

Human Capital and Industrialization: Evidence from the Age of Enlightenment

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Motivation

- Education strong predictor of contemporaneous development
- But typically described as unimportant for early industrialization
 - ▶ Scandinavia vs. England
 - ▶ Downward trend in skill premium (Clark, 2005)
 - ▶ Galor (2005): "Before 1850, education served mostly religious and social goals"
- Previous findings based on *average* worker skills (literacy)
- Importance of top-end of the skill distribution
 - ▶ Historically: "Density in the upper tail" crucial for innovation and diffusion of modern technology (Mokyr, 2005)
 - ▶ Contemporaneously: entrepreneurial skills (Gennaioli et al. 2013), math and science skills (Hanushek and Kimko, 2000)
- Distinguish between upper-tail and average skills \Rightarrow Reinstatement of importance of human capital during the First Industrial Revolution?

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This Paper – Simple Model of Technology Diffusion

Theoretical distinction: Worker Skills vs. Upper Tail Knowledge

▶ Def.

- Average worker skills raise productivity for *given* technology
- Upper tail knowledge (entrepreneurs) foster adoption of *new* manufacturing technology \Rightarrow particularly useful when technological progress is rapid (Nelson and Phelps, 1966)
- Predictions:
 - ▶ As technological growth becomes more rapid, a larger local knowledge elite is associated with higher income, manufacturing employment, and *growth*
 - ▶ Worker skill *levels* raise wages in both sectors (and thus income in the cross-section), but *not* growth

▶ Model

This Paper – Empirics

Challenge: Proxy for upper tail knowledge (knowledge elites)

- List of more than 7,000 subscriptions to the *Great Encyclopédie* in 193 French cities in mid-18C France
- Subscriber density (*Subs.Density*): proxy for local scientific elites
- Evidence for local persistence of knowledge elites: Scientific Societies, famous scientists, innovations exhibited at 1851 World Fair

This Paper – Empirics

Main findings:

- *Subs.Density* uncorrelated with literacy [▶ Detail](#)
- Cities with higher *Subs.Density* grow faster after 1750; small or no effect pre-1750 [▶ Detail](#)
- Departments with higher *Subs.Density* have higher income and industrialization in mid-19C, but not before 1750
- Firm census: Wage effects strongest in innovative modern sectors
- Literacy positively associated with income in the cross-section *before and after* 1750, but not with growth

Notes:

- We do NOT claim that the Encyclopédie *caused* growth
- We show that upper tail knowledge is a *proximate* driver of growth, but not necessarily a fundamental one
- We show that upper tail knowledge became more important after 1750 – but it probably mattered in some earlier periods, too (Commercial Revolution)

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Related Literature

- Explaining Industrial Revolution (IR)
 - ▶ Unified Growth Theory – human capital important factor (Galor and Weil, 2000; Galor, 2011)
 - ▶ Empirically education/skills typically assessed as unimportant during first phase: Mokyr (1990), Mitch (1993), Clark (2005), O'Rourke, Rahman, and Taylor (2013). Skills become more important during second phase.
- Distinguishing upper tail and average human capital
 - ▶ Contemporaneous context: Importance of high performers (Hanushek and Woessmann, 2012)
 - ▶ Historical context: Mokyr (2005), Mokyr and Voth (2009), Kelly et al. (2014)
- Book printing / upper tail knowledge before Industrial Revolution
 - ▶ Baten and van Zanden (2008), Dittmar (2011)
 - ▶ Dittmar (2013), Cantoni and Yuchtman (2014)
- Importance of Enlightenment / culture for economic growth
 - ▶ David (1998): Emergence of "Open Science"
 - ▶ Mokyr (2005): Crucial ('useful' knowledge and its dissemination)
 - ▶ Max Weber – Protestantism (Becker and Woessmann, 2009; Cantoni, 2013; Bai and Kung, 2014)

Plan for the Talk

- 1 Historical Background
- 2 Empirical Evidence

Historical Background

Industrialization in France

- Growth started around 1750 [▶ France growth](#)
 - ▶ No clear take-off. French industrialization "different but not inferior" (Crouzet, 2003)
 - ▶ Lagged behind Britain by about a generation – "Retardation" mostly due to temporary slowdown after Revolution (O'Brien and Keyder, 1978) [▶ More Detail](#)
 - ▶ Growth then accelerated again. By mid-19C, France had become "a centre of invention and diffusion for modern technologies" (Crouzet, 2003) [▶ France vs England](#)
- Spatially dispersed economic activity [▶ Spatial Dispersion](#)
- Upper tail knowledge important for industrialization – similarity to Britain (Dowey, 2014)
 - ▶ British know-how reached France (scientific reports, industrial spies)
 - ▶ French entrepreneurs often hired British experts
 - ▶ State and provincial governments supported science and industry

[▶ Access to Science](#)

[▶ Role of the State](#)

Enlightenment, Knowledge, and Industrialization

- Baconian motive: Understand and command nature to attain material progress
 - ▶ Connected those who knew things ("savants") with those who made things ("fabricants")
 - ▶ New agenda: focus on 'useful knowledge'
- Already contemporaries recognized importance of advanced knowledge
 - ▶ *"The genre of modern industrial production requires extended knowledge of mechanics, notion of calculus, great dexterity at work, and enlightenment in the underlying principles of the crafts. This combination of expertise . . . has only been achieved in this [18th century] period, where the study of science has spread widely, accompanied by an intimate relationship between savants and artisans." (Chaptal, 1819)*

Upper Tail Knowledge and Entrepreneurship

Antoine Lavoisier (1743-1794)

- Nobleman and chemist. Father of the "Chemical Revolution" in 18C
- Education in spirit of enlightenment; fascinated by *Dictionnaire de Chymie* (1766)
- Recognized and named oxygen and hydrogen. Predicted existence of silicon.
- Studied role of oxygen in combustion, and street lighting.

Alexandre Vandermonde (1735-1796)

- Mathematician attracted to machinery and chemistry
- Fostered first major industrial application of Lavoisier's chemistry in iron production

Jean-Antoine Chaptal (1756-1832)

- Public lectures on chemistry and experimental physics
- Well-connected with the scientific network (e.g., James Watt)
- Founded the largest chemical factory in France
- Founded government-supported institutions: Among others the *Société d'Encouragement pour l'Industrie National*, bringing together scientists, industrialists, and bureaucrats

In textiles: Koechlin and Dollfus families

- Descended from the mathematician Bernouilli
- Daniel Dollfus-Ausset (1797-1879): chemist; major innovations in bleaching; running his own textile firm
- André Koechlin (1789-1875): manufacturing of textile machineries, wool spinning. Later: locomotives and railroad equipment
- co-founders of the *Société industrielle de Mulhouse*: promoted technological progress via conferences and publications
- their dynasties later married with other scientific families such as the Curies and the Friedels

▶ More examples

Encyclopedia: Editions and History

- *"Most paradigmatic Enlightenment triumph"* (Mokyr, 2005)
- Earlier editions: Luxury items, sold only to exclusive circle of courtiers and progressive parlementaires.

