Scientific Voids and the Rise of American Corporate Research, 1900-1940

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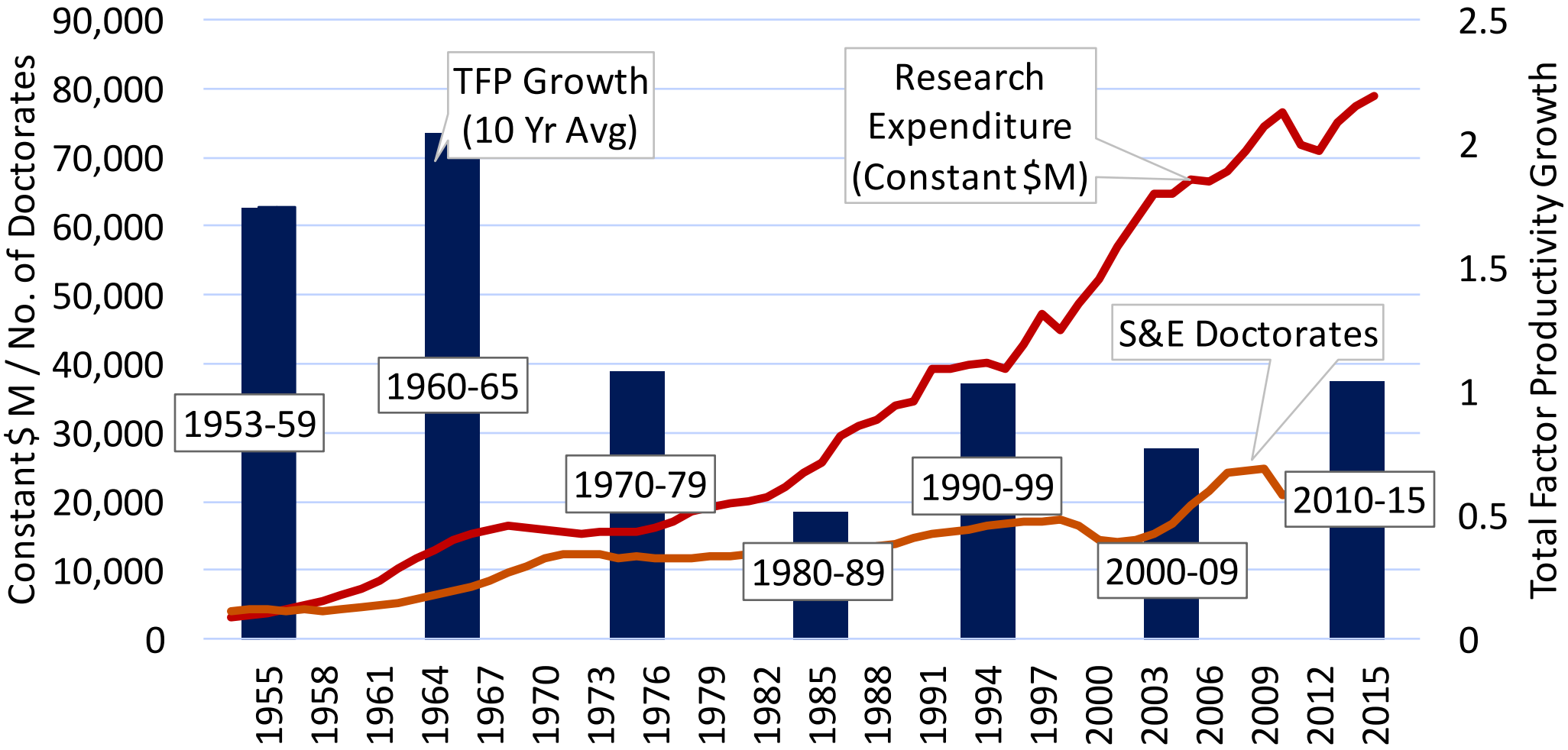
More Science for Less Growth



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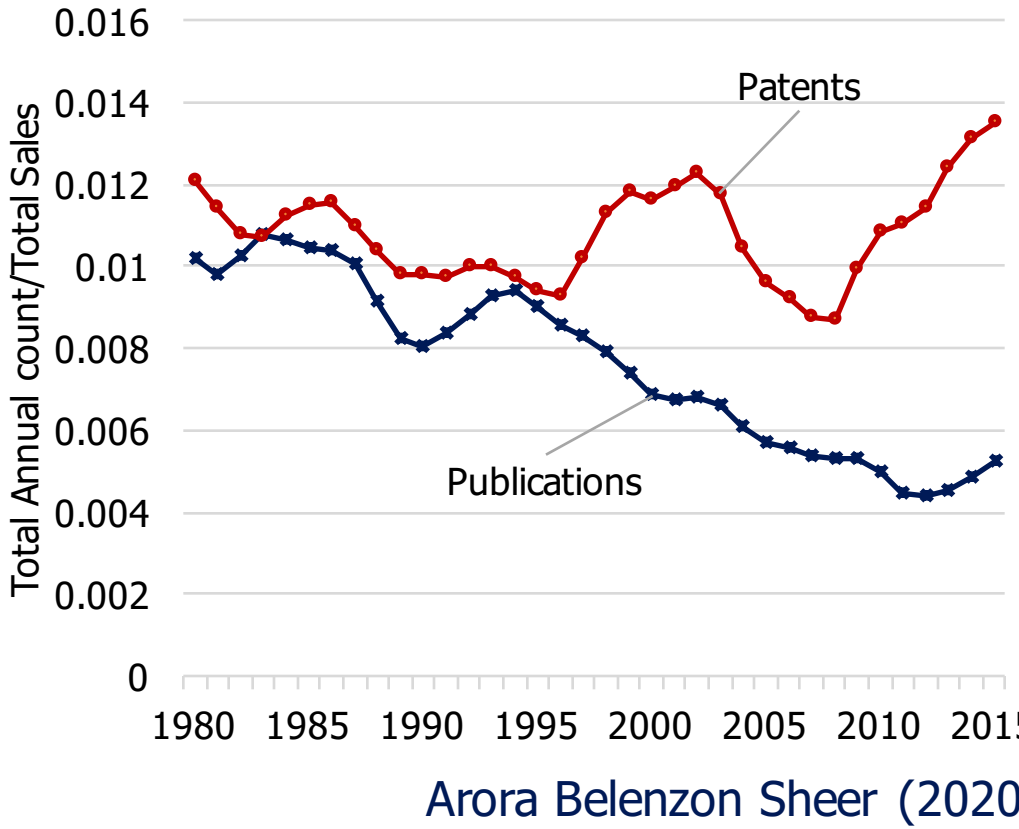
Less R in corporate R&D: corporate labs are in decline

