Engineering Growth

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Macro Lunch

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Economic Motivation

- Economic importance of technology and innovation
- Large theoretical literature stressing the important role of human capital for long term growth
- Surprisingly hard to document empirically
  - Specific types of human capital
  - Endogeneity and reverse causality
  - Lack of historical data, especially at the sub-national level

Contributions

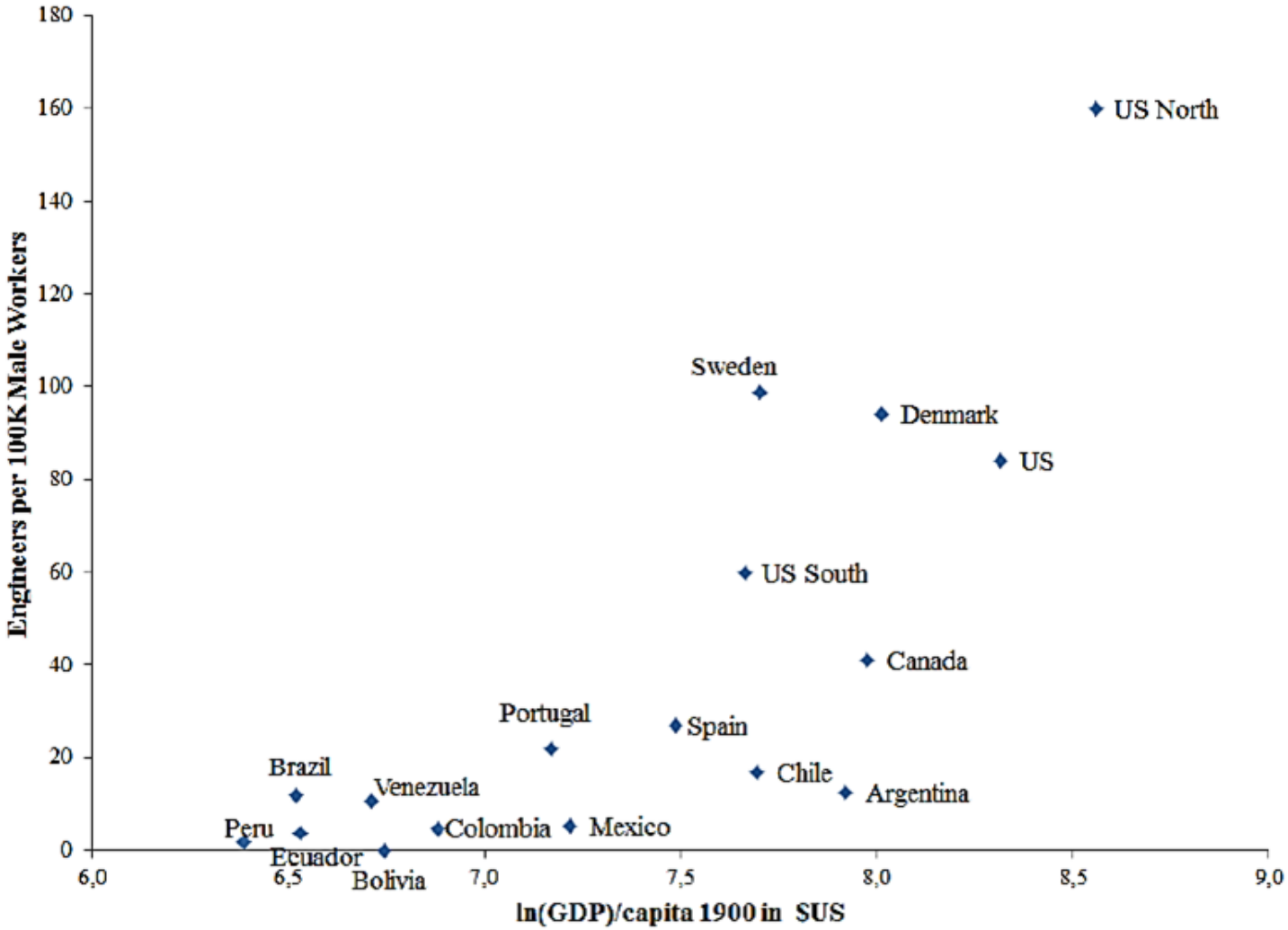
- New data set on early domestic innovative capacity in the Americas: engineers and patents
  - National and sub-national (state and **county**) levels
- Show the long-term impact of early (Second Industrial Revolution) investments in advanced human capital on modern day income
  - Complementary to basic literacy and other human capital variables
  - Robust to controls and IV estimation
- Tease out the contributions of innovation through patents vs. adoption via engineers
- Explore mechanisms of influence: technological adoption and entrepreneurship (structural transformation)

Key Findings

Upper tails of knowledge matter for long-run growth:

1. One standard deviation in engineering density (instrumented) in 1880 accounts for a 10-15% increase in US county income today
2. One standard deviation in historical patenting activity contributes another 10%
3. Could explain up to a third of the Great Divergence in the Americas during the key period of the Second Industrial Revolution

National Engineering Density: Historically



▸ France and Germany

Relevant Literature

- **Human Capital and Growth:** Nelson and Phelps (1966), Lucas (1988), Romer (1990), Baumol (1990), Murphy et al. (1991), Mankiw et al. (1992), Aghion and Howitt (1997), Barro (2001), Galor and Moav (2006), Benhabib and Spiegel (2005), Galor (2011)
  - Long theoretical tradition and seminal empirical pieces
- **Empirical Studies:** Acemoglu and Angrist (2000), Krueger and Lindahl (2001), Aghion et al. (2009), Goldin and Katz (2009), Gennaioli et al. (2013), Kantor and Whalley (2014 and 2019), Castelló-Climent et al. (2016), Toivanen and Väänänen (2016), Freeman and Salzman (2018)
  - Inconclusive empirical results: causality, basic literacy / years of schooling, secondary vs. tertiary, lawyers vs. engineers?
- **Historically:** Mariscal and Sokoloff (2000), Meisenzahl and Mokyr (2011), Becker at al. (2011), Waldinger (2012), Squicciarini and Voigtländer (2014), Yutchman (2014), Hornung (2014), De la Croix et al. (2015), Cinnirella and Streb (2017), Akcigit et al. (2017)
  - Upper tails of knowledge during the Second Industrial Revolution

Historical Background

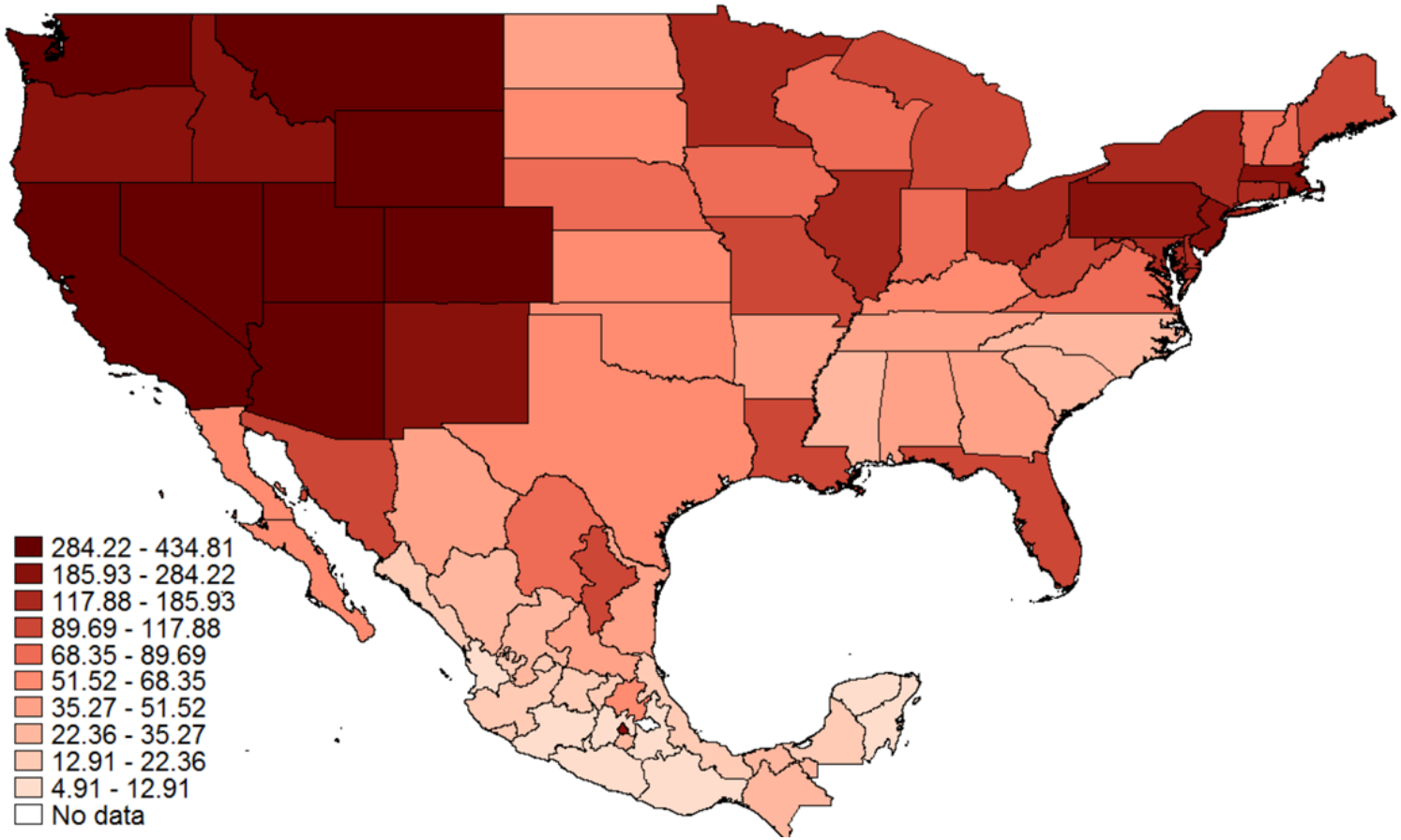
- Second Industrial Revolution (1870-1914): a period of intense technological change (Mokyr, 1998 and Gordon, 2016)
  - "trained engineers, capable mechanics and dexterous craftsmen on whose shoulders inventors could stand." Mokyr (2005)
- Northern leadership in engineering training
  - 1800s: West Point, Norwich, New York
  - First professional societies in 1850-1870
- Southern schools developed later and were partly encouraged by the Morrill Land Grand Act in 1862 and 1890 (used as instrument)
- Later, weaker and less specialized in Latin America
  - Argentina (1870) and Peru (1880)
  - Colombia and Mexico: political instability (country fixed effects)