Quarto Edition of the Great Encyclopédie (1777-1780)

- More affordable (price less than 1/4 of earlier editions). First commercial version for "diffusion on a massive scale" (Darnton, 1979)
 - ▶ Price of 384 livres easily affordable for middle-class and entrepreneurs; but not for skilled workers – about 26 weeks' wages for locksmiths or carpenters (Darnton, 1973)
- Highest print run:
 - ▶ 7,081 in France (out of 8,500 total subscriptions)
- Importance of visualization
 - ▶ Each craft carefully described and illustrated: plates reached technical mastery (Mokyr, 2000) [▶ Plates](#)

Encyclopedia Subscribers and Scientific Knowledge

Does local subscriber density reflect the presence of scientific elites?

List of individual subscribers survived for Besançon:

- 11% to the first estate (clergy)
- 39% to the nobility – often engaged in industrialization:
*"Over a whole range of activities and enterprises, nobles, either alone or in association with members of the greater business bourgeoisie, showed their dynamism, their **taste for invention and innovation, and their ability as economic leaders:** ... their ability to direct capital..., to choose investments according to their productiveness and their modernity, and ... to **transmute the forms of production into an industrial revolution.**" (Chaussinand-Nogaret, 1985)*
- 17% to professionals, merchants, and manufacturers
- 28% to public officials
 - ▶ Also often involved in fostering local industrialization (Horn, 2006)
- Indirect access for lower social ranks: Organized lectures, symposia, scientific societies, libraries, lodges, and coffeehouses (Roche, 1998)

Empirical Evidence

Data: Encyclopedia Subscribers

Quarto Edition of the Great Encyclopédie (1777-1780)

- Data on number of subscriptions per city
- Secret document found at the Société Typographique de Neuchâtel by Darnton (1973) [▶ Map](#)
- Define subscriber density as $\ln(1 + \textit{subs}/\textit{pop})$

[▶ Tree](#)

Data: Outcomes Variables

- City Population, 1000-1850: Bairoch et al. (1988)
- Dep. level industry employment and output per capita for 1861: Enquête Industrielle (1861)
- Department level wages in industry and agriculture for 1852: Goreaux, (1956)
- Soldier height pre-1750: Komlos (2006)
- Soldier height 1800s: Aron, Dumont and Le Roy Ladurie (1972)
- French firm census \Rightarrow wages by sector for 1839-1847 (Arr. level): Chanut (2000)

Data: Control Variables

- Literacy 1686-1786: Furet and Ozouf (1977)
- School Rate in 1837 (Dep. level): Diebolt (2005)
- Printing Cities in 1500: Febvre and Martin (1958), Clair (1976)
- Number of books published in 1500: ISTC (2008)
- Universities in 1750: Jedin, Latourette, and Martin (1970); Julia and Revel (1989)
- Scientific Societies: McClellan (1985)
- Atlantic Port, Mediterranean Port, Navigable River: Dittmar (2011)
- Non-French Speaking: "Lexigolos"
- Nobility: Almanach de Gotha
- Executions during the Reign of Terror: "Les Guillotinés de la Révolution"
- Pre-industrial centers: Abramson and Boix (2013)
- Pop. Density (Dep. level) 1876: Annuaire Statistique de la France (1878)
- Firm census 1839-1847 (Arr. level): Chanut (2000)
- British Patents Index 1617-1841: Nuvolari and Tartari (2011)
- Encyclopedia Plates: ARTFL Project

Balancedness

Table: Correlations with subscriber density (*Subs.Density*)

<u>Baseline Controls</u>			<u>Worker skills and additional controls</u>			
	(1)	(2)		(3)	(4) [‡]	(5) [‡]
Cities included:	All	Subs>0	Departments included:	All	All	Subs>0
Population in 1750	0.374*** (0.073)	-0.234** (0.110)	Literacy 1686 [†]	0.551 (0.593)	0.905 (0.650)	0.026 (0.777)
Atlantic Port	0.081 (0.207)	-0.222 (0.213)	Literacy 1786 [†]	0.290 (0.345)	0.358 (0.323)	0.054 (0.383)
Mediterranean Port	0.022 (0.276)	-0.129 (0.223)	School Rate 1837 [†]	0.363 (0.350)	0.313 (0.335)	0.200 (0.412)
Navigable River	0.422** (0.202)	-0.167 (0.210)	<u>Additional Controls</u>			
Non French-Speaking	-0.376** (0.146)	-0.719** (0.297)	<i>InSTNBooksDens</i>	0.242*** (0.041)	0.194*** (0.050)	0.062 (0.056)
<u>Early Knowledge Controls</u>			<i>Pays d'Eléction</i>	0.046 (0.129)	0.137 (0.128)	0.048 (0.205)
University	1.030*** (0.186)	0.316 (0.194)	<i>InPreIndDens</i> [†]	-0.027 (0.830)	-0.033 (0.829)	-0.546 (0.846)
Printing Press	0.712*** (0.170)	0.203 (0.182)	<i>InNoblesDens</i> [†]	0.233 (0.278)	0.253 (0.301)	0.736*** (0.249)
ln(Books Printed 1500)	0.171*** (0.061)	0.039 (0.066)	<i>InDistanceCoal</i>	-0.173** (0.083)	-0.104 (0.083)	0.025 (0.106)

[‡] Includes baseline controls. [†] Department level.

Empirical Results: Agenda

Main Results

1. City Growth, 1750-1850
2. Soldier height, pre-1750 and in 1820s
3. Income and employment shares in industry at department level, mid-19C

Interpretation

4. Other proxies for knowledge elites
5. Deeper roots of local upper tail knowledge: The Huguenots
6. Innovative sectors and firm census in France

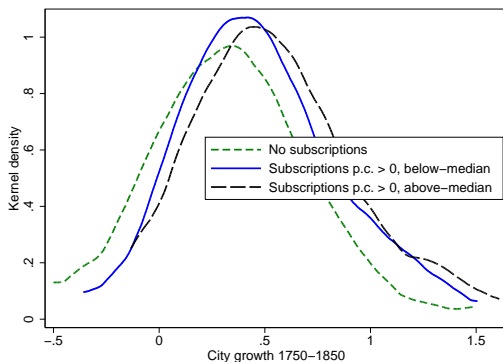
Agenda

1. City Growth, 1750-1850

City Growth, 1750-1850

City growth distribution shifts to the right with increasing Encyclopédie subscriptions

City growth by p.c. subscriptions



► Role initial city size

Propensity Score Estimation

Matching by city size and geographic location

Table: Matching Estimation by City Size and Location

Dependent variable: log city growth over the indicated period

	(1)	(2)	(3)	(4)	(5)	(6)
	Period 1750-1850				1700-1750	
City size percentiles incl.:	All	10-90 pct	All	10-90 pct	All	10-90 pct
$I_{Subs>0}$	0.146** (0.07)	0.155** (0.07)	0.267*** (0.07)	0.163** (0.07)	0.087 (0.06)	0.063 (0.05)
Matching variables						
Population	✓	✓	✓	✓	✓	✓
Location			✓	✓	✓	✓
Observations	177	154	167	144	129	110