Bell Labs Holmdel Complex, 1963



Arora Belenzon Sheer (2020)

Bell Labs Holmdel Complex, 2010s

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The new division of innovative labor and gaps in the innovation ecosystem

Large Corporate Labs

Venture Capital + Startups + Universities

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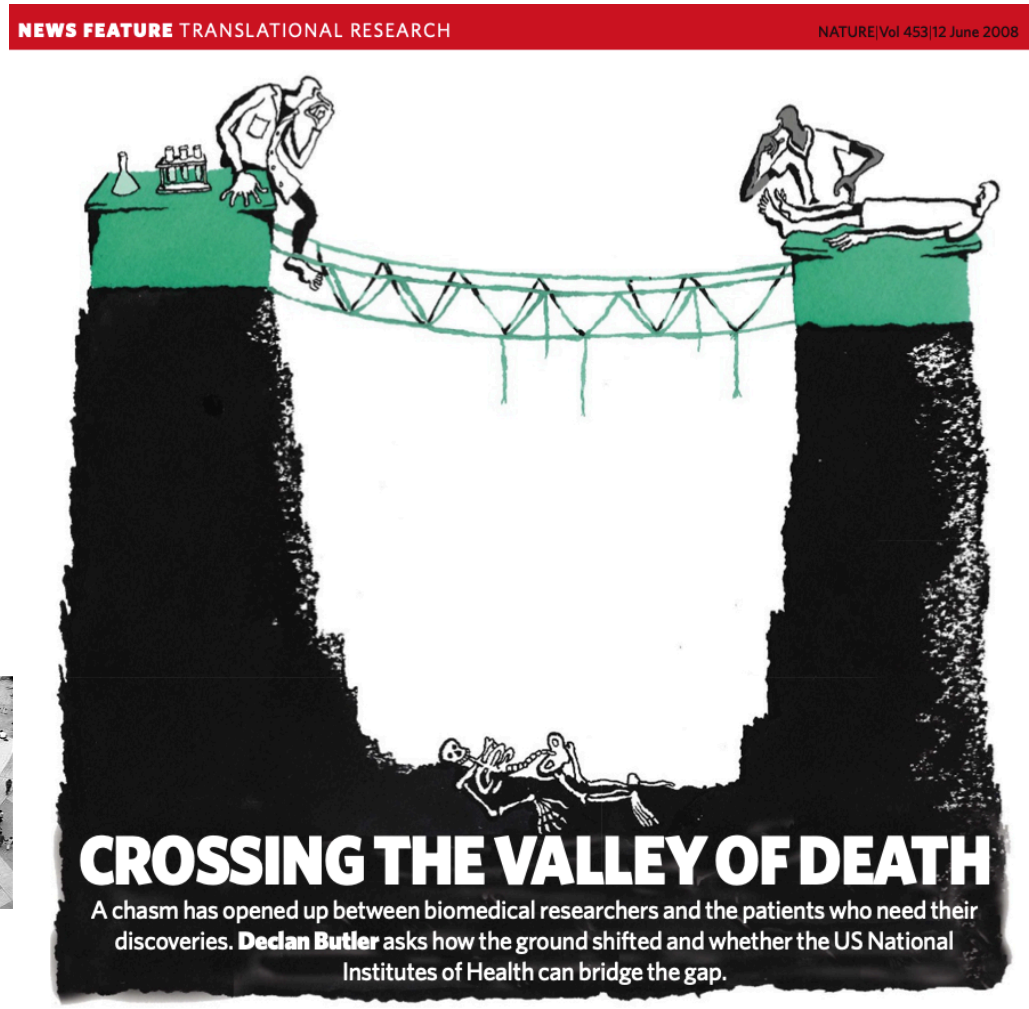

This paper:

Is the emergence of corporate science a response to a **scientific void** in the early 20C American innovation ecosystem?

- Inform current discussion on the division of innovative labor between companies and universities
- Contribute to our understanding of the nature of substitution between corporate and university research [even today, 20% of research is performed by industry]
- Develop firm level data on R&D activity for early 20th century, accounting for ownership changes