Data

- **Engineering Density:** Domestic engineers per 100,000 male workers in 1900
  - Engineering graduates, engineering societies and census data for eleven countries in the Americas
  - State level for Argentina, Chile, Colombia, Mexico, Venezuela and the US
  - County level for the the US (1880)
- **Patents:** US Patent and Trademark Office (USPTO) at the county level
- **Sub-national Income:** World Bank (2009) and US Census (2000)
  - **Education Controls:** Literacy, secondary schooling, college, lawyers, physicians
  - **Historical Controls:** Population density, railroads, mining, manufacturing output, slavery, total acres in agriculture, religion, foreigners
  - **Geographic and Weather Controls:** Temperature, altitude, rainfall, agricultural suitability, river density, distance to coast, ruggedness

Sub-national Engineering Density

US and Mexico



Summary Statistics

US County Level

Variable	mean	p50	sd	min	max	Obs
Ln Income	10.043	10.032	0.219	9.165	11.360	1905
Engineers	0.022	0.000	0.038	0.000	0.299	1905
Patents	0.453	0.274	0.602	0.000	6.041	1905
Ln LGC distance	0.176	0.281	0.683	-5.450	1.765	1905
Rainfall	0.077	0.076	0.042	0.009	0.393	1905
Altitude	0.025	0.023	0.019	0.000	0.175	1905
Ruggedness	0.005	0.003	0.006	0.000	0.043	1905
Distance to river	0.017	0.014	0.014	0.000	0.141	1905
Average Temperature	-0.002	-0.006	0.061	-0.160	0.188	1905
Dist. from Coast	0.027	0.023	0.020	0.000	0.102	1905
Population Density	0.003	0.001	0.049	0.000	2.055	1905
Manufacturing GDP	0.042	0.018	0.066	0.000	0.576	1905
Slavery	0.153	0.019	0.215	0.000	0.925	1905
Railroads	0.584	1.000	0.493	0.000	1.000	1905
Literacy	0.759	0.829	0.203	0.151	1.000	1905
School Assistance 12-17	0.051	0.055	0.018	0.000	0.090	1905
Educational Score	0.073	0.073	0.019	0.035	0.168	1905
Lawyers	0.001	0.001	0.001	0.000	0.005	1905
Physicians	0.002	0.002	0.001	0.000	0.004	1905

▸ State Level

Estimating Equations

US Counties

$$Y_{2000,ij} = \alpha + \beta Eng_{1900,ij} + \gamma Geo_{1900,ij} + \lambda ED_{1900,ij} + \lambda HI_{1900,ij} + \mu_j + \epsilon_{ij} \quad (1)$$

- Y : Income (county i state j)
- Eng: Engineering density (plus patents later)
- Pat: Patents
- Geo: Geographic controls
- ED: Education controls
- HI: Historic Controls
- μ : State-fixed effect
- ϵ: Error term

Innovative Capacity and Income

US Counties

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) OLS
Engineers	0.224***	0.289***	0.188***	0.147***	0.184***	0.118***	0.112***	0.0938***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Rainfall	0.0283	0.0328	0.0364	0.0557	0.0236	0.0739	0.0828	0.131
	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.07)	(0.08)
Altitude	-0.00325	-0.0195	0.0335	0.00472	0.0418	0.0168	-0.0108	-0.0716
	(0.03)	(0.08)	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)	(0.06)
Ruggedness	-0.0817	-0.0813	-0.104	-0.0295	-0.115	-0.0780	-0.0342	-0.0193
	(0.08)	(0.1)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)
River Dist.	0.0236	0.0148	0.0220	0.0187	0.0187	0.0352	0.0296	0.0293
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Temperature	-0.281***	-0.310***	-0.124**	-0.0113	-0.0781	-0.131*	-0.0361	-0.0784
	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)	(0.07)	(0.07)	(0.2)
Coast Dist.	-0.171***	-0.236***	-0.168***	-0.128**	-0.174***	-0.176***	-0.129***	-0.0725
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.09)
Pop. Density			0.0930***	0.0952***	0.0934***	0.0831***	0.0896***	0.0993***
			(0.007)	(0.007)	(0.007)	(0.009)	(0.008)	(0.008)
Manuf. Output			0.193***	0.173***	0.212***	0.169***	0.161***	0.122***
			(0.04)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)
Slavery			-0.102	0.179	-0.0419	-0.0216	0.161	0.178**
			(0.07)	(0.1)	(0.08)	(0.08)	(0.1)	(0.07)
Railroad			0.161***	0.112***	0.144***	0.124***	0.106***	0.0957***
			(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
Literacy				0.463***			0.395***	0.502***
				(0.1)			(0.1)	(0.07)
Secondary					0.120**		0.00482	0.0374
					(0.05)		(0.05)	(0.05)
Tertiary						0.142**	0.0471	0.0588
						(0.05)	(0.04)	(0.04)
Lawyers						0.131***	0.112***	0.119***
						(0.04)	(0.04)	(0.03)
Physicians						-0.000377	-0.0463	0.0179
						(0.05)	(0.04)	(0.03)
N	2380	1905	1905	1905	1905	1905	1905	1905
R^2	0.188	0.238	0.313	0.362	0.319	0.345	0.371	0.476
FE	No	No	No	No	No	No	No	Yes

Patenting Activity

- Direct measure of innovation (Sokoloff, 1988; Khan, 2015; Acemoglu et al., 2013; Perlman 2016; Kuegler 2016; Donges et al. 2016; Akcigit et al. 2017)
- Patents between 1890-1910 normalized by population
- Innovation outside the patent system (Moser, 2013)
  - "Not all inventions are patentable, not all inventions are patented." (Griliches, 1998)
- Institutional environment, innovation vs. adaptation
- Interaction with engineers and independent effect

Engineers and Patents

US Counties

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS
Engineers	0.308***	0.295***	0.188***	0.188***	0.187***	0.124***	0.120***
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Rainfall		-0.167	-0.192	-0.193	-0.192	-0.134	-0.141
		(0.2)	(0.2)	(0.2)	(0.2)	(0.1)	(0.1)
Altitude		0.211*	0.215**	0.215**	0.212**	0.217**	0.213**
		(0.1)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)
Ruggedness		-0.184	-0.187*	-0.189*	-0.183*	-0.175*	-0.181**
		(0.1)	(0.1)	(0.1)	(0.1)	(0.09)	(0.08)
River Dist.		-0.0221	0.0283	0.0286	0.0297	0.0323	0.0362
		(0.05)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
Temperature		-0.0269	-0.00366	-0.00887	-0.0203	0.0183	-0.0519
		(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Coast Dist.		-0.253**	-0.202**	-0.202**	-0.195**	-0.227***	-0.229***
		(0.10)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Pop. Density			0.0182**	0.0182**	0.0183**	0.0103	0.00874
			(0.008)	(0.008)	(0.008)	(0.007)	(0.007)
Manuf. Output			0.507***	0.508***	0.495***	0.459***	0.442***
			(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Slavery			-0.0802***	-0.0854***	-0.0985***	-0.0692**	-0.144***
			(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
Railroad			-0.0483	-0.0473	-0.0440	-0.0833***	-0.0734**
			(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Literacy				-0.0128			-0.144**
				(0.04)			(0.06)
Secondary					-0.0672*		-0.0950**
					(0.04)		(0.04)
Tertiary						0.104**	0.141***
						(0.04)	(0.04)
Lawyers						0.203***	0.203***
						(0.06)	(0.05)
Physicians						-0.00798	0.0181
						(0.03)	(0.04)
N	1905	1905	1905	1905	1905	1905	1905
R^2	0.316	0.340	0.471	0.471	0.472	0.505	0.511
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Patents and Income

US Counties

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) OLS
Patents	0.129***	0.317***	0.203***	0.167***	0.204***	0.115***	0.125***	0.114***
	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)
Rainfall	0.0357	0.0438	0.0353	0.0607	0.0339	0.0775	0.0860	0.142
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)
Altitude	0.0340	-0.0734	-0.00734	-0.0306	0.00126	-0.00613	-0.0370	-0.0964
	(0.04)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)
Ruggedness	-0.0738	-0.0161	-0.0506	0.0161	-0.0628	-0.0477	-0.00177	0.00274
	(0.08)	(0.10)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)
River Dist.	0.0265	0.0160	0.0243	0.0205	0.0206	0.0371	0.0306	0.0268
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Temperature	-0.264***	-0.271***	-0.114*	-0.00204	-0.0633	-0.124*	-0.0248	-0.0681
	(0.06)	(0.04)	(0.06)	(0.05)	(0.06)	(0.07)	(0.07)	(0.2)
Coast Dist.	-0.212***	-0.200***	-0.154***	-0.115**	-0.161***	-0.169***	-0.119**	-0.0537
	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.09)
Pop. Density			0.0912***	0.0937***	0.0916***	0.0820***	0.0889***	0.0983***
			(0.007)	(0.006)	(0.007)	(0.008)	(0.007)	(0.008)
Manuf. Output			0.150***	0.134***	0.169***	0.148***	0.135***	0.0886**
			(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Slavery			-0.0946	0.195*	-0.0256	-0.0184	0.175	0.189**
			(0.08)	(0.1)	(0.08)	(0.08)	(0.1)	(0.07)
Railroad			0.182***	0.128***	0.163***	0.137***	0.117***	0.106***
			(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
Literacy				0.476***			0.408***	0.512***
				(0.1)			(0.1)	(0.07)
school 12-17					0.136**		0.0147	0.0448
					(0.05)		(0.05)	(0.05)
edscor						0.142***	0.0397	0.0533
						(0.05)	(0.04)	(0.04)
Lawyers						0.137***	0.113***	0.117***
						(0.04)	(0.04)	(0.04)
Physicians						-0.00144	-0.0496	0.0152
						(0.04)	(0.04)	(0.03)
N	2382	1905	1905	1905	1905	1905	1905	1905
R^2	0.158	0.246	0.309	0.362	0.316	0.342	0.370	0.476
FE	No	No	No	No	No	No	No	Yes

