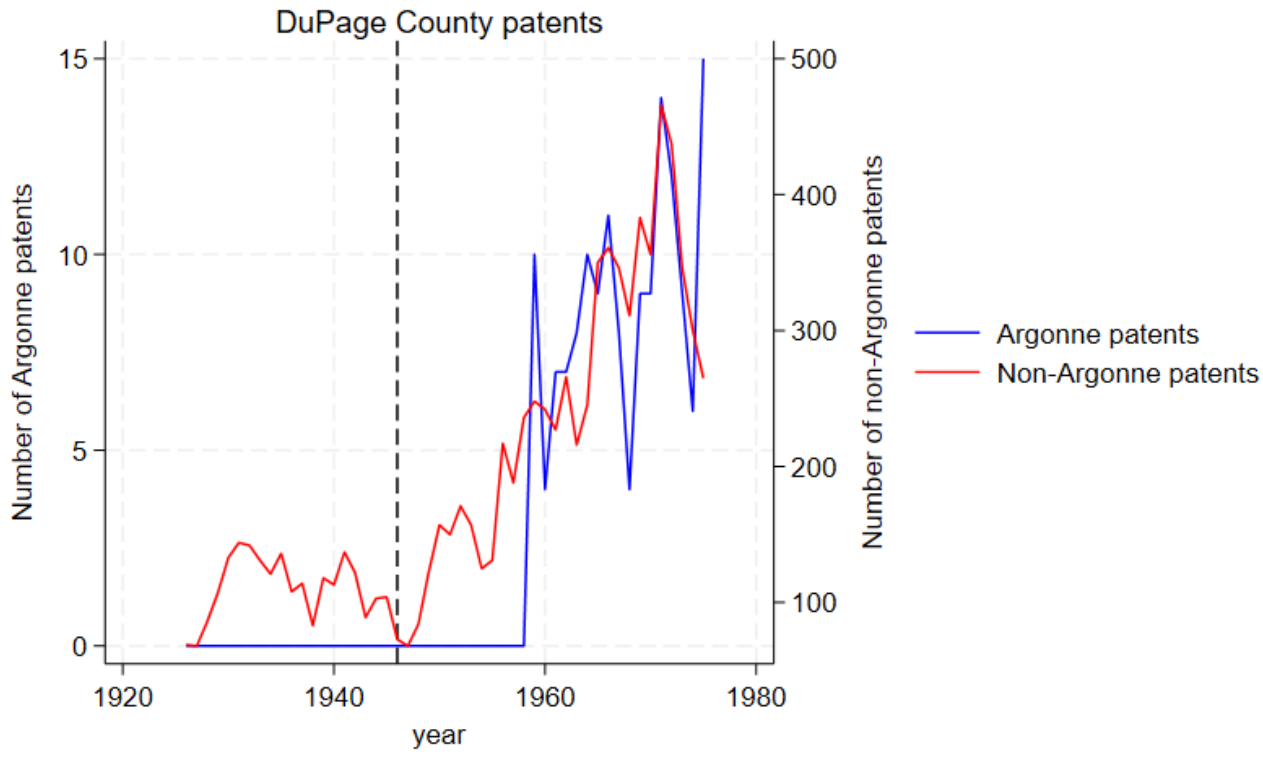


Figure 3: Dis-aggregated patents in DuPage county, Illinois.

2. Knowledge Spillovers: Increase Patenting in Lab Areas

- Idea spread to non-lab patents not yet evident in citations, but clear in patent classifications.