Encyclopédie Subscriptions and City Growth

Cities with more subscriptions per capita grow faster after 1750

Dependent variable: log city growth, 1750-1850

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				incl. dummy	subs>0	unweighted	no log	1700-1750
SubsDensity	0.100** (0.039)	0.171*** (0.036)	0.169*** (0.033)	0.132*** (0.043)	0.117** (0.045)	0.204*** (0.036)	0.040*** (0.008)	0.008 (0.037)
<i>InPop_{initial}</i>	0.055*** (0.014)	-0.085** (0.041)	-0.089* (0.048)	-0.130*** (0.047)	-0.150*** (0.053)	-0.156*** (0.051)	-0.071 (0.049)	-0.058 (0.040)
Atlantic Port		0.221*** (0.082)	0.242** (0.094)	0.253** (0.099)	0.214* (0.120)	0.349** (0.162)	0.253*** (0.090)	0.087 (0.101)
Mediterranean Port		0.779*** (0.076)	0.794*** (0.091)	0.823*** (0.083)	0.883*** (0.093)	0.752*** (0.142)	0.824*** (0.102)	-0.203** (0.094)
Navigable River		0.095 (0.068)	0.068 (0.072)	0.075 (0.071)	0.089 (0.090)	0.134* (0.069)	0.081 (0.073)	0.001 (0.076)
Paris		0.575*** (0.136)	0.610*** (0.132)	0.617*** (0.130)	0.574*** (0.145)	0.760*** (0.171)	0.614*** (0.130)	-0.020 (0.135)
Non French Speaking		0.337*** (0.089)	0.330*** (0.097)	0.281*** (0.107)	0.184 (0.118)	0.428*** (0.145)	0.328*** (0.093)	0.100 (0.129)
University			-0.063 (0.067)	-0.050 (0.065)	-0.011 (0.073)	-0.123 (0.084)	-0.056 (0.066)	0.122* (0.069)
Printing Press in 1500			0.093 (0.094)	0.057 (0.090)	-0.023 (0.106)	0.188* (0.098)	0.119 (0.091)	-0.078 (0.083)
In(Books Printed 1500)			-0.001 (0.020)	0.012 (0.020)	0.026 (0.022)	0.006 (0.025)	-0.012 (0.020)	0.029* (0.017)
<i>I_{Subs>0}</i>				0.134 (0.089)				
R ²	0.12	0.36	0.36	0.37	0.48	0.27	0.35	0.17
Observations	193	193	193	193	85	193	193	148
Magnitude: subscriber density [‡]								
0-75 percentile	0.188** [0.011]	0.323*** [0.000]	0.320*** [0.000]	0.384*** [0.000]	0.221** [0.012]	0.387*** [0.000]	0.226*** [0.000]	0.016 [0.822]
beta coeff. SubsDensity	0.213	0.365	0.362	-	0.286	0.347	0.340	0.027

► Terciles

► Subs>0

◀ ► Robustness Checks

Literacy and Additional Controls

Literacy does not explain growth; subscriber density is robust

Dependent variable: log city growth, 1750-1850

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>InSubDens</i>	0.180*** (0.040)	0.198*** (0.042)	0.176*** (0.038)	0.178*** (0.039)	0.187*** (0.040)	0.176*** (0.041)	0.194*** (0.042)	0.154*** (0.051)
Literacy 1786	-0.209 (0.142)	-0.156 (0.135)	-0.276** (0.133)	-0.179 (0.149)	-0.190 (0.143)	-0.208 (0.144)	-0.240 (0.149)	-0.276* (0.148)
<i>InSTNBooksDens</i>		-0.025 (0.021)					-0.023 (0.022)	-0.020 (0.022)
<i>InPreIndDens</i>			1.107*** (0.363)				0.985** (0.399)	0.916** (0.398)
<i>InDistanceCoal</i>				-0.020 (0.039)			0.025 (0.047)	0.034 (0.045)
Pays d'Élection					-0.076 (0.065)		-0.060 (0.075)	-0.074 (0.073)
<i>InNoblesDens</i>						0.085 (0.135)	0.145 (0.111)	0.104 (0.114)
<i>I_{Subs>0}</i>								0.142 (0.099)
ln(Pop 1750)	-0.075* (0.043)	-0.053 (0.041)	-0.067 (0.040)	-0.080* (0.045)	-0.086* (0.045)	-0.061 (0.055)	-0.025 (0.050)	-0.074 (0.051)
Baseline Controls	✓	✓	✓	✓	✓	✓	✓	✓
R ²	0.38	0.39	0.40	0.38	0.39	0.38	0.41	0.42
Observations	166	166	166	166	164	166	164	164

Sub-Periods 1750-1800 and 1800-1850

Unobserved factors driving growth over both sub-periods are unlikely

Dependent variable: log city growth over the indicated period

	(1)	(2)	(3)
Period	1750-1800	1800-1850	1800-1850 Control for prior growth
<i>InSubDens</i>	0.108*** (0.035)	0.059** (0.028)	0.073*** (0.027)
Growth 1750-1800			-0.187*** (0.069)
Baseline Controls	✓	✓	✓
R ²	0.29	0.39	0.42
Observations	192	192	192

2. Soldier height data, pre-1750 and in 1820s

- Uncorrelated with *Subs.Density* prior to 1750; strongly correlated in 1820s
- Correlated with literacy in both periods
- *Change* in literacy also associated with growth

Conscript Height 1819-1826

Soldier height as a proxy for income (at the department level)

Dependent variable: Soldier height in cm (1819-1826)

	(1)	(2)	(3)	(4)
<i>InSubDens</i>	0.416*** (0.136)	0.450*** (0.129)	0.362** (0.139)	0.421*** (0.130)
Literacy 1786	2.805*** (0.398)	3.056*** (0.360)		
Change in literacy 1686-1786			3.043*** (1.007)	4.165*** (0.763)
Literacy 1686			1.749** (0.851)	1.516* (0.827)
Height pre-1750			0.408* (0.210)	0.192 (0.145)
Baseline Controls		✓		✓
R ²	0.42	0.60	0.49	0.65
Observations	77	77	74	74

Size of effects [std across dept: 1.3cm]

- One-std increase in *Subs.Density* \Rightarrow Height \uparrow by 0.33cm
- One-std increase in literacy \Rightarrow Height \uparrow by 0.24cm
- One-std increase in Δ literacy \Rightarrow Height \uparrow by 0.66cm



Soldiers Height pre-1750

Soldiers Height - sub pc

3. Income and employment shares in industry at department level, mid-19C

- Higher in departments that had more subscriptions per capita a century earlier

Income, Employment Shares and Wages in mid-19C

Income, industrial output and employment are significantly larger in departments with higher *Subs.Density*.

Dep. var.	(1)	(2)	(3)	(4) (5)	
	Disp. income (1864)	Ind. Output (1861)	Ind. Employm. (1861)	Wages (1852) Industry Agric.	
<i>InSubDens</i>	0.055* (0.030)	0.224* (0.114)	0.195** (0.088)	0.056*** (0.017)	0.031 (0.024)
School Rate 1837	0.151 (0.110)	0.410 (0.399)	0.349 (0.365)	0.207*** (0.062)	0.382*** (0.076)
Baseline Controls	✓	✓	✓	✓	✓
R ²	0.41	0.22	0.25	0.51	0.57
Observations	83	80	80	75	78

► Proto-industrialization

4. Other proxies for knowledge elites

- Does subscriber density reflect upper tail knowledge?
- Is the distribution of knowledge elites locally persistent?