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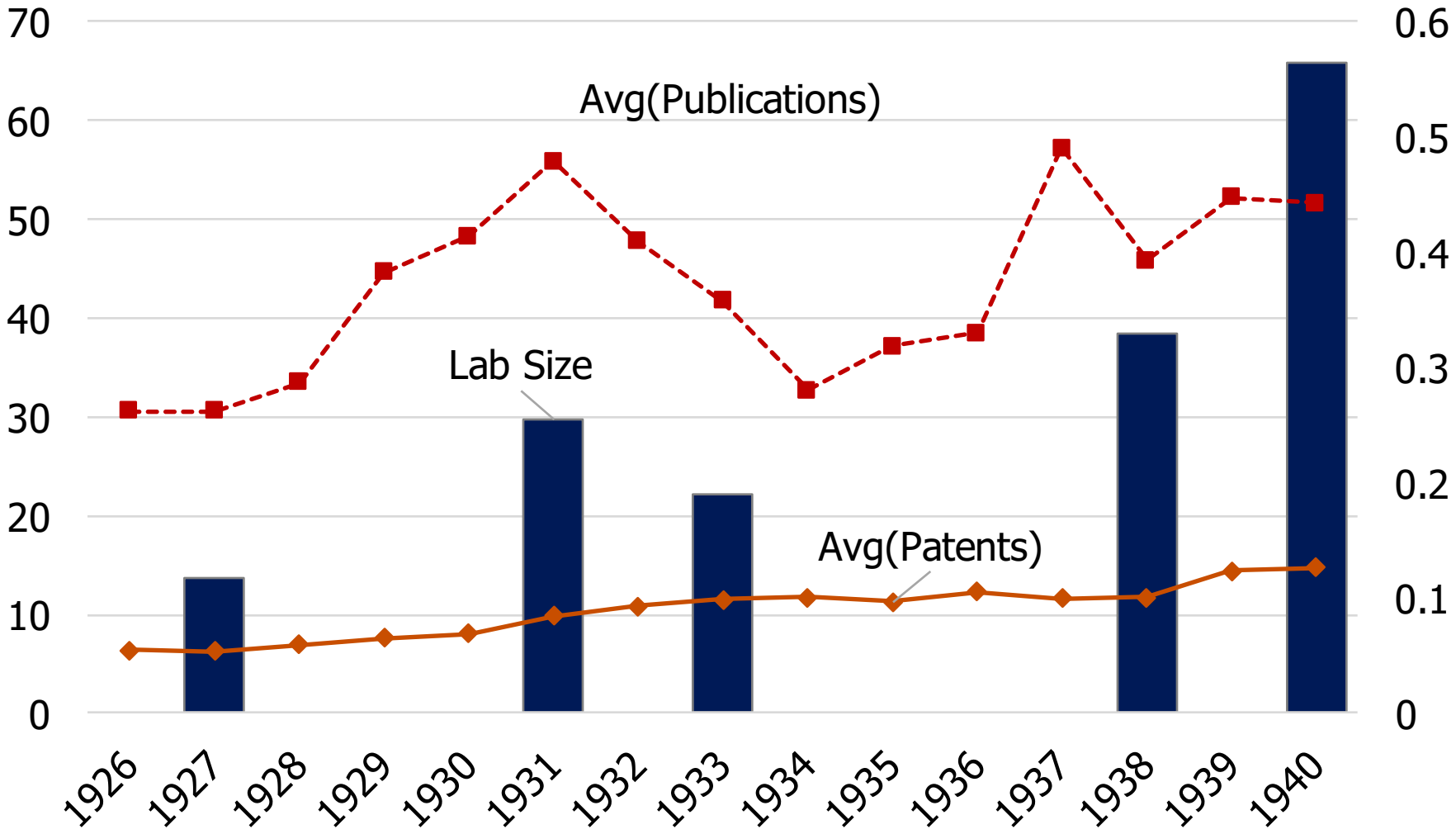
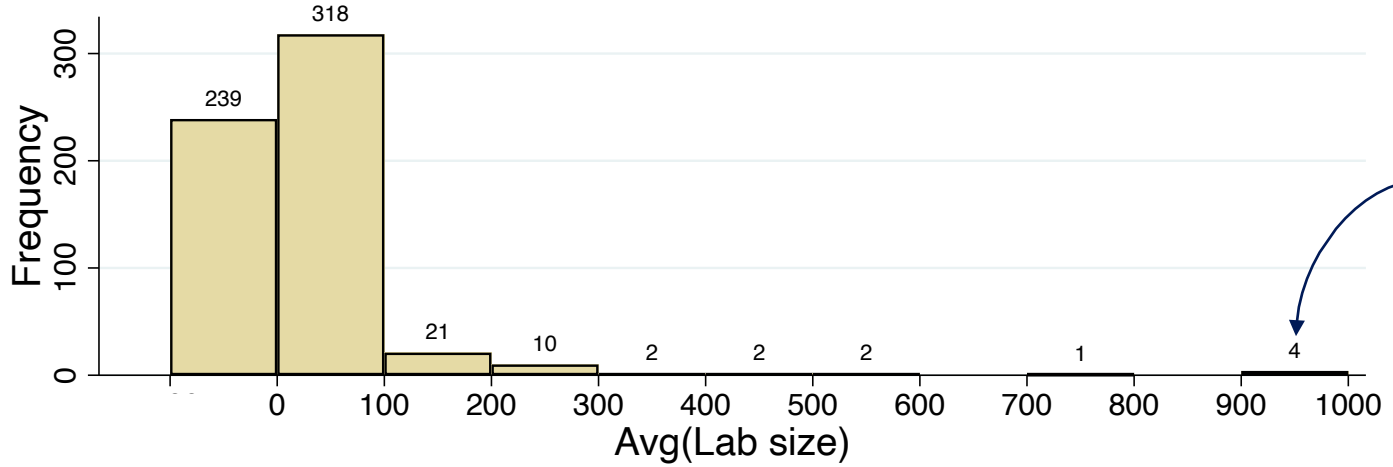
Rise of corporate research, 1926-1940