Innovative Capacity and Income

US Counties: Engineers and Patents

	(1) OLS	(2) OLS	(3) OLS	(4) OLS
Engineers			0.0959***	0.0817***
			(0.03)	(0.02)
Patents	0.125***	0.114***	0.105**	0.101***
	(0.04)	(0.04)	(0.04)	(0.04)
Rainfall	0.0860	0.142	0.0815	0.145*
	(0.08)	(0.08)	(0.07)	(0.08)
Altitude	-0.0370	-0.0964	-0.0359	-0.0932
	(0.07)	(0.06)	(0.08)	(0.06)
Ruggedness	-0.00177	0.00274	-0.0115	-0.000973
	(0.08)	(0.07)	(0.08)	(0.07)
River Dist.	0.0306	0.0268	0.0276	0.0256
	(0.03)	(0.03)	(0.02)	(0.03)
Temperature	-0.0248	-0.0681	-0.0385	-0.0731
	(0.07)	(0.2)	(0.06)	(0.2)
Coast Dist.	-0.119**	-0.0537	-0.118**	-0.0493
	(0.05)	(0.09)	(0.05)	(0.09)
Pop. Density	0.0889***	0.0983***	0.0891***	0.0985***
	(0.007)	(0.008)	(0.008)	(0.008)
Manuf. Output	0.135***	0.0886**	0.119***	0.0770*
	(0.04)	(0.04)	(0.04)	(0.04)
Slavery	0.175	0.189**	0.174	0.193***
	(0.1)	(0.07)	(0.1)	(0.07)
Railroad	0.117***	0.106***	0.114***	0.103***
	(0.03)	(0.02)	(0.03)	(0.02)
Literacy	0.408***	0.512***	0.401***	0.516***
	(0.1)	(0.07)	(0.1)	(0.07)
Secondary	0.0147	0.0448	0.0148	0.0470
	(0.05)	(0.05)	(0.05)	(0.05)
Tertiary	0.0397	0.0533	0.0290	0.0446
	(0.04)	(0.04)	(0.04)	(0.04)
Lawyers	0.113***	0.117***	0.0916**	0.0986***
	(0.04)	(0.04)	(0.04)	(0.03)
Physicians	-0.0496	0.0152	-0.0441	0.0161
	(0.04)	(0.03)	(0.04)	(0.03)
N	1905	1905	1905	1905
R^2	0.370	0.476	0.376	0.480
FE	No	Yes	No	Yes
F statistical (robust)				
F statistical (robust and cluster)				
F Cragg-Donald				

Instrumental Variable

- Land Grant Colleges (Card, 2001; Moretti, 2004; Cantoni and Yutchman, 2014; Toivanen and Väänänen, 2016)
- 1862 Morrill Land Grand Act
  - Columbia School of Mines, Worcester Polytechnic Institute, Dartmouth, Cornell
    - "Promoted the emergence of the most effective engineering schools in the globe." (Nevins et al., 1962)
    - "Provided the foundation, both in training and in number, for twentieth-century American professional engineering." (Nienkamp, 2010)
- Second Wave in 1890
  - Western, Midwestern and Southern schools (used as placebo)
- Supply driven
  - Low student demand (Johnson, 1981)

US Land Grant Colleges

1872 and 1890

Source: National Academy of Sciences and Engineering

Land Grant Colleges and Early Manufacturing

US Counties: Manufacturing in 1850

	Value of products...	Employed...	Capital Invested...	Value of homemade...
	... in manufacturing			
A. Dependent variable is the variable in the column				
Instrument	-4990.4	-7.918	-13605.4	-1214.5
	(57112.1)	(54.1)	(29818.3)	(756.0)
N	1388	1388	1388	1384
R^2	0.730	0.694	0.603	0.361
Controls	Yes	Yes	Yes	Yes
B. Dependent variable is the variable in the column per capita				
Instrument	0.571	-0.000576	-0.531	-0.0516
	(1.6)	(0.0009)	(0.4)	(0.03)
N	1388	1388	1388	1384
R^2	0.079	0.256	0.441	0.481
Controls	Yes	Yes	Yes	Yes

First Stage: Engineers on Land Grant Colleges

US Counties: 1862 and 1890 Waves

	Engineers	*Lawyers*	*Physicians*
A. Linear regression			
Distance LGC 1862	-0.103***	-3.18e-05	0.0120
	(0.0370)	(2.74e-05)	(0.0417)
Observations	1,905	1,905	1,905
R-squared	0.011	0.003	0.000
Distance LGC 1890	-0.0461	7.85e-06	0.0344
	(0.0348)	(2.74e-05)	(0.0405)
Observations	1,905	1,905	1,905
R-squared	0.002	0.000	0.001

Innovative Capacity and Income

US Counties: Instrumented

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) IV
Engineers			0.0959***	0.0817***	0.111***
			(0.03)	(0.02)	(0.03)
Patents	0.125***	0.114***	0.105**	0.101***	0.120***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Rainfall	0.0860	0.142	0.0815	0.145*	0.145*
	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)
Altitude	-0.0370	-0.0964	-0.0359	-0.0932	-0.105*
	(0.07)	(0.06)	(0.08)	(0.06)	(0.05)
Ruggedness	-0.00177	0.00274	-0.0115	-0.000973	-0.00529
	(0.08)	(0.07)	(0.08)	(0.07)	(0.07)
River Dist.	0.0306	0.0268	0.0276	0.0256	0.0310
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
Temperature	-0.0248	-0.0681	-0.0385	-0.0731	-0.0507
	(0.07)	(0.2)	(0.06)	(0.2)	(0.2)
Coast Dist.	-0.119**	-0.0537	-0.118**	-0.0493	-0.0411
	(0.05)	(0.09)	(0.05)	(0.09)	(0.09)
Pop. Density	0.0889***	0.0983***	0.0891***	0.0985***	0.0946***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Manuf. Output	0.135***	0.0886**	0.119***	0.0770*	0.0829*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Slavery	0.175	0.189**	0.174	0.193***	0.175***
	(0.1)	(0.07)	(0.1)	(0.07)	(0.07)
Railroad	0.117***	0.106***	0.114***	0.103***	0.189***
	(0.03)	(0.02)	(0.03)	(0.02)	(0.04)
Literacy	0.408***	0.512***	0.401***	0.516***	0.509***
	(0.1)	(0.07)	(0.1)	(0.07)	(0.07)
Secondary	0.0147	0.0448	0.0148	0.0470	0.0285
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Tertiary	0.0397	0.0533	0.0290	0.0446	0.0502
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Lawyers	0.113***	0.117***	0.0916**	0.0986***	0.112***
	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)
Physicians	-0.0496	0.0152	-0.0441	0.0161	0.0127
	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)
N	1905	1905	1905	1905	1905
R^2	0.370	0.476	0.376	0.480	
FE	No	Yes	No	Yes	Yes
F statistical (robust)					14.023
F statistical (robust and cluster)					7.755
F Cragg-Donald					20.34

Innovative Capacity and Income: Spillovers

US Counties: Instrumented Excluding LCGs Counties

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) IV
Engineers			0.0950***	0.0801***	0.111***
			(0.0266)	(0.0242)	(0.0311)
Patents	0.121***	0.108**	0.102**	0.0958**	0.113***
	(0.0441)	(0.0404)	(0.0419)	(0.0385)	(0.0388)
Rainfall	0.0861	0.145*	0.0815	0.146*	0.147*
	(0.0769)	(0.0849)	(0.0753)	(0.0816)	(0.0844)
Altitude	-0.0345	-0.0958	-0.0352	-0.0945	-0.106*
	(0.0743)	(0.0601)	(0.0765)	(0.0639)	(0.0548)
Ruggedness	-0.00321	0.00218	-0.0108	-0.000102	-0.00695
	(0.0769)	(0.0694)	(0.0795)	(0.0740)	(0.0682)
River Dist.	0.0324	0.0275	0.0293	0.0265	0.0340
	(0.0262)	(0.0266)	(0.0248)	(0.0262)	(0.0275)
Temperature	-0.0246	-0.0720	-0.0375	-0.0770	-0.0519
	(0.0659)	(0.161)	(0.0620)	(0.161)	(0.153)
Coast Dist.	-0.120**	-0.0539	-0.119**	-0.0490	-0.0365
	(0.0493)	(0.0870)	(0.0486)	(0.0868)	(0.0863)
Pop. Density	0.0904***	0.0988***	0.0905***	0.0988***	0.0940***
	(0.00758)	(0.00792)	(0.00793)	(0.00826)	(0.00855)
Manuf. Output	0.134***	0.0910*	0.116**	0.0794*	0.0836*
	(0.0458)	(0.0455)	(0.0455)	(0.0436)	(0.0441)
Slavery	0.177	0.187**	0.177	0.190***	0.172**
	(0.113)	(0.0693)	(0.112)	(0.0684)	(0.0669)
Railroad	0.114***	0.103***	0.111***	0.100***	0.0925***
	(0.0297)	(0.0201)	(0.0299)	(0.0200)	(0.0198)
Literacy	0.414***	0.516***	0.407***	0.520***	0.511***
	(0.105)	(0.0721)	(0.106)	(0.0726)	(0.0710)
Secondary	0.0185	0.0452	0.0186	0.0474	0.0246
	(0.0537)	(0.0527)	(0.0526)	(0.0518)	(0.0547)
Tertiary	0.0352	0.0486	0.0252	0.0401	0.0507
	(0.0414)	(0.0378)	(0.0425)	(0.0382)	(0.0361)
Lawyers	0.111***	0.115***	0.0902**	0.0971***	0.112***
	(0.0399)	(0.0357)	(0.0386)	(0.0339)	(0.0375)
Physicians	-0.0493	0.0126	-0.0440	0.0135	0.0126
	(0.0394)	(0.0301)	(0.0391)	(0.0301)	(0.0292)
Constant	-0.00538	-0.00528***	-0.00487	-0.00477***	0.00107***
	(0.0544)	(0.000787)	(0.0542)	(0.000816)	(0.000230)
Observations	1,872	1,872	1,872	1,872	1,872
R-squared	0.368	0.484	0.374	0.488	
FE	No	Yes	No	Yes	Yes