Scientific Societies before 1750

Earlier Indicator for Local Scientific Knowledge

- Dummy for whether a city had a scientific society prior to 1750
- Strong predictor of subscriptions per capita

Table: Subscriptions and Scientific Societies

	(1)	(2)
Scientific Society	Subs. Dummy	Subs pc
Yes	0.91	4.54
No	0.26	1.23

Descriptions des Arts et Métiers 1761-1788

Another Indicator for Local Scientific Knowledge

- Detailed explanations and engravings of handicrafts and manufacturing processes of 18th century France
- Often complemented Encyclopédie entries, providing further detail
- 13,000 pages and more than 1,800 plates.
- Dummy for 45 cities that had sales of the *Descriptions des Arts et Métiers* (from STN)

Table: Subscriptions and Descriptions des Arts et Métiers

	(1)	(2)
Descr. Arts et Métiers	Subs. Dummy	Subs pc
Yes	0.8	4.23
No	0.24	1.08

Scientific Societies, Description des Arts et Métiers, and Growth

Alternative proxies for scientific knowledge yield very similar results as subscriber density

Dependent variable: log city growth over the indicated period

Variable x :	(1) pre-1750 1750-1850	(2) Scientific Societies 1700-1750	(3)	(4) Desc. Arts et Métiers 1750-1850	(5)
<i>Panel A: Matching Estimation</i>					
$I_{x>0}$	0.204** (0.098)	0.193** (0.095)	0.028 (0.083)	0.193** 0.082	0.140 0.096
Matching variables					
Population	✓	✓	✓	✓	✓
Location		✓	✓		✓
Observations	185	175	136	177	167
<i>Panel B: OLS Estimation</i>					
$\ln \text{Density}(x)$	0.285*** (0.083)	0.295** (0.126)	0.041 (0.098)	0.533*** (0.167)	0.460** (0.208)
$I_{x>0}$		-0.010 (0.130)			0.048 (0.086)
Controls	✓	✓	✓	✓	✓
R ²	0.34	0.34	0.22	0.32	0.32
Observations	158	158	118	166	166

Subscriber Density and Scientific Activity

- Data from *Index Bio-Bibliographicus Notorum Hominum* (IBN), as coded by de la Croix and Licandro (2012). Total of 21,633 people in France born in 1000–1887. City of birth/death known.
 - ▶ 2,513 of them in ‘upper tail professions’: science, mathematics, chemistry, physics and medicine.
- Info on exhibitions at 1851 World Fair from Moser (2005)
- Number of people in ‘upper tail professions’ in 1851 (dept level) from the *Récensement 1851*.

Dep. Variables (local density of)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>FamousScientists1000 – 1887</i>				<i>Exhibitors1851</i>		<i>ScienceProfessionals1851</i>	
	by birth city		by death city				(dept. level)	
<i>Subs.Density</i>	0.118*** (0.024)	0.125*** (0.033)	0.080*** (0.022)	0.070*** (0.019)	0.023** (0.011)	0.021* (0.011)	0.110** (0.051)	0.117** (0.050)
Baseline Controls		✓		✓		✓		✓
R ²	0.15	0.20	0.11	0.22	0.19	0.32	0.04	0.42
Observations	193	166	193	166	193	165	84	84

Notes: All regressions include dummies for Paris and for non-French speaking departments. Regressions in columns 1-6 are run at the city level, while regressions in columns 7-8 are run at the department level. In column 7 we also control for the share of employment in industry in 1861. Standard errors (clustered at the department level in column 2, 4, and 6) in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

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5. Deeper Local Roots of Upper Tail Human Capital: The Huguenots

Deeper Local Roots of Upper Tail Human Capital: The Huguenots

- Protestant minority in France. Important part of the entrepreneurial and knowledge elite
- Persecution and suppression, especially after *Edict of Nantes* was revoked in 1685: Protestantism declared illegal
- Huguenots as "penalized minority" (Scoville, QJE 1953):
"The severity of the laws directed against them leads to a perpetual self-examination. They are aided and abetted by the principles of their religion which render them more enlightened and capable of grasping all new ideas and of borrowing new technical processes from abroad which will help them gain success."

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Huguenots, Subscriber Density, and City Growth

Huguenots and subscriber density vs. literacy

Dep. Var.:	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Subs.Density</i>	Literacy		Log City Growth 1750-1850	Log City Growth 1700-1750	
<i>InHugDens</i> ₁₆₇₀	0.590*** (0.168)	-0.058 (0.060)	0.197** (0.077)	0.070 (0.089)	-0.039 (0.074)	-0.060 (0.069)
<i>InSubDens</i>				0.216*** (0.055)		0.035 (0.039)
Baseline Controls	✓	✓	✓	✓	✓	✓
R ²	0.20	0.06	0.15	0.25	0.04	0.04
Observations	163	150	163	163	132	132

Notes: All regressions are run at the city level and include dummies for Paris and for non-French speaking departments. Standard errors (clustered at the department level) in parentheses. * p<0.1, ** p<0.05, *** p<0.01

6. How did knowledge elites foster growth? Evidence from French firm census in 1830s

- Identify innovative sectors using UK patent data
- Show that these are a) strongly represented in Encyclopédie plates, and b) wage effects are stronger in innovative sectors
- Results hold even after controlling for sector and department FE

British Patents, Encyclopedia Plates, and Wages

- Share of inventive output (Nuvolari and Tartari, 2011)
 - ▶ Adjust patents for "quality" (citations) and industry-specific patenting frequency (from 1851 World Fair)
 - ▶ Period 1617-1841
- Use this measure to classify 'modern' and 'old' sectors ▶ List

Table: Modern vs. old sectors: Share of inventive output and encyclopedia plates

	(1)	(2)
	Share Invent. Output	Share Plates Encyclopedia
Modern	0.084	0.67
Old	0.016	0.33

Firm Productivity in Modern and Old Sectors

Evidence from 1839-47 firm census. Effect of *Subs.Density* particularly strong within modern industrial sectors.