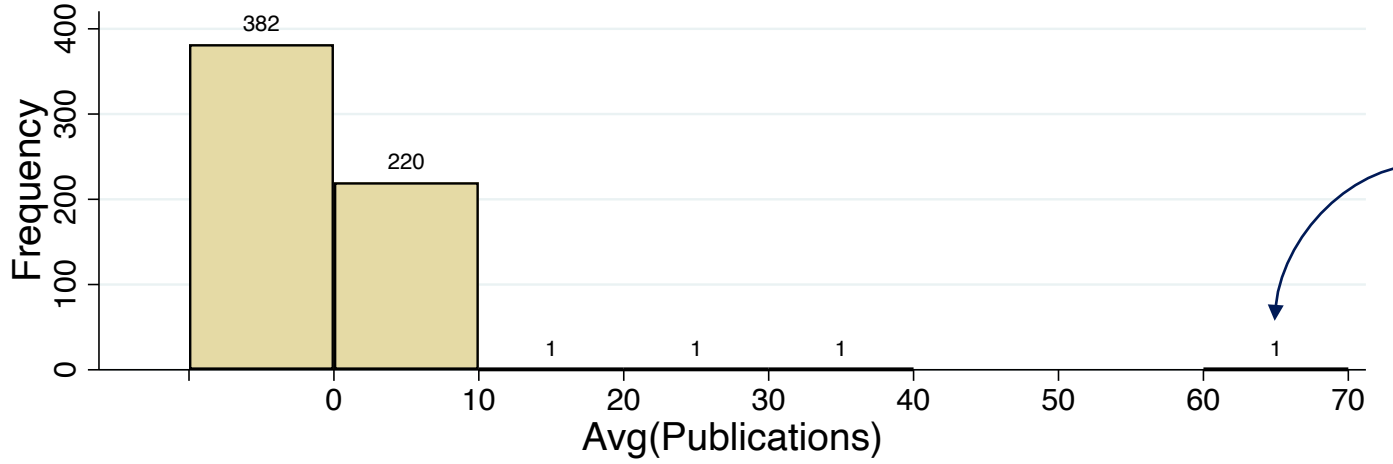


AT&T Bell Labs, 1931

Distribution of Labs and Publications by Firms



Company Name	Avg(Personnel)
E.I. duPont de Nemours & Co.	1357
General Electric Co.	1083
American Telephone & Telegraph Co.	1500
Western Electric Company, Inc	1139



Company Name	Avg(Publications)
General Electric Co.	61

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Scientific voids in the United States

- Areas of American strength: mechanical engineering, thermodynamics
- Areas of American weakness: organic chemistry, quantum mechanics

5th Solvay Conference (1927)

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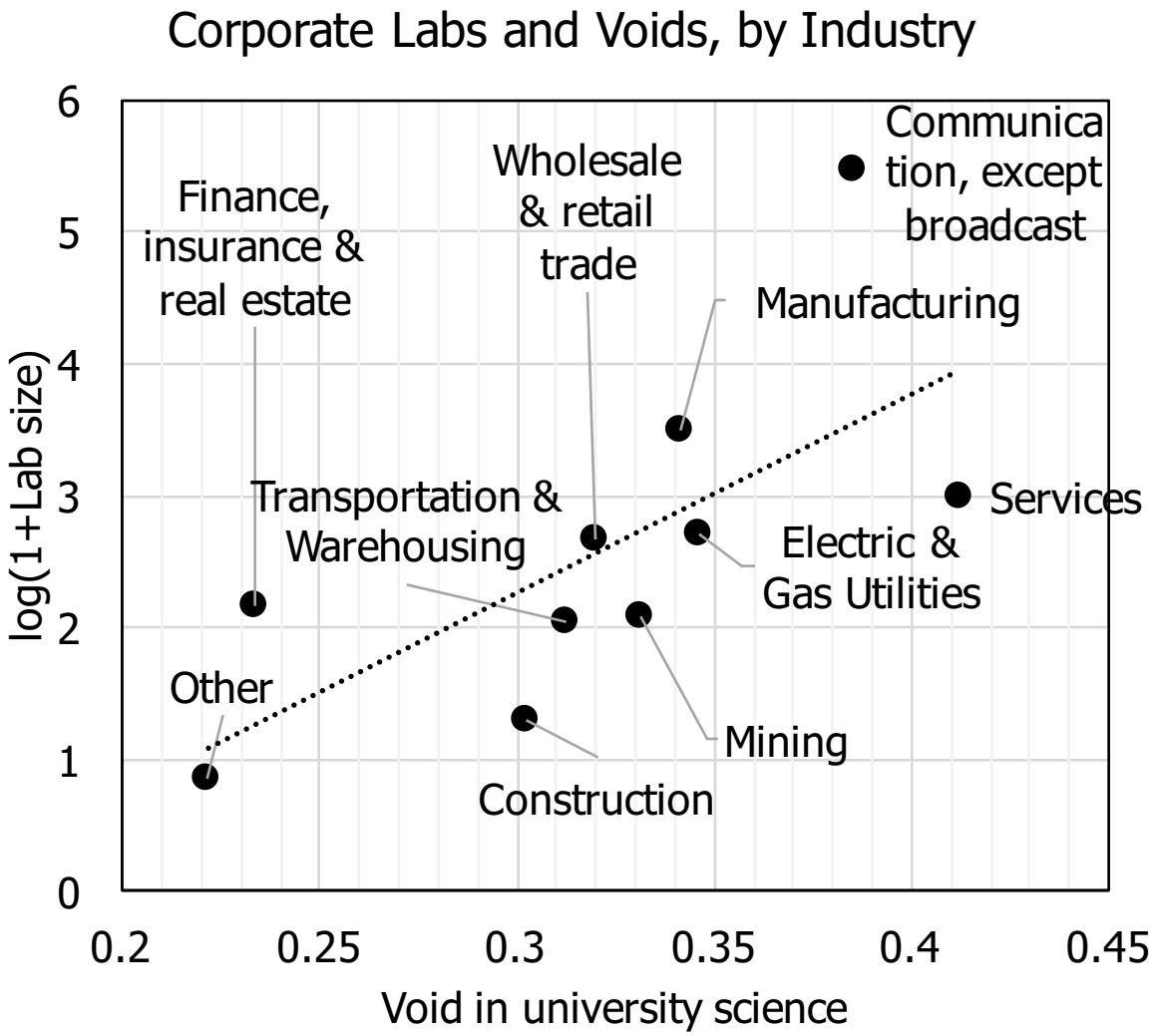
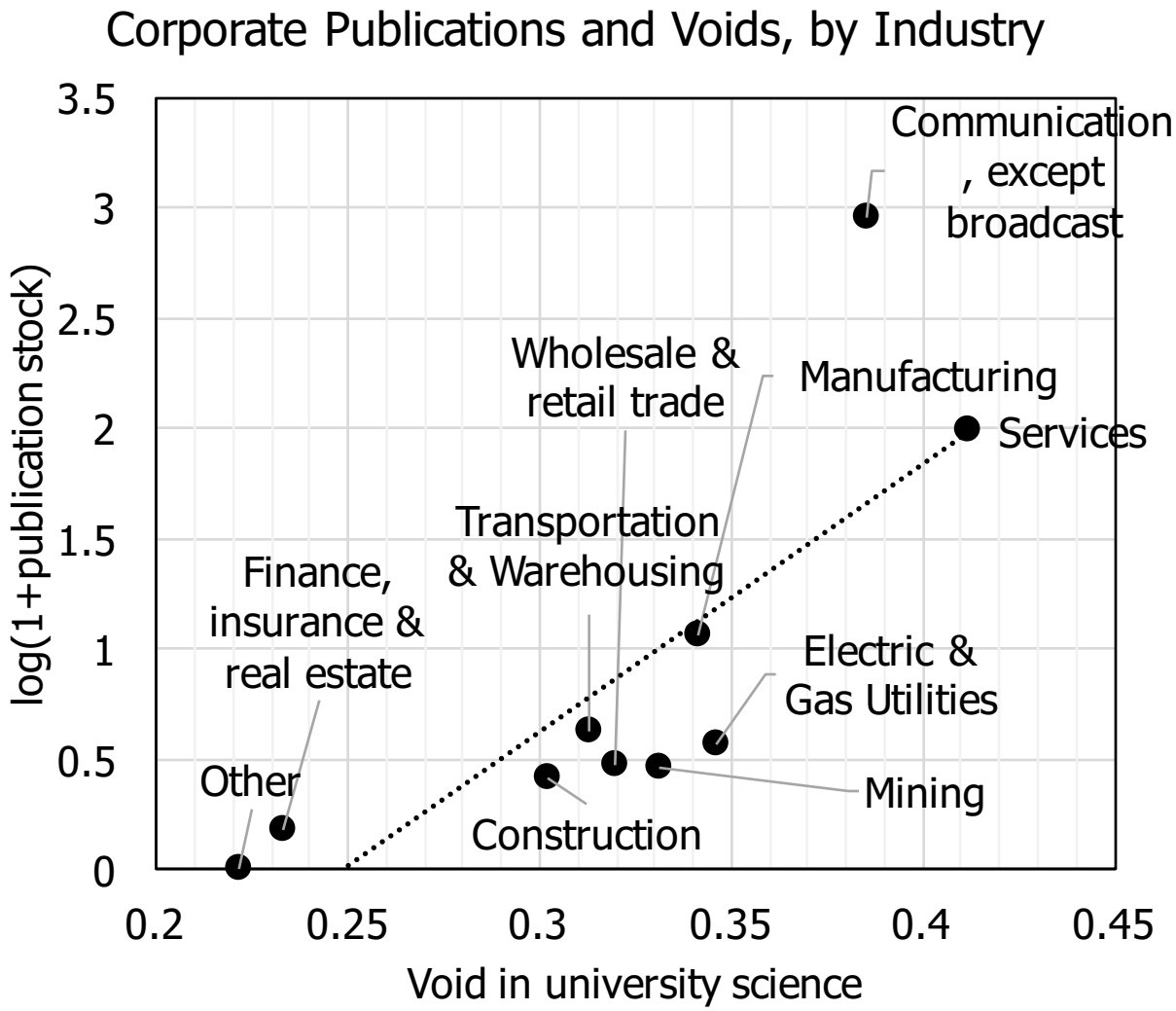
Firms respond to voids