Innovative Capacity and Income: Placebo

US Counties: Instrumented 1890 Wave

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) OLS
LGC1890dist_centroid_ln	-0.00751	-0.0613	-0.0409	-0.0193	-0.0212	-0.0162	-0.0157	-0.0174
	(0.05)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Rainfall		0.0494	0.0585	0.0354	0.0178	0.0358	0.0479	0.0497
		(0.07)	(0.05)	(0.05)	(0.03)	(0.04)	(0.05)	(0.05)
Altitude		0.198***	0.0406	0.102	0.0799	0.106	0.0477	0.0416
		(0.06)	(0.09)	(0.09)	(0.07)	(0.09)	(0.09)	(0.09)
Ruggedness		0.00982	0.0962*	0.0185	0.0675*	0.0126	0.0454	0.0566
		(0.07)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.06)
River Dist.		0.0170	0.0174	0.0119	0.00938	0.0100	0.0369	0.0365
		(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Temperature		-0.00278	-0.0516	0.196*	0.267**	0.221*	0.148	0.156
		(0.08)	(0.08)	(0.1)	(0.1)	(0.1)	(0.10)	(0.1)
Coast Dist.		-0.182***	-0.159**	-0.0486	-0.0206	-0.0521	-0.0454	-0.0364
		(0.05)	(0.07)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)
Pop. Density				0.0151	0.0161	0.0153	-0.00217	-0.00122
				(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
Manuf. Output				0.346***	0.324***	0.357***	0.266***	0.260***
				(0.04)	(0.04)	(0.05)	(0.03)	(0.04)
Slavery				-0.156**	0.0365	-0.121**	-0.0450	-0.0209
				(0.07)	(0.04)	(0.06)	(0.04)	(0.04)
Railroad				0.0732**	0.0383	0.0640**	0.0166	0.0152
				(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Literacy					0.311***			0.0735
					(0.07)			(0.05)
school 12-17						0.0678		-0.0243
						(0.07)		(0.05)
edscor							0.167***	0.153***
							(0.05)	(0.05)
Lawyers							0.276***	0.272***
							(0.05)	(0.05)
Physicians							-0.0593	-0.0637
							(0.05)	(0.05)
N	2471	2471	1905	1905	1905	1905	1905	1905
R^2	-0.000	0.080	0.038	0.169	0.191	0.170	0.264	0.264

Innovative Capacity and Income: Sub-national Regressions

Americas: Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)
Engineering	0.1***	0.1***	0.07***	0.10***	0.1***	0.05**
	(0.04)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)
Pop Density		0.07**	0.06***		0.1***	0.06***
		(0.03)	(0.02)		(0.04)	(0.01)
Literacy			0.4***			0.4***
			(0.13)			(0.10)
Area				-0.03	0.08	-0.04
				(0.06)	(0.05)	(0.04)
Ruggedness				-0.03	-0.06	-0.04*
				(0.05)	(0.04)	(0.02)
Rainfall				-0.1*	-0.1	-0.09
				(0.06)	(0.08)	(0.06)
Altitude				-0.03	-0.07	-0.03
				(0.05)	(0.06)	(0.05)
Landlocked				-0.02	-0.003	-0.02
				(0.03)	(0.02)	(0.04)
Constant	0.6	0.6	0.6**	0.5	0.5	0.6**
	(0.42)	(0.40)	(0.28)	(0.39)	(0.37)	(0.23)
N	170	166	166	160	156	156
N Countries	6	6	6	6	6	6
R^2	0.11	0.18	0.37	0.19	0.29	0.48

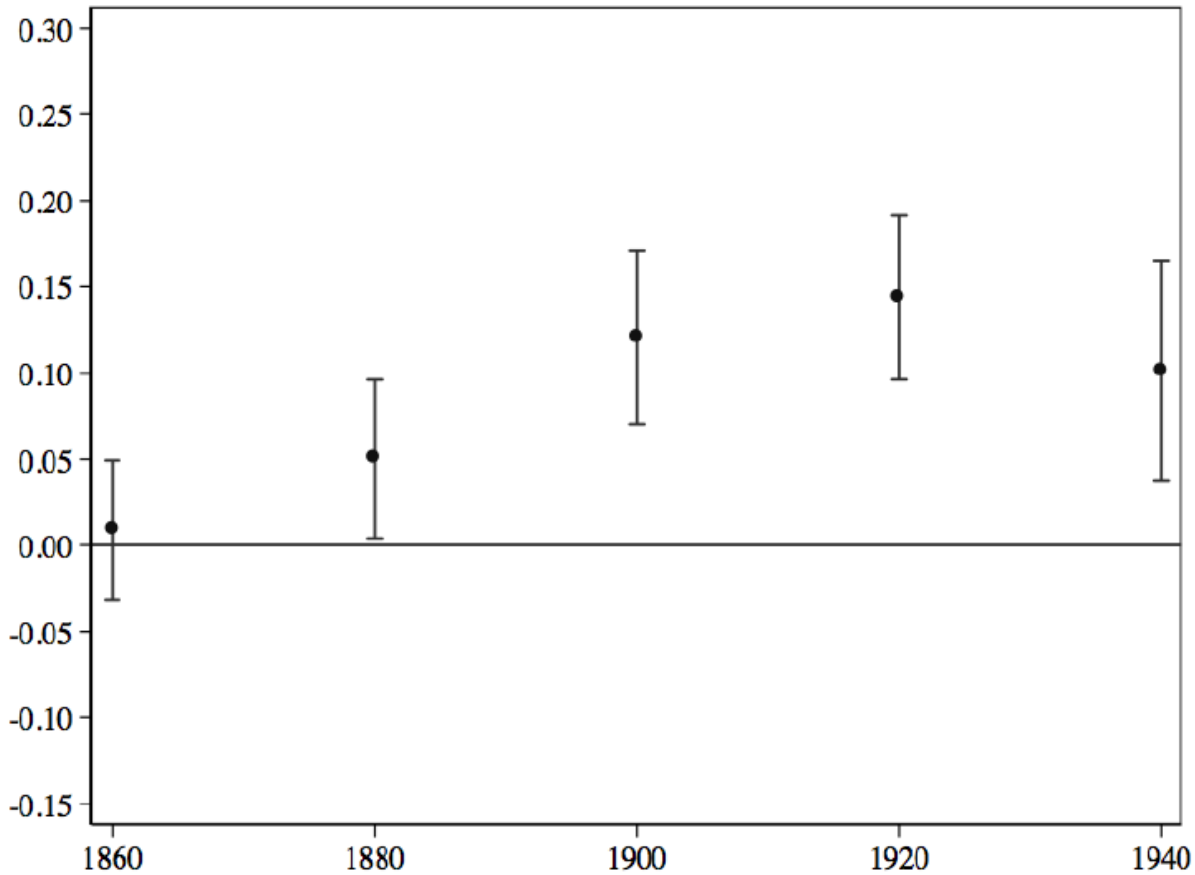
Mechanisms of Influence

- Structural transformation (cf. Fiszbein 2014; Kantor and Whalley 2019)
  - Intermediate historical outcomes (1860-1940)
- Technological adoption: horsepower in manufacturing
- Entrepreneurship: Murphy et al. (1991)
  - Number of retail stores
- Technology adoption and mechanization in agriculture (Skinner and Staiger, 2007)
- High-tech sector (CBP 2012) and Knowledge Intensive Business Services (KIBS)

▸ Cross Country

Mechanisms of Influence: Manufacturing 1860-1940

Manufacturing Value Added



Mechanisms of Influence

Technological Adoption and Entrepreneurship in 1930

	(1) *Value manuf. per capita*	(2) *Horsepower in manuf.*	(3) *Establishment per capita*	(4) *Retail stores per capita*	(5) *Wholesale sales per capita*
Engineers	0.0688**	0.0464**	0.0611**	0.0794**	0.0937***
	(0.0258)	(0.0214)	(0.0271)	(0.0344)	(0.0298)
Rainfall	0.120	0.357***	0.0722	-0.0960	-0.127
	(0.136)	(0.106)	(0.155)	(0.136)	(0.0912)
Altitude	0.120*	0.0837*	0.156**	0.110	0.136**
	(0.0592)	(0.0465)	(0.0739)	(0.0854)	(0.0608)
Ruggedness	-0.113*	0.0954**	-0.161*	-0.141	-0.264**
	(0.0657)	(0.0444)	(0.0801)	(0.106)	(0.0998)
River Dist.	-0.00689	-0.0422*	0.0168	0.0175	0.0185
	(0.0201)	(0.0222)	(0.0248)	(0.0229)	(0.0236)
Temperature	0.0722	0.00190	0.257	0.257*	0.152
	(0.144)	(0.135)	(0.174)	(0.148)	(0.119)
Coast Dist.	-0.209***	-0.128	-0.334***	-0.233***	-0.0133
	(0.0657)	(0.0807)	(0.0903)	(0.0660)	(0.0923)
Pop. Density	-0.0439***	-0.0998***	-0.00397	-0.0378***	0.0206***
	(0.0128)	(0.0194)	(0.00937)	(0.0122)	(0.00737)
Manuf. Output	0.296***	0.243***	0.254***	0.155***	0.207***
	(0.0471)	(0.0394)	(0.0472)	(0.0471)	(0.0411)
Slavery	-0.222***	-0.0139	-0.498***	-0.514***	-0.206***
	(0.0387)	(0.0542)	(0.0455)	(0.0508)	(0.0520)
Railroad	0.0838***	0.112***	-0.0319	-0.0540	0.00231
	(0.0276)	(0.0245)	(0.0358)	(0.0418)	(0.0330)
Farms per capita	-0.0668*	-0.0791**	-0.000692	0.00544	-0.102*
	(0.0359)	(0.0337)	(0.0344)	(0.0426)	(0.0600)
Literacy	0.0333	0.0663	-0.158*	-0.199**	-0.116
	(0.0630)	(0.0534)	(0.0847)	(0.0978)	(0.0734)
Secondary	-0.176***	-0.0923**	-0.189***	-0.190***	-0.129**
	(0.0409)	(0.0424)	(0.0502)	(0.0609)	(0.0477)
Tertiary	0.128***	0.0192	0.137**	0.137***	0.195***
	(0.0354)	(0.0340)	(0.0540)	(0.0429)	(0.0391)
Lawyers	0.173***	-0.0204	0.200***	0.248***	0.263***
	(0.0365)	(0.0337)	(0.0376)	(0.0389)	(0.0471)
Physicians	-0.0377	-0.0277	-0.0504	-0.0665	-0.0364
	(0.0343)	(0.0331)	(0.0365)	(0.0446)	(0.0402)
Observations	1,745	1,722	1,745	1,884	1,761
R-squared	0.490	0.514	0.486	0.470	0.419
FE	Yes	Yes	Yes	Yes	Yes