Dep. Var.: log wages (by sector and arrondissement)

	(1)	(2)	(3)	(4)	(5)	(6)
<i>InSubDens</i>	0.041** (0.016)	0.040** (0.015)	0.031** (0.014)	0.025 (0.015)	0.012 (0.021)	
<i>InSubDens</i> × <i>modern</i>	0.069*** (0.015)	0.056*** (0.015)	0.052*** (0.017)	0.062*** (0.018)	0.066*** (0.019)	0.060*** (0.021)
School Rate 1837	0.248*** (0.071)	0.234*** (0.072)	0.242*** (0.072)	0.205*** (0.066)		
<i>School</i> × <i>modern</i>	-0.002 (0.069)	-0.015 (0.067)	-0.016 (0.072)	0.017 (0.082)	0.040 (0.087)	0.047 (0.094)
Establishment Size	0.055*** (0.008)	0.045*** (0.009)	0.043*** (0.010)	0.044*** (0.011)	0.044*** (0.010)	0.038*** (0.010)
<i>Size</i> × <i>modern</i>	-0.074*** (0.012)	-0.036*** (0.011)	-0.035*** (0.013)	-0.034** (0.015)	-0.039*** (0.015)	-0.034** (0.016)
Modern Sector	0.129*** (0.035)					
Sector FE		✓	✓	✓	✓	✓
Baseline Controls			✓	✓	✓	✓
Additional Controls				✓	✓	✓
Department FE					✓	(✓)
Arrondissement FE						✓
R ²	0.14	0.23	0.35	0.37	0.48	0.58
Observations	1,480	1,480	969	879	879	879

Size of effects:

- One-std increase in *Subs.Density* ⇒ modern (old) sector wages ↑ by 6% (2%)
- One-std increase in schooling ⇒ modern (old) sector wages ↑ 5% (4%)

Subscriber density and firm productivity within individual industries

Coefficient on *Subs.Density* strongest in modern sectors

Sector Name	(1)	(2)	(3)	(4) (5)	
	Sector type	Coefficient <i>Subs.Density</i>	R ² Obs.	Engines per 1,000 Steam	Water, Wind
Transportation Equipment	modern	0.114*** (0.026)	0.63 39	2	9
Printing Technology, and Scientific Instruments	modern	0.103*** (0.021)	0.20 221	1	26
Textile and Clothing	modern	0.067*** (0.018)	0.28 298	3	8
Furniture and Lighting	modern	0.056* (0.033)	0.54 75	13	1
Metal and Metal Products	old	0.042* (0.024)	0.16 273	6	34
Leather	old	0.041* (0.022)	0.19 165	3	46
Mining	old	0.038** (0.018)	0.31 188	3	15
Ceramics and Glass	old	0.003 (0.020)	0.27 168	4	5

Conclusion

- Role of human capital during first Industrial Revolution typically found to be minor \Rightarrow crucial driver of modern growth appears to be unrelated to the onset of growth itself

This paper:

- Distinction between average skills and ‘upper tail knowledge’
- Proxy for ‘upper tail’: Subscriptions to *Great Encyclopédie*
 - ▶ Strongly related to French industrialization (differential effect, only post-1750)
 - ▶ Literacy/schooling levels related to income in cross-section pre- and post-1750, but not to growth
- Important message for economic development: upper tail knowledge crucial, likely via affecting productivity/adoption of modern technology

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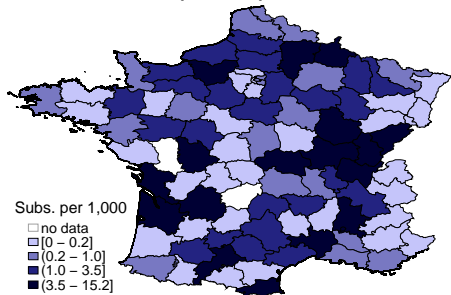
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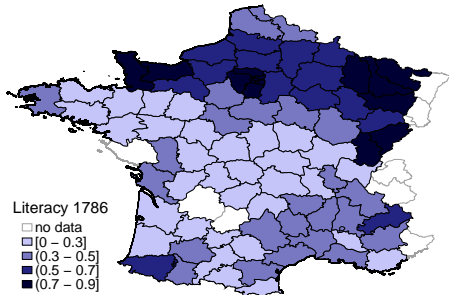
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Encyclopedia Subscriptions and Literacy (I)

Subscriptions per 1,000



Literacy in 1786

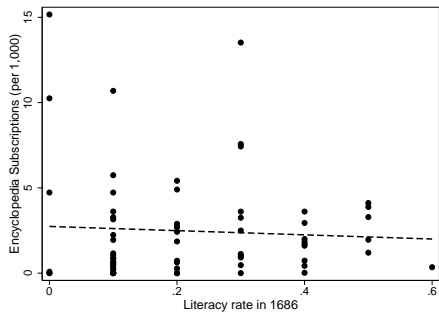


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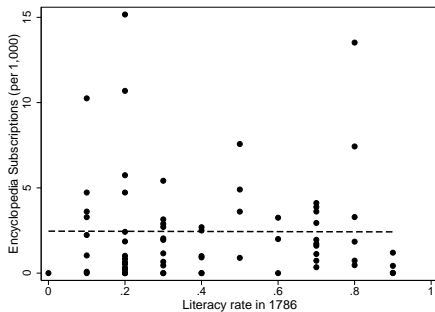
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Encyclopedia Subscriptions and Literacy (II)

Literacy in 1686



Literacy in 1786



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Upper Tail Human Capital – Detail

Aggregate knowledge (technology) frontier:

- Not bound to locations

Upper tail human capital (local knowledge elites) \Rightarrow shorter local distance to frontier

- Lower access costs to modern technology
 - ▶ Crucial for adoption of technology
 - ▶ Several dimensions:
 - ★ Scientific publications
 - ★ Scientific societies and ‘enlightened’ officials fostering spread of useful knowledge
 - ★ Networks of knowledge elites
- Inventions and improvements of existing technology

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Worker Skills: 3 Categories

1. Unskilled workers

- ▶ Miners and farm- or factory workers
- ▶ Typically illiterate

2. Skilled workers

- ▶ At least some skills, such as cutlers, glaziers, and tailors
- ▶ More likely to be literate (Nicholas and Nicholas, 1992; Mitch, 1993)

Rough approximation for 2. vs. 1: Literacy ("clear hierarchy of literacy rates by occupation" Mitch, 1993)

3. High-quality craftsmen

- ▶ Engineers, instrument makers, and mechanics
- ▶ Small elite at the top (<5%: de Pleijt and Weisdorf, 2014)
- ▶ France typically "imported" these 'tweakers and implementers'
- ▶ Within this group, Enlightenment deeply rooted: Meisenzahl and Mokyr (2012): sample of 759 'implementers', more than 1/2 were members in scientific societies and/or published scientifically

⇒ Proxy for the presence of enlightened elites probably also reflects at least some of the spatial variation in top-quality craftsmen.