Main findings

- Firms responded to a void in scientific knowledge by investing in research
- Response was stronger for larger, diversified, and inventive firms
- Firms responding to voids were valued more on the stock market

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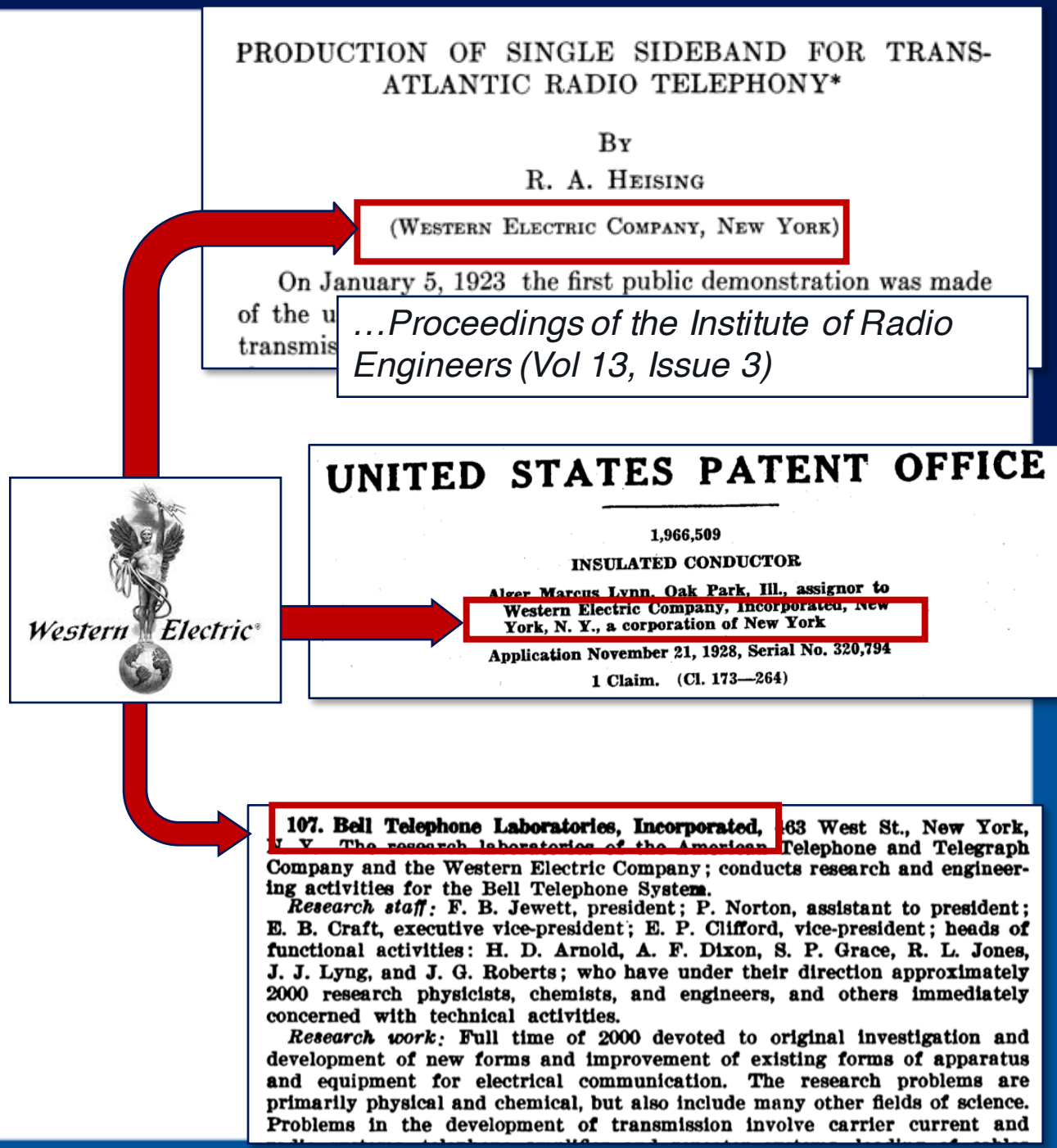
Data