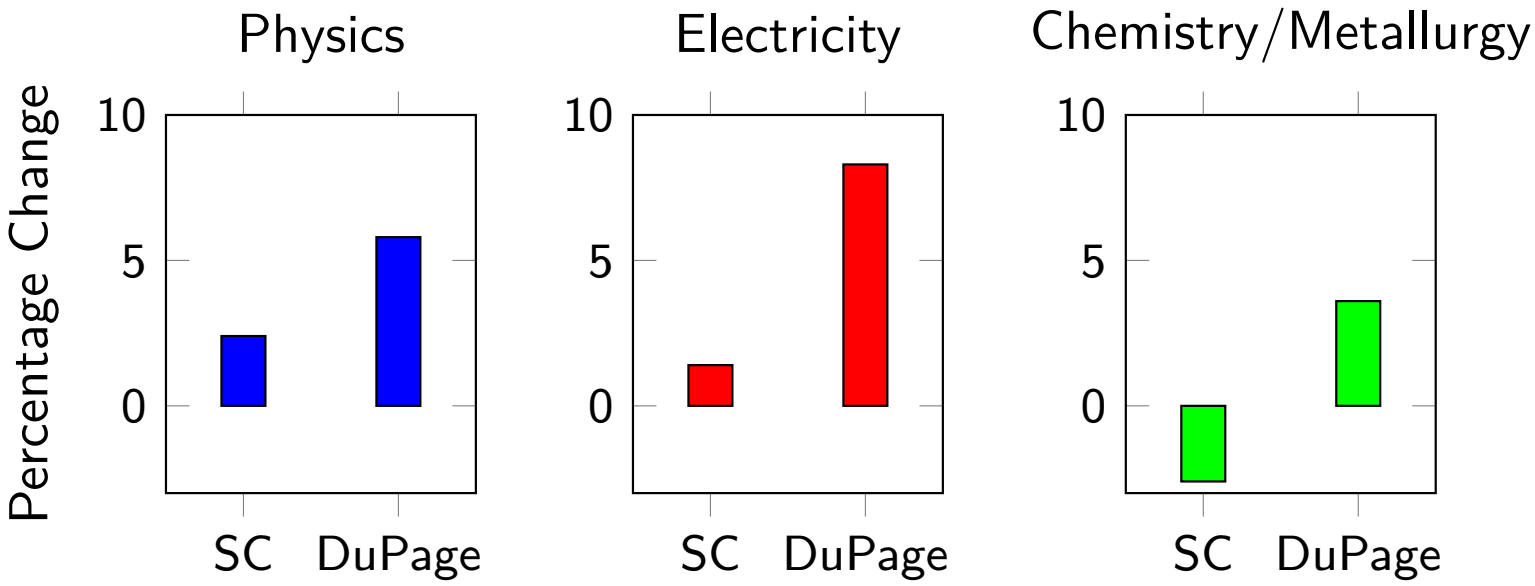
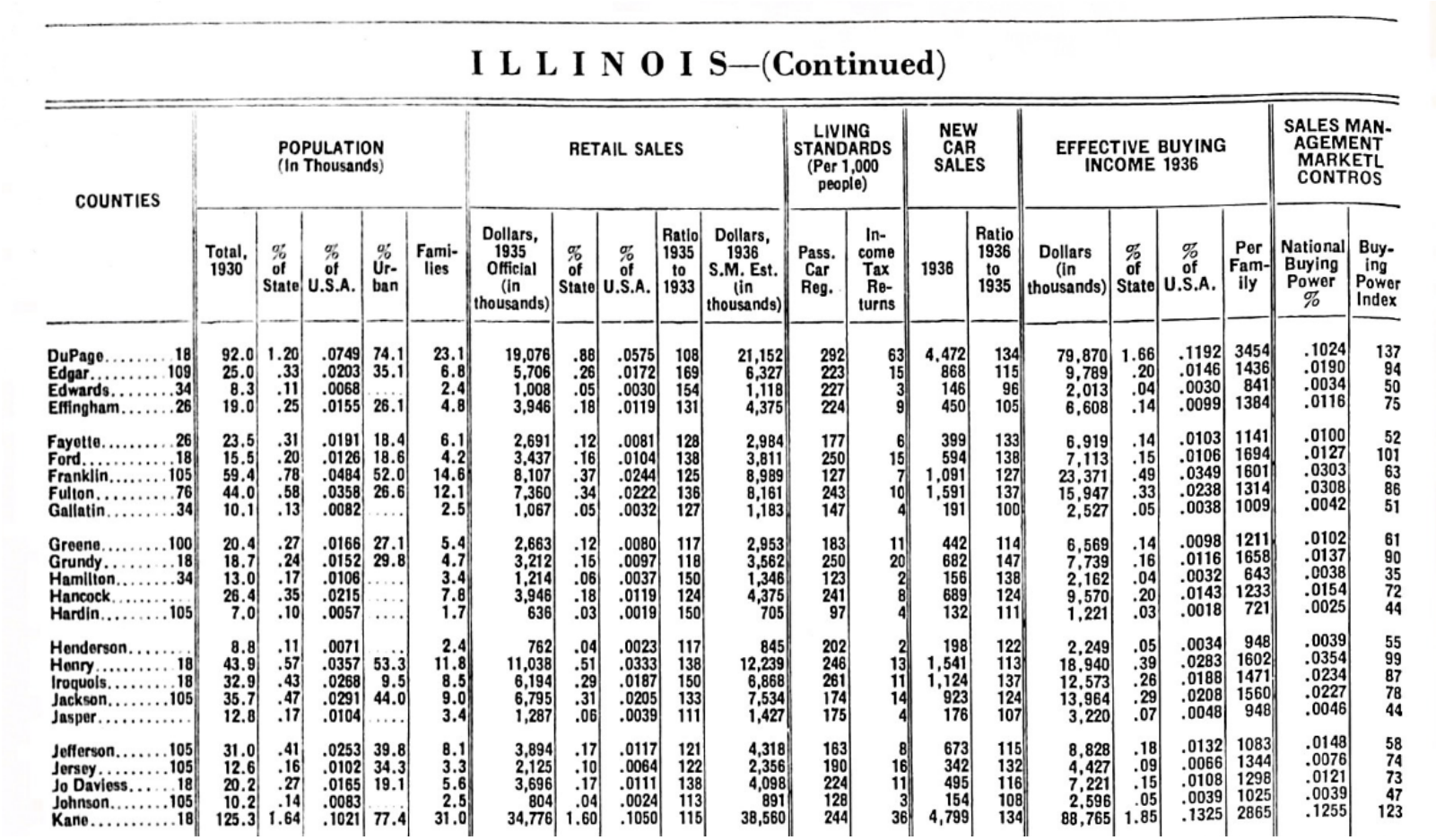


Figure 4: The y-axis measures before/after changes in the share of patents in each patent classification category: 1920-1945 versus 1946-1975. 'SC' stands for Synthetic-control Counties.

3. Economic Impact: Discovery of Annual Economic Data



ILLINOIS—(Continued)