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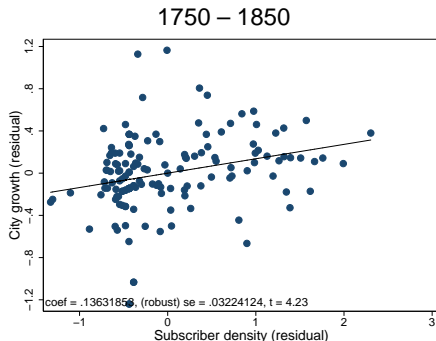
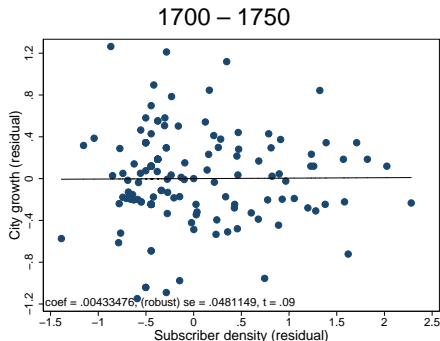
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Encyclopedia subscriptions and city population growth

– before and after 1750



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Elevation of Mechanical Arts

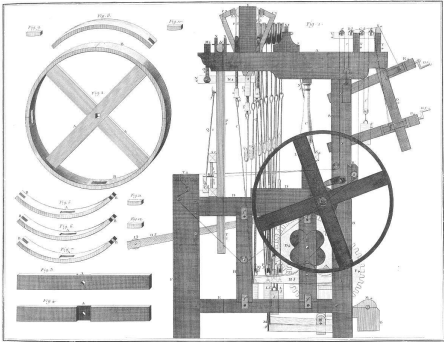
- *the advantage which the liberal arts have over the mechanical, because the former demands hard, intellectual work and requires difficulty to excel, is sufficiently compensated by the far greater usefulness the latter arts for the most part provide for us. But society, in justly respecting the great geniuses, which have enlightened it, need not on that account vilify the hands of those who serve it (Discourse Préliminaire, Vol 1)*
- *it is desirable that someone leaves the bosom of the Academies and goes down into the shops, collects material about the [mechanical] arts, exposes them in book that stimulates artisans to read, philosophers to think along useful lines, and authorities to finally make worthwhile use of their authority and their rewards (Art, Vol. 1: 717)*

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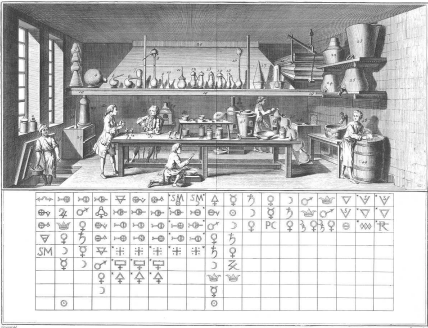
Plates

Ribbon Loom, Side Elevation



Métier à faire le Ruban, Mécanisme Latéral.

Chemistry: Laboratory and Table of Affinities



Laboratoire et table des Rapports

Data Source: The Encyclopedia of Diderot and d'Alembert: Collaborative Translation Project

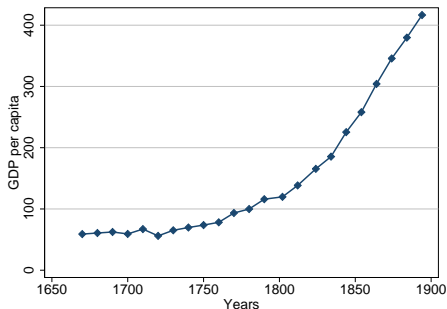
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Growth and Industrialization in France, 1700-1900

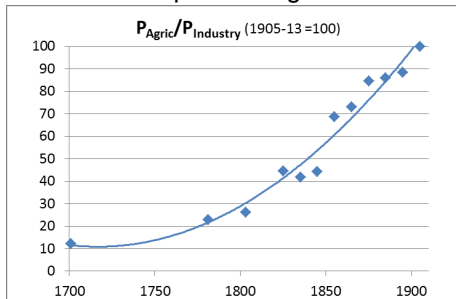
GDP per capita grows while the relative price of industrial goods falls

(Real) income per capita



Source: GDP and price deflators from Marczewski (1961). Population data from McEvedy and Jones (1978).

Relative price of Agriculture



Source: Marczewski (1961).

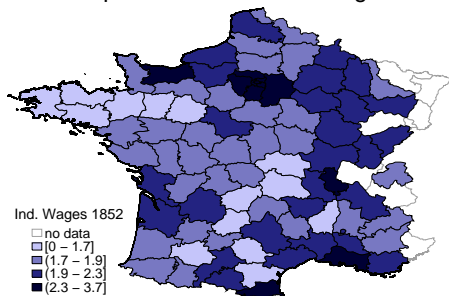
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Spatial Dispersion of Economic Activity in 19C France

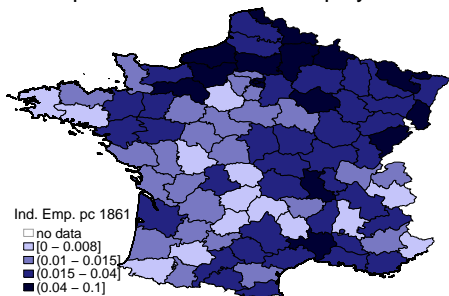
Departement-Level Data. Maps

Dispersion of Industrial Wages



Data Source: Goreaux (1956)

Dispersion of Industrial Employment



Data Source: Enquête Industrielle (1861)

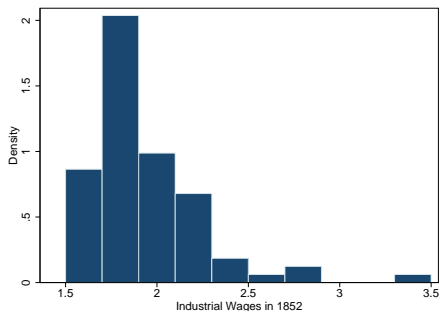
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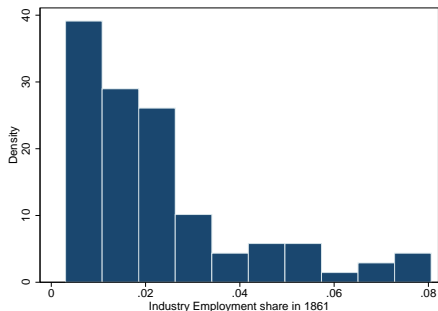
Departement-Level Data. Histograms

Dispersion of Industrial Wages



Data Source: Goreaux (1956)

Dispersion of Industrial Employment



Data Source: Enquête Industrielle (1861)

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More Detail on French Industrialization

- Period of revolutionary and Napoleonic wars: temporary slow-down, England pulls ahead
 - ▶ Wars not widely destructive for capital stock. Most damaging factor: Reduced trade due to British maritime blockade (Crouzet, 1964)
 - ▶ Also, communication with Britain (and migration of skilled workers) cut off ⇒ adoption of British innovation more difficult (Milward and Saul, 1973)
- After 1815, growth returns to English levels [▶ Table](#)
- Entrepreneurs and sectors (Verley, 1985):
 - ▶ In metallurgy: nobles and rich bourgeoisie. Then, introduction of "*dirigeants*"
 - ▶ Cotton industry: especially merchants, and some "ouvriers qualifiés"

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Industrialization in France and England (I)

- Timing the French 'take-off' is difficult, no dramatic breakthrough
 - ▶ "France seems somehow to have had an industrial revolution almost without its being noticed" (Berrill, 1964)
 - ▶ "France lacked not an industrial revolution, but a takeoff" (Roehl, 1976)
- Instead, steady growth starting in mid-18th century: "discontinuous upturn" (Marczewski, 1960)
- Family owned and small-scale firms
 - ▶ On average 9.6 workers per firm in 1865 (Verley, 1985)
 - ▶ 71 percent of the firms only family-employees in 1901 (Nye, 1987)
- However, no inefficiency or backwardness of French entrepreneurship:
 - ▶ "French firms suited the economic and technological conditions of the day... and would not have stood to gain much in efficiency simply by being larger" (Nye, 1987)

Industrialization in France and England (II)

Population and Output, 1700-1780

	<i>France</i>		<i>Britain</i>	
	<i>1700</i>	<i>1780</i>	<i>1700</i>	<i>1780</i>
Population (million)	19.2	25.6	6.9	9.0
Urban population (million)	3.3	5.7	1.2	2.2
Foreign trade (£ million)	9	22	13	23
Iron output (000 tons)	22	135	15	60
Cotton consumption (million lb.)	0.5	11	1.1	7.4
Agricultural output (1700=100)	100	155	100	126
Industrial output (1700=100)	100	454	100	197
Total production (1700=100)	100	169	100	167
Income/head (1700=100)	100	127	100	129

Source: W. W. Rostow, *How It All Began* (New York, 1975) in which the derivation and sources of data are discussed.