1. Firm Panel
   - Kandel et al. (SMJ 2019) + Kogan et al. (QJE 2017)+Graham et al. (JFE 2015)
   - Extended and matched to labs, patents, papers
2. Scientific Publications: Microsoft Academic Graph, Web of Science
   - 4,136 Scientific publications matched to firm panel and universities based on author affiliations
3. American Industrial Research Laboratories (NRC Survey)
   - R&D personnel data (1927, 1931, 1931, 1938, 1940)
4. USPTO Patents
   - 94,287 Patents matched to firm panel based on firm name and assignee name



Measuring Scientific Voids

- Europe: N*81%*19%=.15N
- US: 0.5N*81%*19%=.075N
  → Void= .67

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C07C (19%)
Acyclic/Carbocyclic Compounds

1.04 Chemical Sciences (81%)

European papers: N

American papers: 0.5N

ABSKY (1926-1940)
Automated & manual matching

Marx & Fuegi (1947-57)
NPL Citations from Patents to Science

Web of Science (1900-1920)
Author name classification (Nameprism API)
Minerva – Handbuch der Gelehrten Welt

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Summary Statistics of Main Variables

	Obs	Mean	Std Dev	Min	Max
Lab size	2995	34.00	183.85	0	4669
Patents per year	9090	10.37	48.56	0	838
Publications er year	9090	0.37	3.28	0	88
Patent stock	9090	56.26	280.16	0	4441.06
Publication stock	9090	2.16	19.53	0	440.33
Total assets ($1M)	5944	1056.59	2840.68	1.42	60114.66
Market capitalization ($1M)	4646	967.49	2674.45	0.69	37352.08

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Mean comparison test between High vs Low scientific voids

		T-Test (High-Low Void)		High Void	Low Void
	Obs	Difference	Std Error	Mean	Mean
Lab size	2995	8.73	7.20	40.30	31.57
Patents per year	9090	4.69	1.10	13.35	8.66
Publications per year	9090	0.46	0.10	0.62	0.16
Market capitalization ($1M)	4646	101.63	80.71	1044.75	943.12
Total assets ($1M)	5944	69.03	77.49	1125.98	1056.94

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Firms grow their labs and publish more where American universities are weak

	(3)	(4)	(5)	(6)
Dependent variable:	ln(1+Publication stock)	ln(1+Lab size)	Publications (NegBin)	Lab size (NegBin)
Void in university science	0.23	0.72	2.44	3.20
	(0.08)	(0.30)	(0.75)	(0.81)
ln(Assets)	0.19	0.43	0.68	0.50
	(0.01)	(0.03)	(0.05)	(0.04)
Average of dependent variable	0.32	1.268	0.40	36.26
R^2	0.24	0.25		
Number of firms	561	554	561	554
Number of observations	8415	2770	8415	2770

Note: All specifications with year and industry fixed effects

1SD increase in voids associated with .04 more publications (14% of sample mean)

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Results are driven by large and diversified firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	ln(1+Publication stock)					
	Assets below median	Assets above median	Standalone	Group-affiliated	Specialized	Diversified
Void in university science	0.17	1.68	0.05	1.73	0.31	0.89
	(0.04)	(0.25)	(0.16)	(0.29)	(0.19)	(0.24)
ln(Assets)	-0.01	0.26	0.18	0.30	0.24	0.25
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Average of dependent variable	0.14	0.49	0.40	0.51	0.40	0.49
R^2	0.28	0.32	0.22	0.35	0.25	0.30
Number of firms	132	251	225	175	137	132
Number of observations	3585	3765	2184	1411	2010	1965

Note: All specifications with year and industry fixed effects

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Results driven by technologically "advanced" firms

	(1)	(2)	(3)	(4)
Dependent variable:	ln(1+Publication stock)			
	Avg(Patent value) below median	Avg(Patent value) above median	Avg(Patent cites) below median	Avg(Patent cites) above median
Void in university science	0.41	2.80	0.062	0.44
	(0.16)	(0.50)	(0.14)	(0.25)
ln(Assets)	0.17	0.02	0.17	0.27
	(0.03)	(0.03)	(0.02)	(0.02)
ln(MktCap)	0.12	0.45		
	(0.02)	(0.05)		
Average of dependent variable	0.32	0.63	0.33	0.56
R^2	0.53	0.59	0.29	0.41
Number of firms	293	224	526	465
Number of observations	1639	1185	2487	1963

Note: All specifications with year and industry fixed effects

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Responding firms exhibit higher market value