COUNTIES	POPULATION (In Thousands)					RETAIL SALES					LIVING STANDARDS (Per 1,000 people)		NEW CAR SALES		EFFECTIVE BUYING INCOME 1936				SALES MANAGEMENT MARKETL CONTROS	
	Total, 1930	% of State	% of U.S.A.	% Urban	Families	Dollars, 1935 Official (in thousands)	% of State	% of U.S.A.	Ratio 1935 to 1933	Dollars, 1936 S.M. Est. (in thousands)	Pass. Car Reg.	Income Tax Returns	1936	Ratio 1936 to 1935	Dollars (in thousands)	% of State	% of U.S.A.	Per Family	National Buying Power %	Buying Power Index
DuPage.....18	92.0	1.20	.0749	74.1	23.1	19,076	.88	.0575	108	21,152	292	63	4,472	134	79,870	1.66	.1192	3454	.1024	137
Edgar.....109	25.0	.33	.0203	35.1	6.8	5,706	.26	.0172	169	6,327	223	15	868	115	9,789	.20	.0146	1436	.0190	94
Edwards.....34	8.3	.11	.0068	....	2.4	1,008	.05	.0030	154	1,118	227	3	146	96	2,013	.04	.0030	841	.0034	50
Effingham.....26	19.0	.25	.0155	26.1	4.8	3,946	.18	.0119	131	4,375	224	9	450	105	6,608	.14	.0099	1384	.0116	75
Fayette.....26	23.5	.31	.0191	18.4	6.1	2,691	.12	.0081	128	2,984	177	6	399	133	6,919	.14	.0103	1141	.0100	52
Ford.....18	15.5	.20	.0126	18.6	4.2	3,437	.16	.0104	138	3,811	250	15	594	138	7,113	.15	.0106	1694	.0127	101
Franklin.....105	59.4	.78	.0484	52.0	14.6	8,107	.37	.0244	125	8,989	127	7	1,091	127	23,371	.49	.0349	1601	.0303	63
Fulton.....76	44.0	.58	.0358	26.6	12.1	7,360	.34	.0222	136	8,161	243	10	1,591	137	15,947	.33	.0238	1314	.0308	86
Gallatin.....34	10.1	.13	.0082	....	2.5	1,067	.05	.0032	127	1,183	147	4	191	100	2,527	.05	.0038	1009	.0042	51
Greene.....100	20.4	.27	.0166	27.1	5.4	2,663	.12	.0080	117	2,953	183	11	442	114	6,569	.14	.0098	1211	.0102	61
Grundy.....18	18.7	.24	.0152	29.8	4.7	3,212	.15	.0097	118	3,562	250	20	682	147	7,739	.16	.0116	1658	.0137	90
Hamilton.....34	13.0	.17	.0106	....	3.4	1,214	.06	.0037	150	1,346	123	2	156	138	2,162	.04	.0032	643	.0038	35
Hancock.....	26.4	.35	.0215	....	7.8	3,946	.18	.0119	124	4,375	241	8	689	124	9,570	.20	.0143	1233	.0154	72
Hardin.....105	7.0	.10	.0057	....	1.7	636	.03	.0019	150	705	97	4	132	111	1,221	.03	.0018	721	.0025	44
Henderson.....	8.8	.11	.0071	....	2.4	762	.04	.0023	117	845	202	2	198	122	2,249	.05	.0034	948	.0039	55
Henry.....18	43.9	.57	.0357	53.3	11.8	11,038	.51	.0333	138	12,239	246	13	1,541	113	18,940	.39	.0283	1602	.0354	99
Iroquois.....18	32.9	.43	.0268	9.5	8.5	6,194	.29	.0187	150	6,868	261	11	1,124	137	12,573	.26	.0188	1471	.0234	87
Jackson.....105	35.7	.47	.0291	44.0	9.0	6,795	.31	.0205	133	7,534	174	14	923	124	13,964	.29	.0208	1560	.0227	78
Jasper.....	12.8	.17	.0104	....	3.4	1,287	.06	.0039	111	1,427	175	4	176	107	3,220	.07	.0048	948	.0046	44
Jefferson.....105	31.0	.41	.0253	39.8	8.1	3,894	.17	.0117	121	4,318	163	8	673	115	8,828	.18	.0132	1083	.0148	58
Jersey.....105	12.6	.16	.0102	34.3	3.3	2,125	.10	.0064	122	2,356	190	16	342	132	4,427	.09	.0066	1344	.0076	74
Jo Daviess.....18	20.2	.27	.0165	19.1	5.6	3,696	.17	.0111	138	4,098	224	11	495	116	7,221	.15	.0108	1298	.0121	73
Johnson.....105	10.2	.14	.0083	....	2.5	804	.04	.0024	113	891	128	3	154	108	2,596	.05	.0039	1025	.0039	47
Kane.....18	125.3	1.64	.1021	77.4	31.0	34,776	1.60	.1050	115	38,560	244	36	4,799	134	88,765	1.85	.1325	2865	.1255	123

Figure 5: A scan from the Survey of Buying Power (1936). Resource for other researchers.

3. Economic Impact: Total Retail Sales Increase

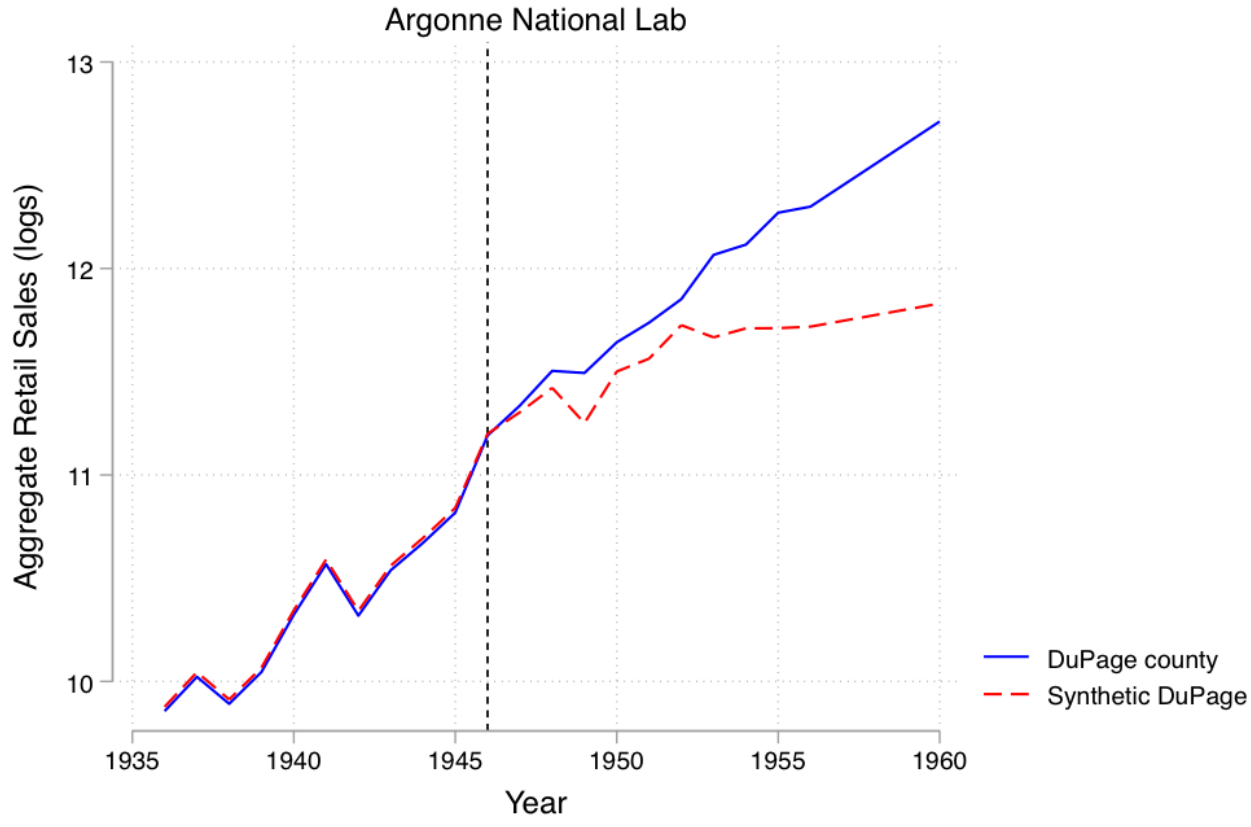


Figure 6: Retail Sales For Argonne National Lab, IL (synthetic control result)

(Click here for more national lab slides.)