Access to Science and Modern Technology in 18-19C France

Flow of ideas from science to entrepreneurs through several channels

- Lectures and demonstrations by professional lecturers
 - ▶ *"...scientists were lecturing to the public about steam engines, and it became common to regard some scientific training as a natural prelude for entrepreneurial activity"* (Mokyr, 2005)
- Learned societies: More than 6,400 members (McClellan, 2003).
Masonic lodges: only 62 prior to 1759, more than 300 in 1780 (Jacob, 1991)
- "Entrepreneurs of Science": careers in building bridges between propositional and prescriptive knowledge: Rozier (agronome and scientific entrepreneur), Chaptal, etc. [▶ Chaptal](#)

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The Role of the State in Innovation and Technology Adoption

- Ancient Regime: State encouragement vs. entrepreneurs' skepticism
 - ▶ Bureau du Commerce (Adams, 1981), State subsidized importation of British workers, entrepreneurs and machinery (Jacob, 1998); Technology spies sent to England (McCloy, 1952).
 - ▶ However, French entrepreneurs held ambivalent attitudes toward government intervention (Hirsch, 1991) and French society as a whole not always receptive to modernity (Adams, 1981)
 - ▶ *"the battles for rational analysis had already been won in the minds of the scientists and bureaucrats. The battleground between tradition and reason was now in the minds of the employers and artisans."* (Parker, 1979)
- State encouragement continued after 1790s (Jacob, 1998):
 - ▶ Industrial exposition and prizes for best engineers. Introduction of machines in engineering schools.

Upper Tail Knowledge and Entrepreneurship

René Antoine Ferchault de Réaumur (1683-1757)

- Mathematician and physician, member of the *Académie des Sciences*
- Invented the Réaumur thermometer scale – freezing point of water at 0°
- Conducted several studies on insects. Founder of ethology.
- Elected Fellow in the Royal Society of London and member of the Royal Swedish Academy of Sciences
- Crucial discoveries in iron and steel; method of tinning iron. Several books and essays.
- Important contributor of the *Descriptions des Arts et Métiers*

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In iron production – diffusion of puddling:

- Puddling invented in 1784 in England. Crucial for producing high-grade bar iron
- Not introduced by majority of French iron producers: "*a typical ironmaster knew little or nothing about science... He was as ignorant of planning, routing, and economics as of metallurgy, and carried on his business in the manner of his fathers, with little knowledge of what went on outside his own district.*" (Dunham 1955, p.119)
- But some exceptions: "*the puddling process was brought successfully from England to France and introduced almost simultaneously at several widely separated establishments run by metallurgists of outstanding ability*" (Dunham, 1955, p.128)
 - ▶ In iron industry: tacit knowledge relatively important (as compared to codifiable knowledge) ⇒ need for British experts, brought in by well-informed entrepreneurs

In silk production:

- Silkworm extremely sensitive to cold, heat, and drafts
- Entrepreneur Camille Beauvais and distinguished chemist d'Arcet studied optimal conditions at the model silk farm of Senart.
- "Productivity of the worm was increased enormously" (Dunham, 1955)
- Findings advertised by scientific organizations, such as the *Société d'Encouragement pour l'Industrie Nationale*

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Model

A Stylized Model – Overview

- Two Sectors
 - ▶ Agriculture (Y_A)
 - ▶ Manufacturing composite (Y_M)
 - ▶ Linear utility
- Province n with population of mass L_n , land X_n
 - ▶ Region-specific average worker skills h_n
 - ▶ Entrepreneurs $i \in [0, 1]$, share s_n with ‘scientific knowledge’
- Technological frontier \bar{A} grows exogenously, first slowly and then more rapidly (Scientific Revolution)
- Highly skilled entrepreneurs profit more from growing \bar{A}

Production

Agriculture: (A)

- $Y_{A,n} = A_A h_n^{\beta_A} L_{A,n}^\alpha X_n^{1-\alpha}$
- wage = average product: $y_{A,n} = A_A h_n^{\beta_A} \left(\frac{x_n}{l_{A,n}} \right)^{1-\alpha}$
- x_n : land-labor ratio in agric. in region n , $l_{A,n}$: share of labor in agric.

Manufacturing composite:

- $Y_{M,n} = \xi \cdot \left(\int_0^1 A_{M,n}(i)^{1-\alpha} z(i)^\alpha di \right) \left(h_n^{\beta_M} L_{M,n} \right)^{1-\alpha}$
- Entrepreneur i produces intermediate $z(i)$, using one unit of final output per unit of $z(i)$
- Entrepreneur also has productivity $A_{M,n}(i)$ specific to i
- All intermediates sold at same price: $p(i) = 1/\alpha$

Production

Agriculture: (A)

- $Y_{A,n} = A_A h_n^{\beta_A} L_{A,n}^\alpha X_n^{1-\alpha}$
- wage = average product: $y_{A,n} = A_A h_n^{\beta_A} \left(\frac{x_n}{l_{A,n}} \right)^{1-\alpha}$
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Aggregate Manufacturing Output

The model simplifies to aggregate output and productivity:

$$Y_{M,n} = A_{M,n} h_n^{\beta_M} L_{M,n}$$

where $A_{M,n} = \int_0^1 A_{M,n}(i) di$

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The Evolution of Productivity

Manufacturing productivity process for individual entrepreneur i :

- $A_{M,n,t}(i) = \eta \bar{A}_t + (1 - \eta) A_{M,n,t-1} \left(1 + \tau(i) \cdot \gamma_{\bar{A},t} \right)$

where $\tau(i) = \begin{cases} 1, & \text{for highly skilled entrepreneurs (share } s_n) \\ 0, & \text{otherwise} \end{cases}$

$\gamma_{\bar{A},t}$: growth rate of technological frontier

The corresponding aggregate process for productivity is:

$$A_{M,n,t} = \eta \bar{A}_t + (1 - \eta) A_{M,n,t-1} \left(1 + s_n \cdot \gamma_{\bar{A},t} \right)$$

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The corresponding aggregate process for productivity is:

$$A_{M,n,t} = \eta \bar{A}_t + (1 - \eta) A_{M,n,t-1} \left(1 + s_n \cdot \gamma_{\bar{A},t} \right)$$