	(1)	(2)	(3)	(4)
Dependent variable:	ln(Stock market value)			
	OLS Baseline	OLS Interaction	2nd Stage IV	2nd Stage IV
ln(1+Publication stock)	0.142	-0.103	1.053	1.284
	(0.022)	(0.140)	(0.471)	(0.399)
ln(1+Publication stock) × Void in university science		0.772		
		(0.426)		
Void in university science		-0.049		
		(0.225)		
Void in university science, current				2.823
				(0.823)
ln(Assets)	0.739	0.733	0.684	0.633
	(0.014)	(0.018)	(0.086)	(0.053)
ln(1+Patent stock)	0.092	0.083	-0.051	-0.045
	(0.011)	(0.011)	(0.068)	(0.037)
ln(1+Avg(Lab size))	0.098	0.101		-0.049
	(0.011)	(0.012)		(0.056)
R^2	0.703	0.708	0.468	0.387
Number of Observations	4544	4408	4510	4443

Instrument:
Share of European to total scientific publications for focal firm [Void], 1900-1920

1SD more publications associated with 40% greater stock market value, relative to sample mean

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Responding firms produce "homerun" inventions

	Top 5% Value (KPSS)		Top 5% Cites		Top 5% Novelty (Fleming)	
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2nd Stage IV	OLS	2nd Stage IV	OLS	2nd Stage IV
ln(1+Publication stock)	1.36	2.34	1.81	1.71	4.92	5.09
	(0.21)	(0.68)	(0.17)	(0.57)	(0.48)	(1.59)
Void in university science, current	-0.46	0.51	-0.37	-0.32	0.92	1.73
	(0.42)	(0.77)	(0.36)	(0.65)	(0.98)	(1.78)
ln(Assets)	0.37	0.29	0.09	0.10	0.32	0.32
	(0.08)	(0.08)	(0.03)	(0.06)	(0.09)	(0.17)
ln(1+Patent stock)	0.28	0.23	0.45	0.48	1.29	1.33
	(0.03)	(0.05)	(0.02)	(0.04)	(0.06)	(0.11)
ln(1+Avg(Lab size))	0.12	-0.01	0.05	0.07	0.19	0.18
	(0.02)	(0.09)	(0.02)	(0.08)	(0.05)	(0.21)
R^2	0.14	0.12	0.39	0.39	0.37	0.38
Number of Observations	8891	8430	8891	8430	8891	8430

1SD more publications associated with 4X more "home-run" patents measured by excess stock market returns (KPSS, QJE 2017) relative to sample mean

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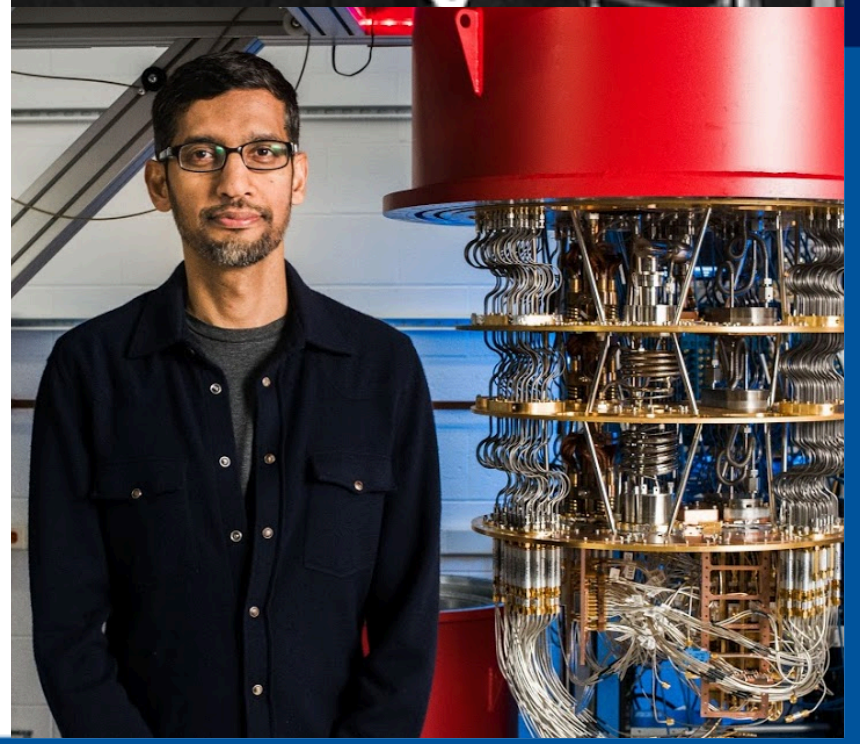
Conclusion

The emergence of corporate science was a response to a scientific void in the early 20C American innovation ecosystem

- This suggests that the rise of American universities was partially responsible for decline in corporate research
- However, university research is not a perfect substitute for corporate research



Thank You

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Measuring Scientific Voids

- Firm i patents in IPC j (1926-1940)
- Patents in IPC j cite articles in field k (1947-1957)
- Scientists in Europe and America publish in field k (1900-1920)
- Void for firm is share of European Science:

$$Void_i := \frac{\sum_j Europe_{ij}}{\sum_j Europe_{ij} + \sum_j USA_{ij}}$$

- Crosswalk between firm and 299 IPCs:

$$Europe_{ij} := \frac{Patents_{ij}}{Patent_i} \times \sum_k Europe_{jk}$$

- Crosswalk between IPC and 35 OECD Scientific Subfields:

$$Europe_{jk} := \frac{Patents_{jk}}{Patents_j} \times European\ Publications_k$$