Heterogeneous Effects: Structural Transformation

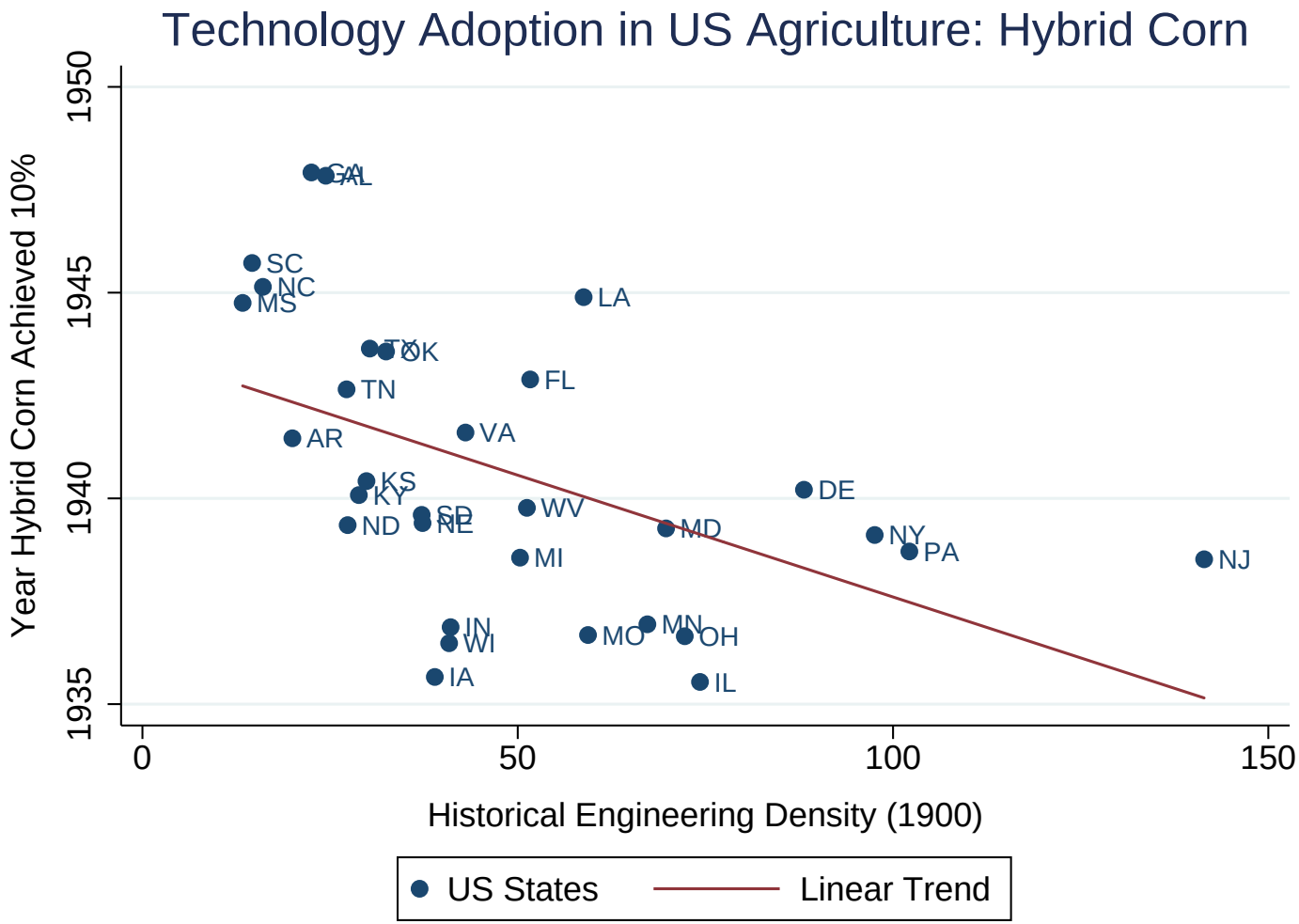
US Counties: Lawyers and Farms

	(1)	(2)	(4)	(5)	(7)	(8)	(10)	(11)
	Lawyers				Agriculture			
	Below		Above		Below		Above	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Engineers	0.0932**	0.0870**	0.0647***	0.110***	0.0961***	0.115***	0.00567	0.0347
	(0.0390)	(0.0381)	(0.0236)	(0.0330)	(0.0267)	(0.0421)	(0.0214)	(0.0332)
Rainfall	0.0470	0.0579	0.131	0.135	0.173	0.143	0.0434	0.0615
	(0.137)	(0.128)	(0.0959)	(0.102)	(0.0907)	(0.0799)	(0.0840)	(0.105)
Altitude	0.0549	0.0373	-0.161**	-0.168***	-0.146**	-0.143***	0.0928	0.0853
	(0.0679)	(0.0712)	(0.0605)	(0.0546)	(0.0569)	(0.0447)	(0.0729)	(0.0705)
Ruggedness	-0.0607	-0.0637	0.0124	0.00723	0.0323	0.0212	-0.0767	-0.0917
	(0.0824)	(0.0879)	(0.106)	(0.103)	(0.101)	(0.0869)	(0.0635)	(0.0752)
River Dist.	0.0215	0.0341	0.00922	0.00947	0.0313	0.0395	0.00927	0.0119
	(0.0398)	(0.0445)	(0.0283)	(0.0278)	(0.0400)	(0.0397)	(0.0264)	(0.0287)
Temperature	-0.0335	-0.0259	-0.143	-0.132	-0.0638	-0.0361	-0.0635	-0.0676
	(0.211)	(0.204)	(0.120)	(0.125)	(0.179)	(0.156)	(0.128)	(0.145)
Coast Dist.	-0.182	-0.166	-0.00269	0.0109	-0.125	-0.0914	-0.0826	-0.0871
	(0.114)	(0.104)	(0.0751)	(0.0862)	(0.110)	(0.0774)	(0.0923)	(0.110)
Pop. Density	6.653*	0.179**	0.0973***	0.135***	0.0871***	0.107***	25.57***	0.339***
	(3.439)	(0.0890)	(0.0103)	(0.0151)	(0.0115)	(0.0146)	(4.853)	(0.0650)
Manuf. Output	0.0754	0.0589	0.00545	0.0114	0.0285	0.0193	0.166**	0.0729**
	(0.0688)	(0.0671)	(0.0560)	(0.0636)	(0.0434)	(0.0556)	(0.0683)	(0.0287)
Slavery	0.134*	0.135*	0.354***	0.261***	0.247**	0.246**	0.122*	0.105*
	(0.0671)	(0.0786)	(0.0723)	(0.0543)	(0.111)	(0.120)	(0.0669)	(0.0586)
Railroad	0.0633**	0.0528*	0.135***	0.128***	0.116***	0.0845***	0.0592*	0.0675*
	(0.0243)	(0.0272)	(0.0291)	(0.0268)	(0.0299)	(0.0237)	(0.0292)	(0.0358)
Farms per capita	0.0896*	0.0495	-0.0349	-0.0651	-0.0241	-0.0589	0.0129	0.00840
	(0.0514)	(0.0418)	(0.0388)	(0.0465)	(0.0678)	(0.0406)	(0.0230)	(0.0179)
Literacy	0.557***	0.574***	0.445***	0.360***	0.519***	0.516***	0.324***	0.350***
	(0.105)	(0.108)	(0.0867)	(0.0696)	(0.141)	(0.136)	(0.0666)	(0.0694)
Secondary	0.0478	0.0393	0.0131	0.00723	-0.00427	-0.00890	0.00596	0.00227
	(0.0629)	(0.0728)	(0.0559)	(0.0495)	(0.0705)	(0.0649)	(0.0449)	(0.0512)
Tertiary	-0.0130	-0.00591	0.0749	0.0624	0.0392	0.0348	-0.0211	-0.0222
	(0.0409)	(0.0373)	(0.0547)	(0.0460)	(0.0610)	(0.0520)	(0.0497)	(0.0556)
Lawyers	0.206***	0.0865***	0.0803**	0.0826**	0.200***	0.207***	-0.0292	-0.0302
	(0.0727)	(0.0334)	(0.0391)	(0.0372)	(0.0525)	(0.0552)	(0.0360)	(0.0375)
Physicians	0.0384	0.0503	0.0137	0.00462	0.0145	0.0102	-0.0187	-0.0219
	(0.0457)	(0.0421)	(0.0325)	(0.0313)	(0.0543)	(0.0478)	(0.0376)	(0.0464)
Patents	-0.000642	0.0155	0.156***	0.200***	0.107***	0.140***	0.182*	0.120*
	(0.0781)	(0.0504)	(0.0348)	(0.0421)	(0.0317)	(0.0370)	(0.0971)	(0.0625)
Constant	0.439***	0.00996*	-0.0268	-0.0242***	-0.0802	-0.0238***	1.175***	0.0191*
	(0.150)	(0.00512)	(0.0618)	(0.00506)	(0.0678)	(0.00668)	(0.240)	(0.0101)
Observations	952	952	952	952	952	952	952	952
R-squared	0.500		0.503		0.553		0.489	
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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