3. Economic Impact: Increase in the Number of Firms

$$\text{No. of firms}_{\text{town,year}} = \alpha + \beta \times (\text{DuPage}_{\text{town}} \times \mathbb{1}_{\text{year=1955}}) + \gamma_{\text{town}} + \lambda_{\text{year}} + \epsilon_{\text{town,year}} \quad (1)$$

Table 1: Data from the Certified List of Domestic and Foreign Corporations.

	(1)
VARIABLES	No. of firms
$\text{Dupage}_{\text{town}} \times \mathbb{1}_{\text{year=1955}}$	37.321***
	(14.000)
Constant	22.444***
	(4.646)
Observations	126
R-squared	0.867
Mean dep. var (1945)	22.44
Mean dep. var (1955)	52.17

Notes: The unit of observation is a town/city and the two time periods used are 1945 and 1955. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4. Distributional Impact: Wages Increase for Prior Residents

Table 2: Data from the 1940 and 1950 census matched individuals (DuPage vs. Synthetic control counties).

	(1)	(2)	(3)	(4)
VARIABLES	Change in Wage (Logs)			
DuPage	0.0175	0.0432*	0.0456*	-0.00446
	(0.0331)	(0.0257)	(0.0253)	(0.0347)
Under 35 × DuPage		0.107**	0.112**	
		(0.0476)	(0.0477)	
College × DuPage			0.0972	0.0727
			(0.0708)	(0.0722)
Professional × DuPage			0.167*	0.133
			(0.0896)	(0.0909)
Control County Mean	0.874	0.874	0.874	0.874
Observations	6,937	6,937	6,937	6,937

Notes: The unit of observation is an individual, and the two time periods used are 1940 and 1950. Robust standard errors in parentheses. All regressions control for 1940 wage levels. *** p<0.01, ** p<0.05, * p<0.1

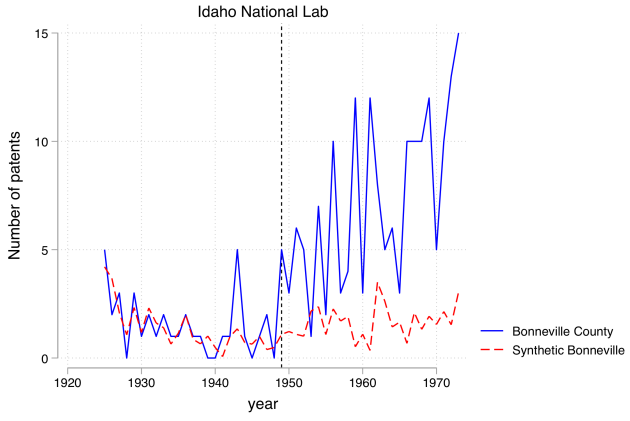
Conclusions

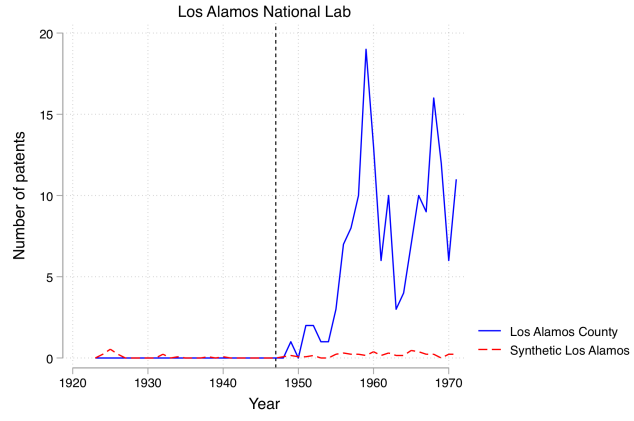
- We find evidence that national labs significantly impacted
  - (1) Patenting - our measure of local innovation.
  - (2) Non-institutional patenting and patent categories - our measure of knowledge spillovers
  - (3) Retail sales and firm creations - our measures of aggregate economic activity
  - (4) Wages for prior residents - our measure of distributional outcomes.

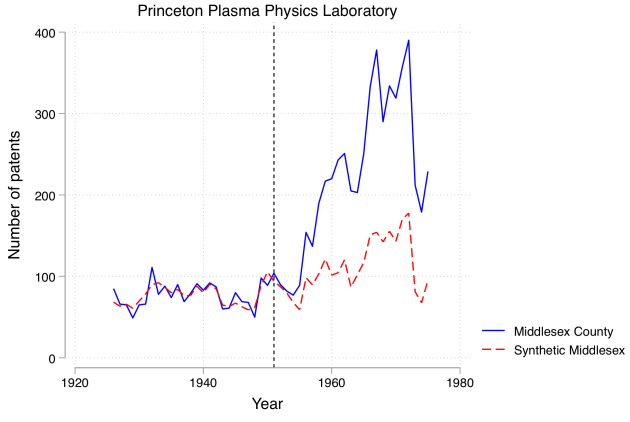
Questions and Future Research

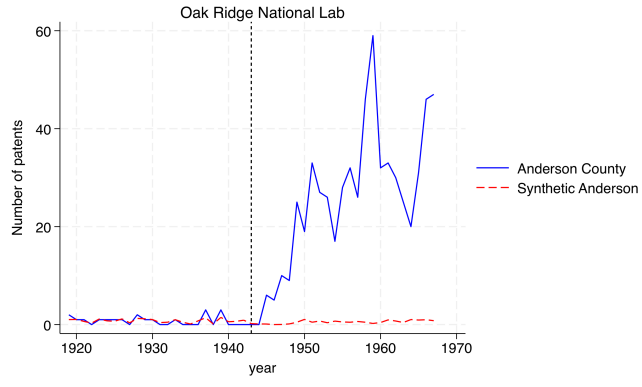
- Potential work to nail down the mechanisms of impact:
  - Impact on in-migrants, prior innovators, etc.
- Long run impacts:
  - Educational attainment, entrepreneurship, productivity, etc.
- Return on investment vs other interventions.
- Heterogeneity in impact across labs and over time.