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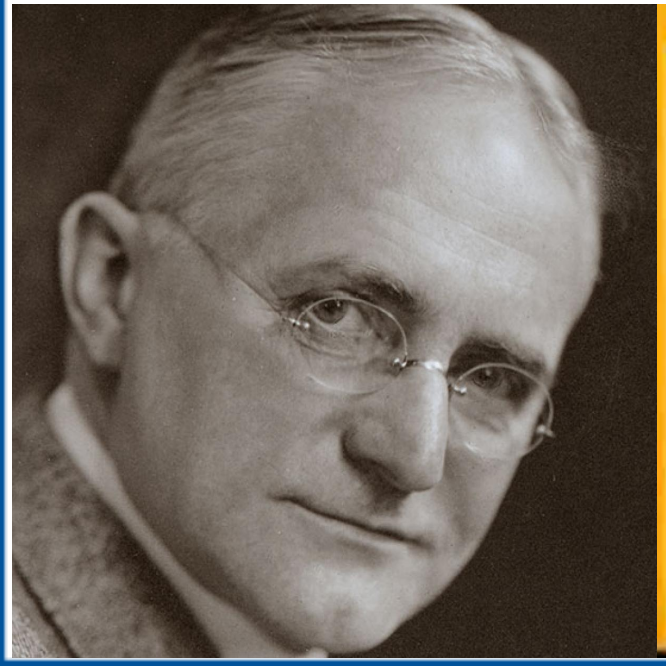
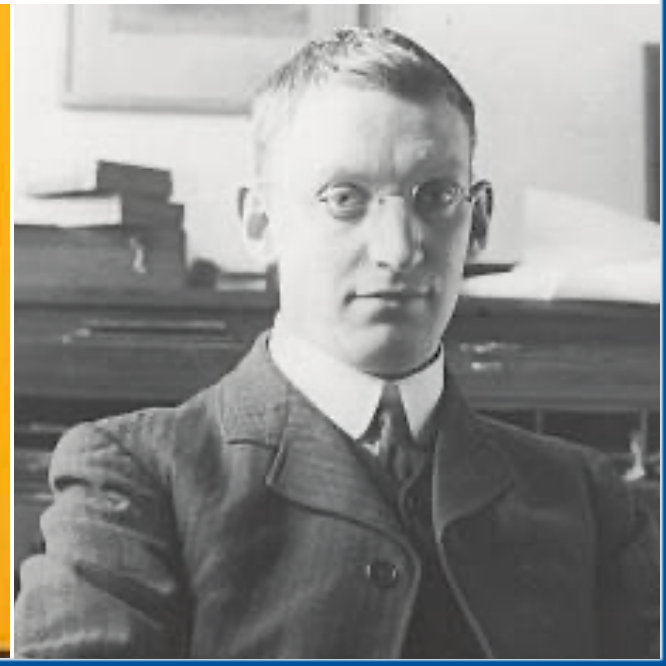
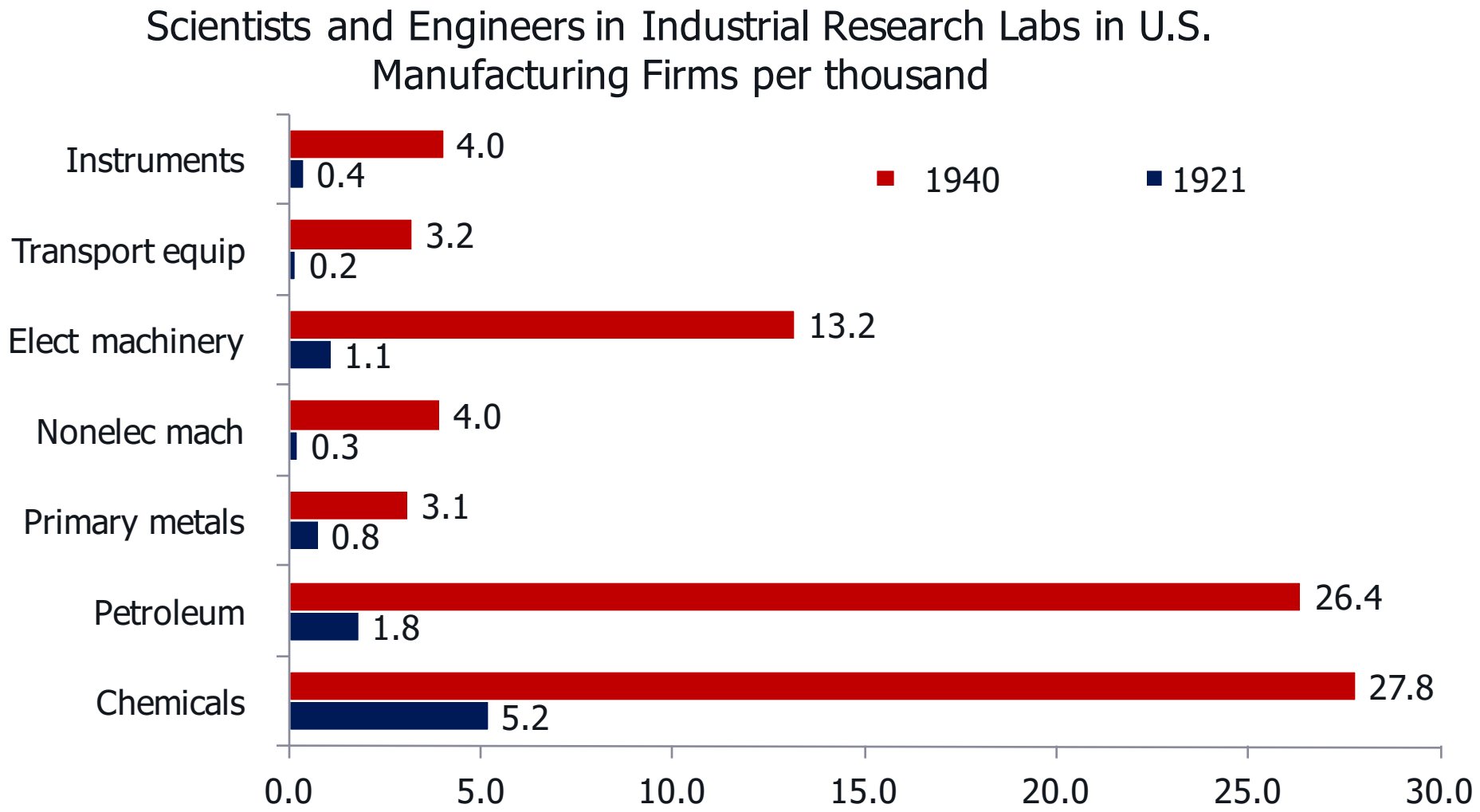
Scientific voids in the United States

- Areas of American strength: mechanical engineering, thermodynamics
- Areas of American weakness: organic chemistry, quantum mechanics





American corporate response to scientific voids was heterogeneous



National Research Council (1921, 1940)

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