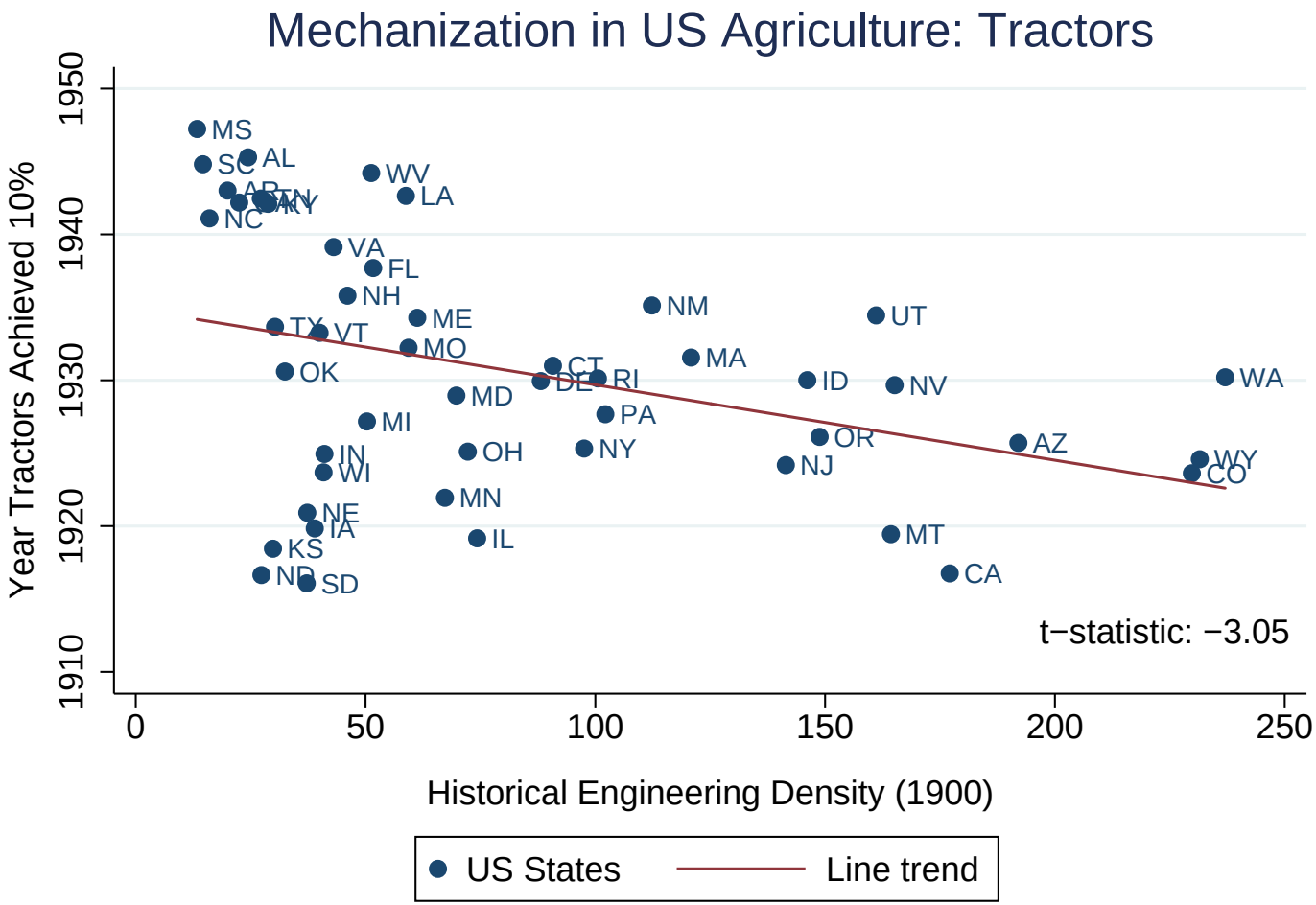
Technology Adoption in Agriculture

Year Hybrid Corn Achieved 10% in the US, by State



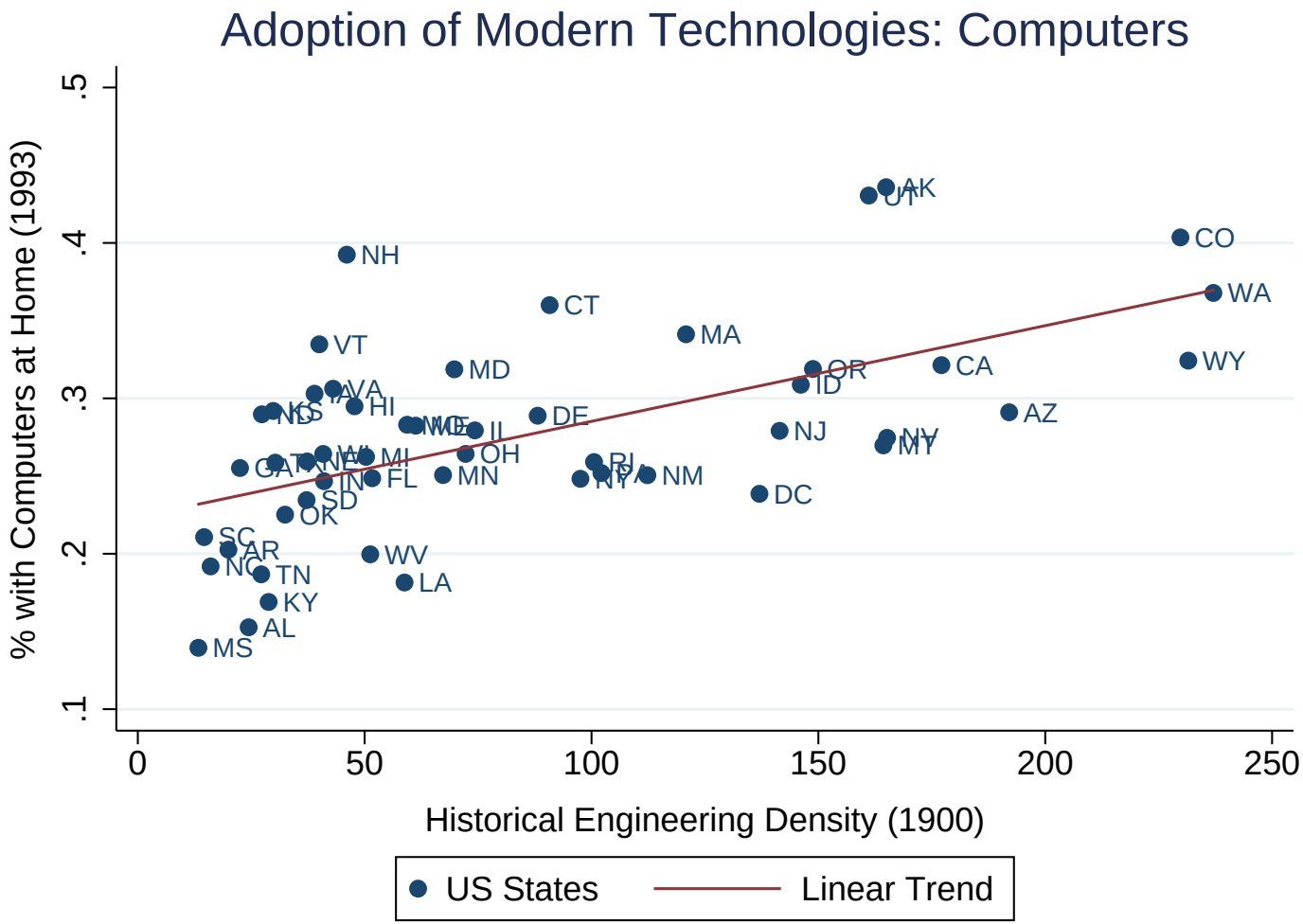
Mechanization in Agriculture

Year Tractors Achieved 10% in the US, by State



Modern Technologies: Computers

% with Computers at Home in 1993 in the US, by State



High-tech and Knowledge Intensive Sectors

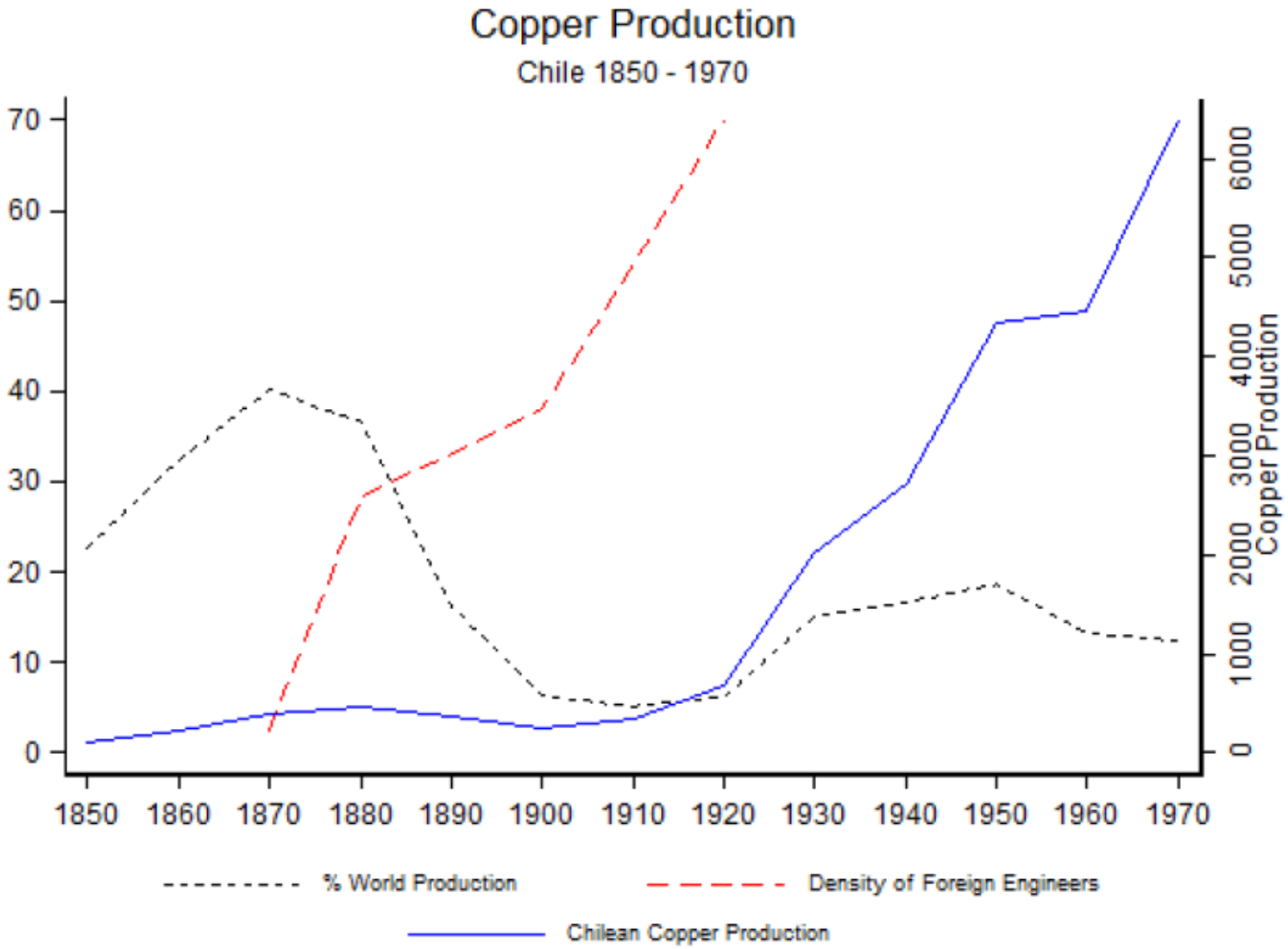
County Business Paterns (2012), KIBS and Ci Technology Database

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	High-tech Sectors			Knowledge Intensive Business Sectors			Investments in Technology		
	Payroll	Employment	Establishments	1930	1980	2010	PCs	Servers	IT budget
Engineers	82.87*	0.917**	0.995**	0.000762***	0.00137***	0.000800**	0.0525***	0.00857**	22.40***
	(44,83)	(0,43)	(0,37)	(0,0002)	(0,0003)	(0,0003)	(0,017)	(0,003)	(7,11)
Observations	1.754	1.754	1.754	1.854	1.799	1.853	1954	1954	1954
R-squared	0,132	0,158	0,192	0,162	0,189	0,195	0,106	0,09	0,084
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