Patents for other national Labs









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Inference (for Argonne National Lab)

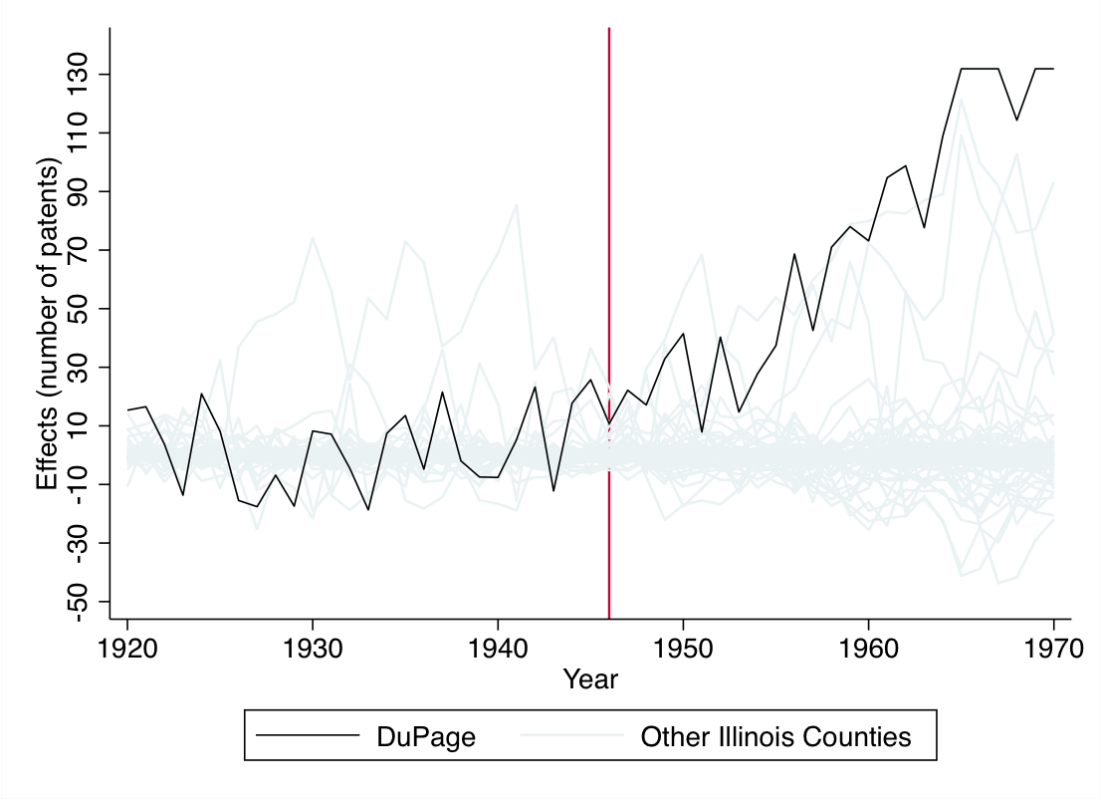

Figure 8: Deviations from their respective synthetic controls. Lightly colored lines are placebo checks for the donor pool. The p-value from the post estimation is 0.03.

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Tax Receipts

Figure 9: Data from the Department of Revenue

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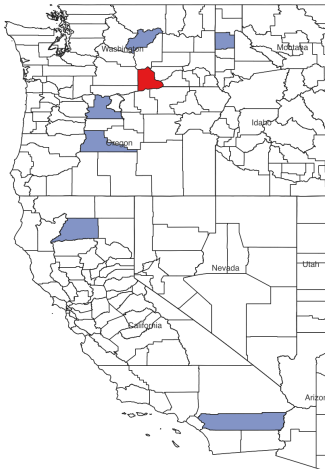
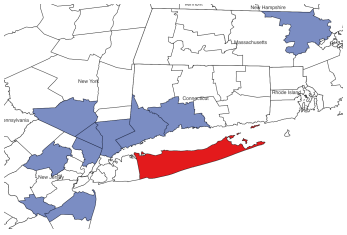
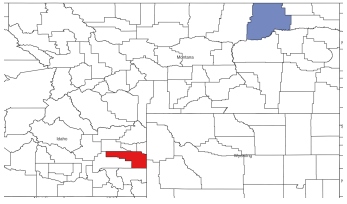
Map of runner-up counties



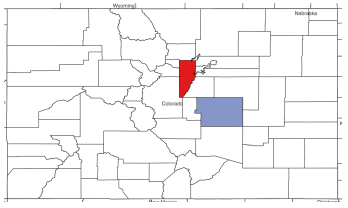
(a) Pacific Northwest National Lab



(b) Brookhaven National Lab



(c) Idaho National Lab



(d) IREL National Lab

Figure 10: Red counties indicate actual lab location, and blue ones are the runner-up counties.

(Click here to go back.)

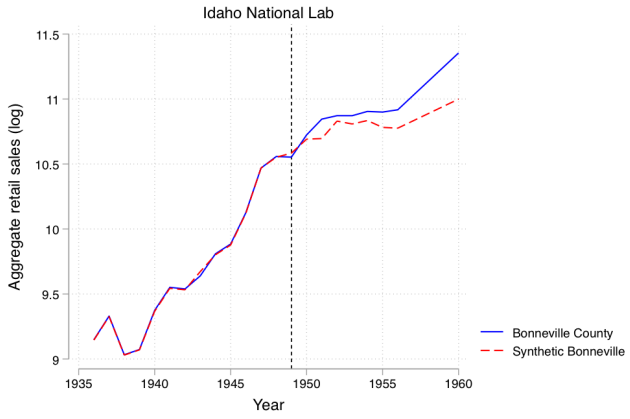
Other labs (wage heterogeneity)

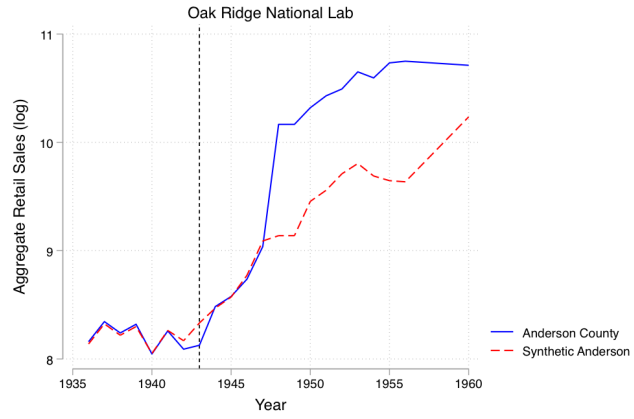
	Change in wages (levels)				Change in wages (logs)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES								
Lab county	82.88	37.75	79.50*	39.66	0.00184	-0.00861	0.0141	-0.0280
	(70.86)	(47.17)	(47.99)	(71.07)	(0.0385)	(0.0273)	(0.0264)	(0.0400)
Under 35	259.3***			247.0***	0.0839***			0.0779***
	(43.47)			(43.60)	(0.0235)			(0.0236)
Under 35 × Lab county	-1.164			1.778	0.0355			0.0337
	(94.42)			(94.23)	(0.0512)			(0.0510)
College		168.0**		163.6*		0.107***		0.0999**
		(84.00)		(87.15)		(0.0399)		(0.0416)
College × Lab county		236.2		245.5		0.171**		0.156**
		(168.4)		(175.3)		(0.0750)		(0.0790)
Professional			-89.38	-145.7			0.0334	0.00114
			(97.82)	(100.5)			(0.0478)	(0.0493)
Professional × Lab county			47.69	-78.51			0.122	0.0561
			(219.6)	(232.3)			(0.101)	(0.105)
Observations	9,231	9,231	9,231	9,231	7,462	7,462	7,462	7,462
R-squared	0.053	0.051	0.049	0.055	0.036	0.037	0.034	0.039

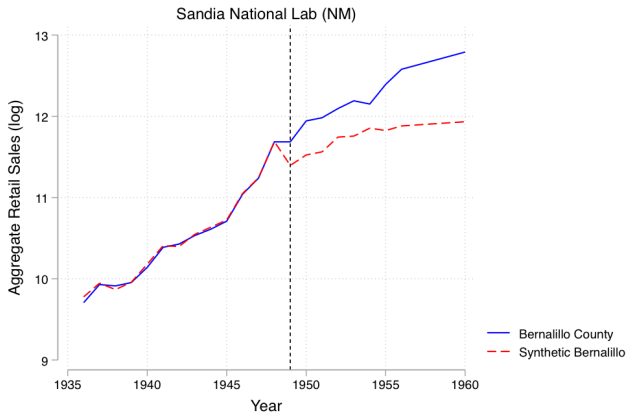
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

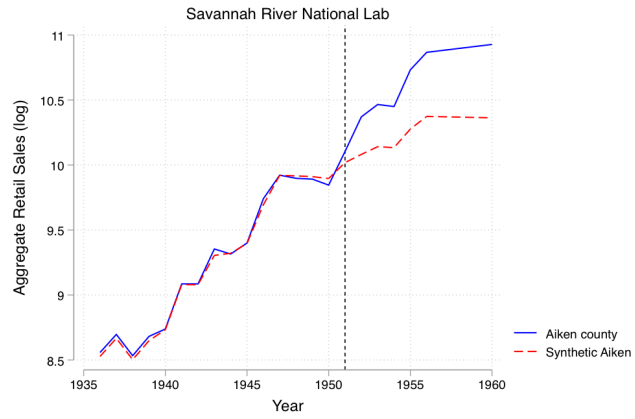
(Click here to go back.)

Retail sales for other National Labs









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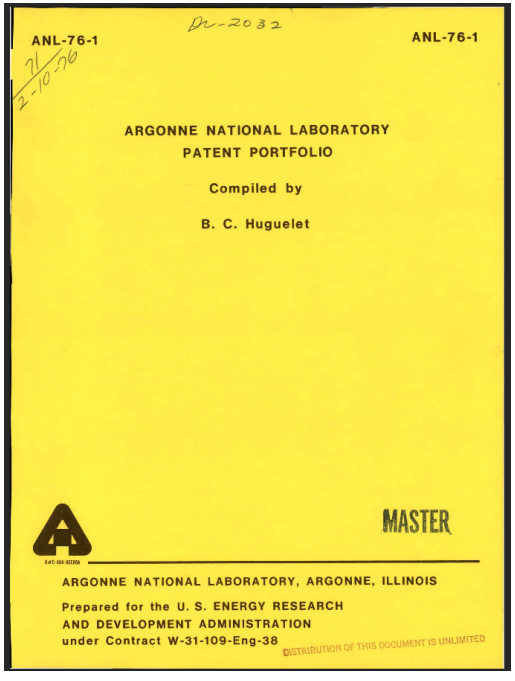
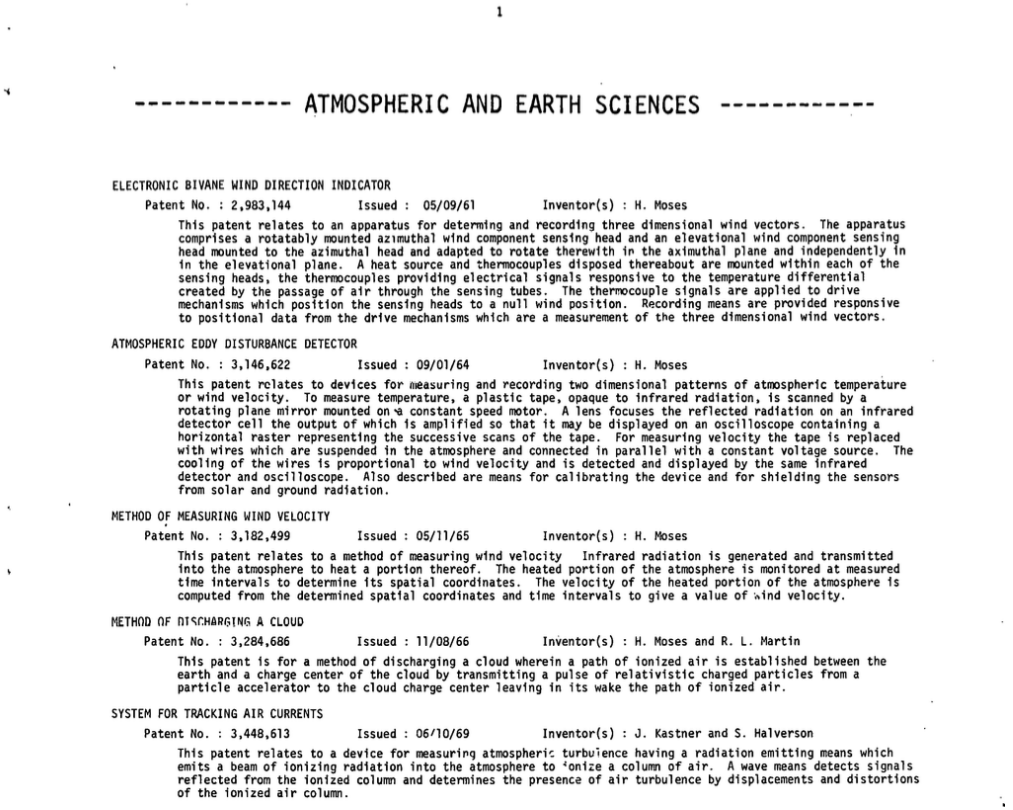
Argonne Patents