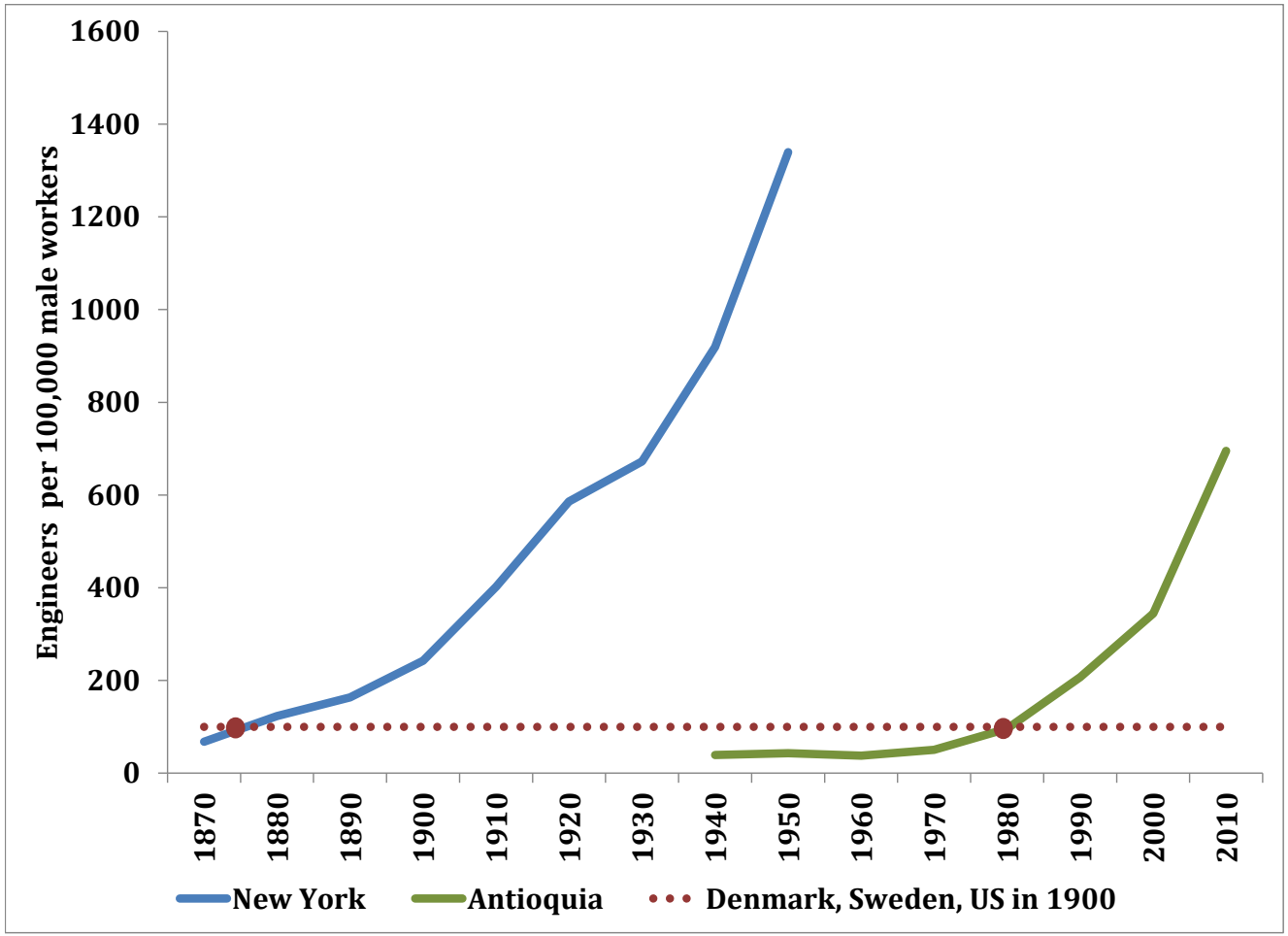
Historical Case Studies

- Relative Innovative Capacity: Aghion and Howitt (1997), Howitt and Mayer-Foulkes (2005)
  - US South: late industrialization, lack of preparation
    - Birmingham Steel Industry: "You have all the elements, but you cannot make steel." (Carnegie, 1900)
- Latin America: technologically backward, little innovation in industry and agriculture
- Mining: underexploited mines and foreign takeover
  - Mexico: Zacatecas, San Luis de Potosi and Guanajuato
  - Chile: copper industry almost abandoned, turnaround

Copper Production in Chile and Foreign Engineers



Enginering Density: New York vs. Antioquia



Innovation Determinants

- Local versus inherited factors
  - Pre-colonial population density (agglomeration)
  - Slavery and early institutions
- Geographical factors: Cobb (1993)
- Religion (Benabou, Ticchi and Vindigni, 2015)
- Cultural traits and colonial heritage (Alesina et al. 2016, Fulford et al. 2016)
- Immigration (Sequeira, Nunn and Quian, 2107)

Innovation Determinants

US Counties: Foreigners and Religion

	Engineers (1)	Patents (2)
Pop. Density	0.01***	0.2**
	(0.004)	(0.07)
South	-0.010***	-0.1**
	(0.004)	(0.06)
Slavery	-0.02***	-0.6***
	(0.006)	(0.08)
River distance	0.02	-0.3
	(0.09)	(1.3)
Temperature	0.1***	1.3*
	(0.04)	(0.7)
Rainfall	-0.04	-0.6
	(0.06)	(0.8)
Altitude	-0.2	1.3
	(0.1)	(2.7)
Coast Distance	0.04	-3.1***
	(0.06)	(0.9)
Ruggedness	0.7**	-9.5
	(0.3)	(6.0)
Foreigners	0.001***	0.01***
	(0.0002)	(0.003)
Churches	-1.9	-52.7***
	(1.2)	(11.5)
N	1659	1662
R^2	0.220	0.292

Robustness

- US county level
  - Andrews (2019) college winners and runner ups sub-sample ▸ Andrews
  - Buchinsky 2SLS quantile regression model, LASSO controls
  - Control for foreigners, religion, total acres in agriculture ▸ Additional Controls
  - Control for the number of engineers today
  - Predict non-engineering income today: managers
- State level for the US
  - Migration, mining output, geographic controls ▸ US States
  - Instrumented ▸ US States IV
- State level for the Americas
  - Deflated census numbers, foreign engineers
  - Geographic and institutional controls

Conclusions

- Importance of upper tails of knowledge during the Second Industrial Revolution for long-term growth
  - Engineering density accounts for a 10-15% increase in US county income
  - Patents (uninstrumented) contributes another 10%
  - Helps explain the Great Divergence in the Americas
- Supported by the historical record (Safford 1976, Wright 1986)
- Matters at the cross country, state and county levels
- Importance of both *innovative* and *adoptive* capacity (Mokyr 2005)
- Potentially working through structural transformation, technology adoption and entrepreneurship (Murphy et al., 1991)

Summary Statistics

State Level, Americas

Variable	mean	p50	sd	min	max	Obs
Ln Income	9.03	8.92	0.91	7.13	11.18	377
Engineers	23.38	11.00	30.08	0.00	84.00	275
Engineers (sub)	82.07	39.68	105.70	0.00	472.59	170
Population Density (1900)	41.06	4.44	243.20	0.00	3319.27	235
Population Density (1500)	8.88	2.00	26.13	0.00	392.34	365
Literacy	40.85	34.00	23.95	11.30	86.70	337
Literacy (sub)	49.06	39.96	30.10	4.60	98.31	175
Railroads	3.15	1.80	2.71	0.30	9.30	377
Railroads (sub)	65.12	48.54	57.46	5.16	309.20	49
south	0.15	0.00	0.36	0.00	1.00	111
Slavery	20.67	3.28	25.16	0.00	72.66	83
Lawyers	218.92	139.22	210.93	1.64	1156.44	114
Mine Output	0.47	0.12	1.06	0.00	6.49	45
Spain	0.81	1.00	0.39	0.00	1.00	390
Land Suitability	0.56	0.58	0.28	0.00	1.00	384
River Density	3.28	3.29	1.23	0.00	6.92	386
Average Temperature	19.97	20.40	5.83	2.38	29.00	332
Rainfall	1.28	1.10	0.95	0.00	8.13	332
Altitude	0.66	0.19	0.92	0.00	4.33	332
Dist. from Coast	0.87	0.91	0.12	0.45	1.00	383
Ruggedness	126.89	99.33	103.53	0.00	474.34	378

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Innovative Capacity and Income

US States

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Engineering	0.5***	0.8***	0.4***	0.4**	0.6***	1.2***	1.2***
	(0.15)	(0.15)	(0.14)	(0.18)	(0.11)	(0.40)	(0.33)
Pop Density		0.04***					-0.008
		(0.01)					(0.03)
Literacy			0.003*				0.01
			(0.00)				(0.01)
Lawyers				0.2			-0.2
				(0.21)			(0.23)
Railroads					0.002***		0.001
					(0.00)		(0.00)
Mining					-14.7		-23.1***
					(10.58)		(7.12)
Slavery						-0.0002	0.006
						(0.00)	(0.00)
South						-0.004	-0.05
						(0.10)	(0.07)
Constant	10.6***	10.4***	10.4***	10.6***	10.5***	10.6***	9.3***
	(0.02)	(0.06)	(0.15)	(0.07)	(0.03)	(0.06)	(0.91)
N	51	51	51	51	44	38	34
R^2	0.14	0.40	0.17	0.17	0.47	0.41	0.60

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Innovative Capacity and Income

US States: Instrumented

	(1)	(2)	(3)	(4)	(5)
Engineering	0.9*	1.6***	0.8**	0.9**	2.1**
	(0.50)	(0.51)	(0.36)	(0.40)	(1.06)
Pop Density		0.07***			0.08**
		(0.02)			(0.03)
Literacy			0.002		-0.002
			(0.00)		(0.00)
Lawyers				-0.02	-0.3
				(0.25)	(0.34)
Constant	10.6***	10.3***	10.4***	10.6***	10.5***
	(0.08)	(0.11)	(0.16)	(0.08)	(0.25)
N	51	51	51	51	51
R^2	0.02	0.06	0.09	0.02	.

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Andrews (2019) Runner Up Colleges

Additional Controls

	(1) OLS	(2) First Stage Engineers	(3) First Stage Lawyers	(4) First Stage Physicians	(5) IV
Engineers	0.136*				0.623*
	(0.0695)				(0.362)
Rainfall	-0.140	-0.0671	-0.125	0.0402	-0.110
	(0.100)	(0.177)	(0.100)	(0.0488)	(0.141)
Altitude	-0.787**	0.414	0.644***	0.230**	-0.974**
	(0.331)	(0.363)	(0.233)	(0.0969)	(0.406)
Ruggedness	0.319*	0.0790	-0.0746	-0.0507	0.284
	(0.167)	(0.147)	(0.0959)	(0.0373)	(0.183)
River Dist.	0.721	-1.533	-1.382*	0.175	1.422
	(1.173)	(1.003)	(0.715)	(0.254)	(1.340)
Temperature	0.0992	0.708***	0.368***	0.102***	-0.233
	(0.136)	(0.140)	(0.0854)	(0.0278)	(0.279)
Coast Dist.	-0.0806	0.350**	0.245***	0.162***	-0.241
	(0.101)	(0.144)	(0.0863)	(0.0307)	(0.181)
Pop. Density	-0.368***	-0.115	-0.0298	0.0393***	-0.283***
	(0.0389)	(0.0849)	(0.0391)	(0.0129)	(0.0835)
Manuf. Output	0.0722	0.132	-0.0433	-0.0129	-0.00464
	(0.0625)	(0.0844)	(0.0404)	(0.0146)	(0.0904)
Slavery	0.0556	0.0318	0.241**	0.0602	0.0560
	(0.210)	(0.167)	(0.119)	(0.0432)	(0.215)
Railroad	0.0646	0.109	0.0910*	0.0546***	-0.000860
	(0.107)	(0.0900)	(0.0541)	(0.0205)	(0.118)
Farms per capita	-0.401***	-0.601***	-0.434***	-0.0239	-0.115
	(0.115)	(0.113)	(0.0718)	(0.0262)	(0.254)
Literacy	0.587**	0.499**	0.630***	0.236***	0.362
	(0.245)	(0.229)	(0.158)	(0.0592)	(0.313)
Secondary	-0.299*	0.128	-0.00307	0.00595	-0.350*
	(0.171)	(0.141)	(0.0929)	(0.0402)	(0.191)
LGC 1862		0.0746**	0.00624	0.00487	
		(0.0305)	(0.0144)	(0.00558)	
Observations	202	202	204	204	202
R-squared	0.420	0.469	0.458	0.377	0.267

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Innovative Capacity and Income

Additional Controls

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) OLS
Engineers	0.223***	0.291***	0.156***	0.129***	0.150***	0.102***	0.103***	0.0866***
	(0.0370)	(0.0363)	(0.0357)	(0.0315)	(0.0357)	(0.0345)	(0.0322)	(0.0269)
Rainfall		0.0116	0.0199	0.0403	0.0217	0.0538	0.0622	0.145*
		(0.0820)	(0.0694)	(0.0737)	(0.0717)	(0.0679)	(0.0732)	(0.0731)
Altitude		-0.0393	-0.0200	-0.0349	-0.0232	-0.0275	-0.0382	-0.0731
		(0.0940)	(0.109)	(0.109)	(0.108)	(0.104)	(0.104)	(0.0794)
Ruggedness		-0.0299	-0.0364	0.0188	-0.0400	-0.0132	0.00642	-0.0220
		(0.116)	(0.108)	(0.0950)	(0.105)	(0.0926)	(0.0892)	(0.0897)
River Dist.		0.0229	0.0289	0.0186	0.0249	0.0364	0.0272	0.0290
		(0.0294)	(0.0305)	(0.0291)	(0.0286)	(0.0300)	(0.0287)	(0.0265)
Temperature		-0.307***	-0.0854	0.0105	-0.0328	-0.0692	0.00158	0.00253
		(0.0615)	(0.0704)	(0.0580)	(0.0698)	(0.0670)	(0.0651)	(0.154)
Coast Dist.		-0.275***	-0.183***	-0.149**	-0.179***	-0.195***	-0.154***	-0.0615
		(0.0444)	(0.0549)	(0.0611)	(0.0564)	(0.0527)	(0.0556)	(0.0835)
Pop. Density			0.0898***	0.0930***	0.0893***	0.0800***	0.0873***	0.0937***
			(0.00827)	(0.00774)	(0.00843)	(0.0105)	(0.00950)	(0.0111)
Manuf. Output			0.161***	0.154***	0.180***	0.163***	0.160***	0.0996**
			(0.0543)	(0.0478)	(0.0525)	(0.0527)	(0.0492)	(0.0464)
Slavery			-0.115	0.130	-0.0477	-0.0243	0.128	0.182**
			(0.0752)	(0.122)	(0.0874)	(0.0940)	(0.125)	(0.0707)
Railroad			0.140***	0.100***	0.128***	0.117***	0.0935***	0.0800***
			(0.0348)	(0.0325)	(0.0331)	(0.0323)	(0.0313)	(0.0204)
Farms per capita			-0.0148	-0.00504	-0.0148	0.0345	0.0238	0.0241
			(0.0613)	(0.0499)	(0.0607)	(0.0588)	(0.0537)	(0.0457)
Churches per capita			-0.0196	-0.0190	-0.0126	-0.000975	-0.00473	-0.0207
			(0.0443)	(0.0343)	(0.0433)	(0.0386)	(0.0346)	(0.0248)
Foreigners per capita			0.0917	0.0662	0.111	0.107	0.0741	0.134
			(0.0846)	(0.0746)	(0.0854)	(0.0880)	(0.0852)	(0.0869)
Literacy				0.406***			0.335***	0.500***
				(0.111)			(0.108)	(0.0808)
Secondary					0.127**		0.0231	0.0819
					(0.0604)		(0.0622)	(0.0570)
Tertiary						0.119**	0.0356	0.0696
						(0.0532)	(0.0458)	(0.0448)
Lawyers						0.116***	0.111***	0.124***
						(0.0403)	(0.0408)	(0.0406)
Physicians						0.0247	-0.0297	0.0419
						(0.0539)	(0.0484)	(0.0320)
Observations	2,380	1,656	1,656	1,656	1,656	1,656	1,656	1,656
R-squared	0.077	0.274	0.345	0.379	0.351	0.371	0.388	0.501
FE	No	No	No	No	No	No	No	Yes

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Mechanisms of Influence

Cross Country

	All	New World
Inputs		
R&D/GDP	0.94	0.96
Firm Innovative Capacity	0.94	0.94
Modern Management	0.93	0.93
Outputs		
Patents	0.95	0.98
Technological Adoption	0.84	0.94

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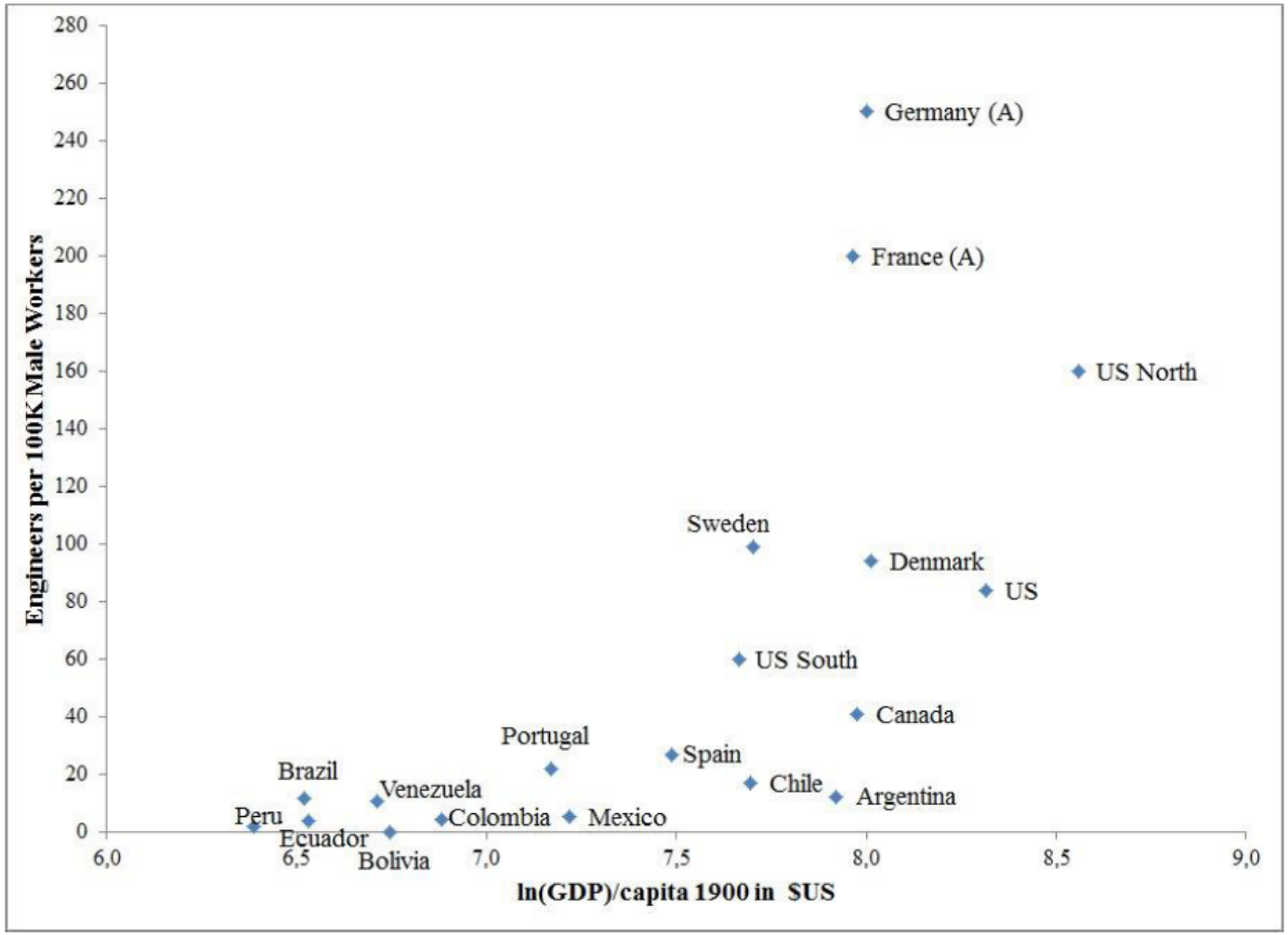
National Engineering Density



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