(a) Front page



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---------- ATMOSPHERIC AND EARTH SCIENCES ----------

ELECTRONIC BIVANE WIND DIRECTION INDICATOR

Patent No. : 2,983,144 Issued : 05/09/61 Inventor(s) : H. Moses

This patent relates to an apparatus for determing and recording three dimensional wind vectors. The apparatus comprises a rotatably mounted azimuthal wind component sensing head and an elevational wind component sensing head mounted to the azimuthal head and adapted to rotate therewith in the aximuthal plane and independently in in the elevational plane. A heat source and thermocouples disposed thereabout are mounted within each of the sensing heads, the thermocouples providing electrical signals responsive to the temperature differential created by the passage of air through the sensing tubes. The thermocouple signals are applied to drive mechanisms which position the sensing heads to a null wind position. Recording means are provided responsive to positional data from the drive mechanisms which are a measurement of the three dimensional wind vectors.

ATMOSPHERIC EDDY DISTURBANCE DETECTOR

Patent No. : 3,146,622 Issued : 09/01/64 Inventor(s) : H. Moses

This patent relates to devices for measuring and recording two dimensional patterns of atmospheric temperature or wind velocity. To measure temperature, a plastic tape, opaque to infrared radiation, is scanned by a rotating plane mirror mounted on a constant speed motor. A lens focuses the reflected radiation on an infrared detector cell the output of which is amplified so that it may be displayed on an oscilloscope containing a horizontal raster representing the successive scans of the tape. For measuring velocity the tape is replaced with wires which are suspended in the atmosphere and connected in parallel with a constant voltage source. The cooling of the wires is proportional to wind velocity and is detected and displayed by the same infrared detector and oscilloscope. Also described are means for calibrating the device and for shielding the sensors from solar and ground radiation.

METHOD OF MEASURING WIND VELOCITY

Patent No. : 3,182,499 Issued : 05/11/65 Inventor(s) : H. Moses

This patent relates to a method of measuring wind velocity Infrared radiation is generated and transmitted into the atmosphere to heat a portion thereof. The heated portion of the atmosphere is monitored at measured time intervals to determine its spatial coordinates. The velocity of the heated portion of the atmosphere is computed from the determined spatial coordinates and time intervals to give a value of wind velocity.

METHOD OF DISCHARGING A CLOUD

Patent No. : 3,284,686 Issued : 11/08/66 Inventor(s) : H. Moses and R. L. Martin

This patent is for a method of discharging a cloud wherein a path of ionized air is established between the earth and a charge center of the cloud by transmitting a pulse of relativistic charged particles from a particle accelerator to the cloud charge center leaving in its wake the path of ionized air.

SYSTEM FOR TRACKING AIR CURRENTS

Patent No. : 3,448,613 Issued : 06/10/69 Inventor(s) : J. Kastner and S. Halverson

This patent relates to a device for measuring atmospheric turbulence having a radiation emitting means which emits a beam of ionizing radiation into the atmosphere to ionize a column of air. A wave means detects signals reflected from the ionized column and determines the presence of air turbulence by displacements and distortions of the ionized air column.

(b) From Page 1 of document

Figure 12: Argonne National Lab Patent Portfolio (1976)

Number of establishments (logs)

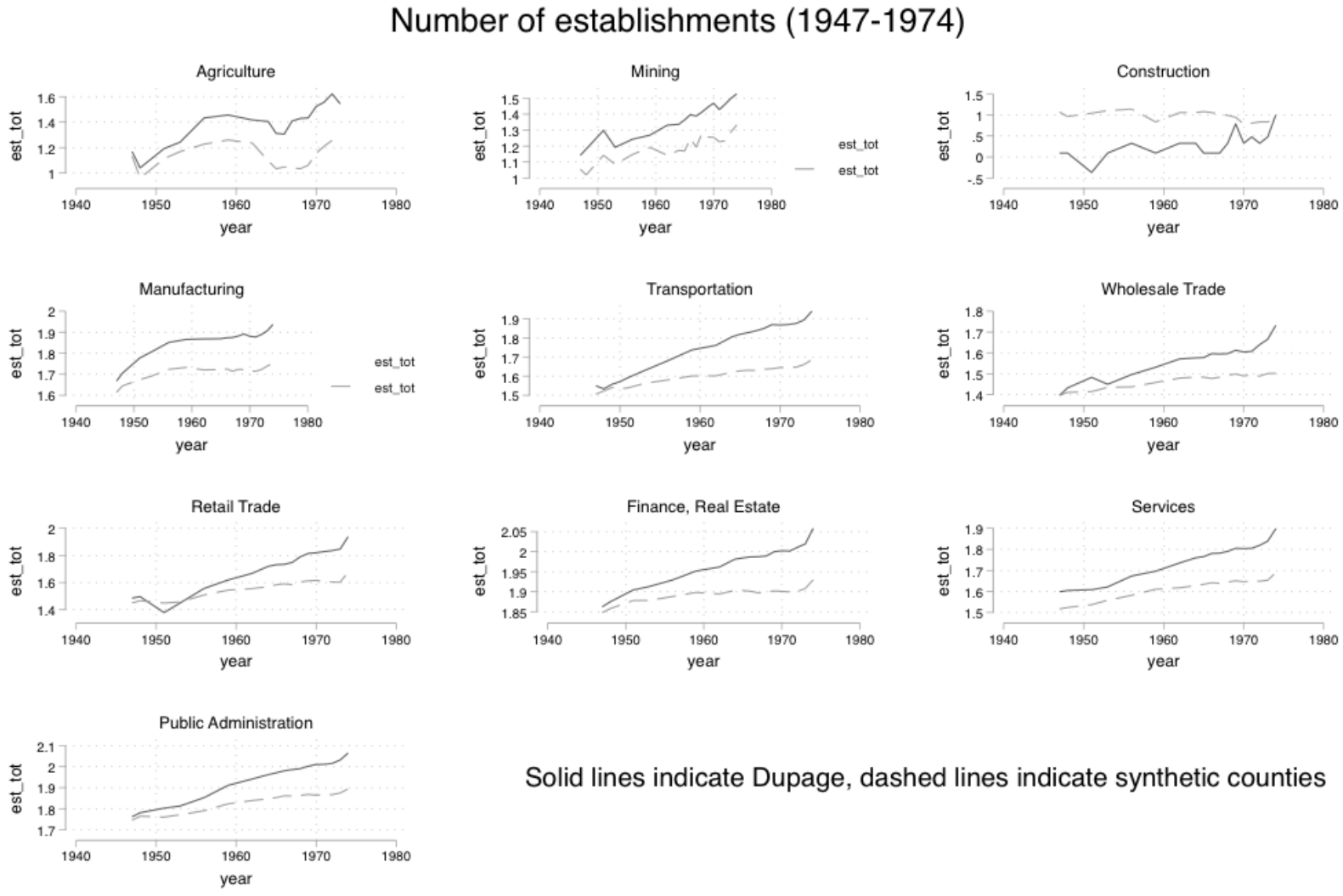

Figure 13: Data from The Early County Business Pattern Files. Y-axis plots the log total number of establishments in each category.

Scans from the Certified List of Domestic and Foreign Corporations

CERTIFIED LIST

OF

Domestic and Foreign Corporations
For the Year 1945

Volume I

Filed with the Recorder of Deeds in Compliance with Section 155 of the Business Corporation Act of Illinois. In Force July 13, 1933, and all acts amendatory thereof.

Compiled by
EDWARD J. BARRETT
Secretary of State

7
(83354)

(a) Front page

LIST OF DOMESTIC AND FOREIGN CORPORATIONS—Continued.

Name and Registered Office of Corporation.	Name and Address of President, Secretary and Registered Agent of Corporation.
Cairo Board of Trade Building Corporation, 216 7th St., Cairo.	Flint Bondurant, 2907 Park Pl. W., Cairo. Velma Reno, 324½ 8th St., Cairo. E. G. Pink, 216 7th St., Cairo.
Cairo City Gas Company, 112 E. Washington St., Monticello.	E. S. Hicht, Delavan. H. E. Johnson, 215 S. Glencoe Ave., Decatur. C. R. Brown, 112 E. Washington St., Monticello.
Cairo Coca-Cola Bottling Company, 424-428 8th St., Cairo.	Catherine M. Miller, Cairo. Virgil L. Yarbrough, Cairo. Virgil L. Yarbrough, 424-428 8th St., Cairo.
Cairo Home Oil Company, 108 N. VanBuren St., Marion.	F. E. Morrison, Marion. E. W. Morrison, Marion. F. E. Morrison, 108 N. Van Buren St., Marion.
Cairo Ice and Coal Company, 2616 Commercial Ave., Cairo.	Edwin Halliday, 712 33rd St., Cairo. Robert Halliday, 614 33rd St., Cairo. Robert Halliday, 2616 Commercial Ave., Cairo.
Cairo Laundry Company, 3312 Commercial Ave., Cairo.	A. A. Seibert, 22 Edgewood Pk., Cairo. Wilma Goodwin, 22 Edgewood Pk., Cairo. A. A. Seibert, 3312 Commercial Ave., Cairo.
Cairo Lumber Company, 3008 Sycamore St., Cairo.	O. B. Archibald, 2905 Elm St., Cairo. Leo. S. Johnson, 2701 Elm St., Cairo. O. B. Archibald, 3008 Sycamore St., Cairo.
Cairo Motor Transit Corporation, 19-21 S. Hazel, Danville.	Peter J. Giacoma, In Armed Forces. John J. Ghibaudy, 2501 Holbrook Ave., Cairo. Dominick J. Giacoma, 19-21 S. Hazel, Danville.
*Cairo Paint and Glass Company, 804 Commercial Ave., Cairo.	Harry B. Bouriand, 916 Lombard Ave., Evansville, Ind. Wm. R. Boots, 1400 Park St., Evansville, Ind. Horel B. Stone, 804 Commercial Ave., Cairo.
Cairo and Thebes Railroad Company, Washington Ave. and 15th St., Cairo.	L. W. Baldwin, 210 N. 13th St., St. Louis, Mo. A. T. Cole, 210 N. 13th St., St. Louis, Mo. E. G. Cowell, Washington Ave. and 15th St., Cairo.
Cairo Water Company, The, 618 Commercial Ave., Cairo.	E. A. Geehan, 50 Broad St., New York, N. Y. H. D. McDowell, 50 Broad St., New York, N. Y. H. L. Hileman, 618 Commercial Ave., Cairo.
Cake Ornaments, Incorporated, 1809 N. Ashland Ave., Chicago 22.	George A. Seidel, 1416 Central Ave., Evanston. Walter F. Seidel, 1017 Grove St., Evanston. Walter F. Seidel, 1809 N. Ashland Ave., Chicago.

* Foreign Corporations.

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