Solving the model is then straightforward

- wage rate in M: $w_{M,n} = (1 - \alpha)A_{M,n}h_n^{\beta_M}$
- ...must equal wage in agriculture
- assume that agricultural TFP evolves as:
$$A_{A,t} = \eta\bar{A}_t + (1 - \eta)A_{A,t-1}$$

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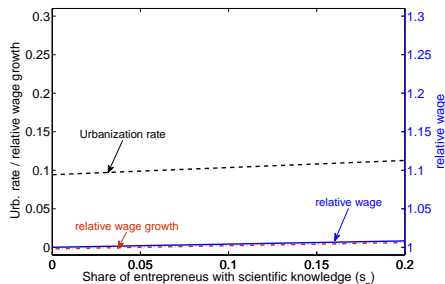
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Model Predictions – Upper Tail Knowledge

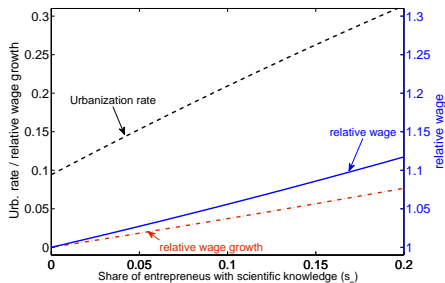
Prediction 1: *[pre-1750:] If the technological frontier expands slowly (low $\gamma_{\bar{A}}$), labor shares in manufacturing, wages, and economic growth are only weakly affected by local upper tail knowledge.*

Prediction 2: *[post-1750:] As the technological frontier expands more rapidly (high $\gamma_{\bar{A}}$), a larger local knowledge elite leads to higher wages, higher manufacturing employment, and faster economic growth.*

1700



1850



Note: Wages are normalized such that they equal 1 for regions without upper tail entrepreneurs ($s_n = 0$).

'Modern' and 'Old' Sectors

Table: Classification of individual industrial sectors into 'modern' and 'old'

Sector Name	(1) Innovation Index	(2) Sector Type
Textile and Clothing	0.145	modern
Printing Technology, and Scientific Instruments	0.094	modern
Furniture and Lighting	0.045	modern
Transportation Equipment	0.040	modern
Metal and Metal Products	0.039	old
Leather	0.018	old
Mining	0.017	old
Ceramics and Glass	0.012	old

Growth in France and England after 1815

Table: Population and Output, 1815-1860

	National Product		Industrial Product	
	Aggregate	Per Capita	Aggregate	Per Capita
France (1815-24 to 1845-54)	1.9	1.4	2.5	2.0
Great Britain (1811-21 to 1841-51)	2.7	1.3	3.7	2.3
France (1825-34 to 1855-64)	1.8	1.3	2.3	1.8
Great Britain (1821-31 to 1851-61)	2.1	0.9	2.3	1.1

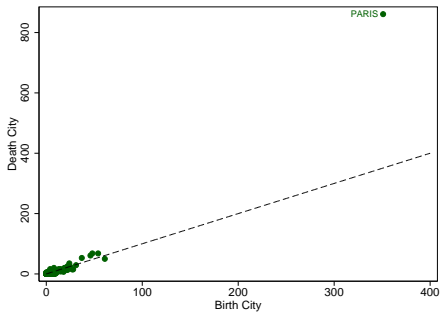
Source: Marczewski, 1965

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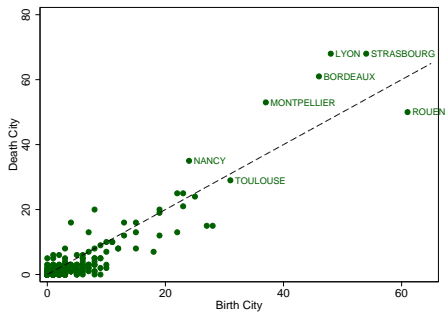
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Famous Scientists by Birth and Death City

All cities



Excluding Paris



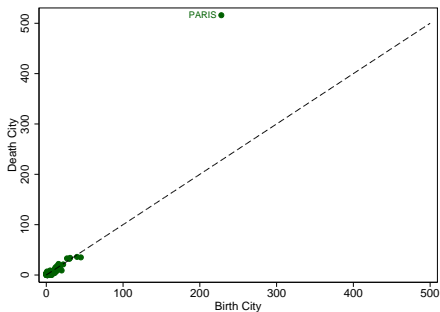
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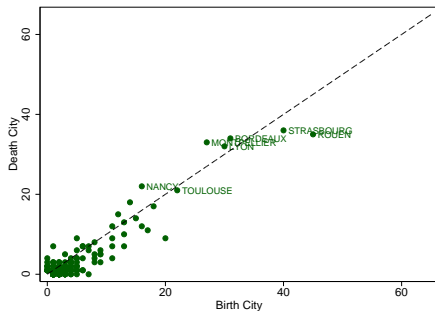
Famous Scientists by Birth and Death City

Only for scientists with known city of birth and city of death

All cities



Excluding Paris



52% (or 64% when excluding Paris) of scientists were born and died in the same city

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The Role of Initial City Size

Table: Subscriptions and control variables – descriptive statistics

	All cities				Cities with subs > 0 (Paris excl.)			
	(1) All	(2) Subs > 0	(3) No Subs	(4) t-test	(5) All	(6) Above median	(7) Below median	(8) t-test
Subscriptions per 1,000	1.73 (3.14)	3.94 (3.71)			3.97 (3.72)	6.81 (3.40)	1.27 (0.99)	10.26
Population in 1750	15 (42.57)	26.05 (62.52)	6.31 (3.05)	3.28	19.57 (18.68)	19.07 (21.45)	20.05 (15.85)	-0.24
Atlantic Port	0.06 (0.24)	0.08 (0.27)	0.05 (0.21)	1.03	0.08 (0.28)	0.07 (0.26)	0.09 (0.29)	-0.33
Mediterranean Port	0.03 (0.17)	0.04 (0.18)	0.03 (0.16)	0.3	0.04 (0.19)	0.02 (0.16)	0.05 (0.21)	-0.54
Navigable River	0.09 (0.28)	0.16 (0.37)	0.03 (0.16)	3.41	0.15 (0.36)	0.12 (0.33)	0.19 (0.39)	-0.81
University	0.11 (0.32)	0.25 (0.43)	0.01 (0.10)	5.53	0.24 (0.43)	0.34 (0.48)	0.14 (0.35)	2.21
Printing Press	0.18 (0.39)	0.33 (0.47)	0.06 (0.25)	5.01	0.32 (0.47)	0.39 (0.49)	0.26 (0.44)	1.32
ln(Books Printed 1500)	0.48 (1.31)	0.87 (1.74)	0.17 (0.7)	3.82	0.78 (1.55)	0.93 (1.62)	0.64 (1.49)	0.87
Literacy 1786	0.43 (0.25)	0.46 (0.25)	0.39 (0.25)	1.73	0.45 (0.25)	0.42 (0.24)	0.49 (0.25)	-1.32

Subscriptions by terciles

Table: Dep. Var.: $\ln(\text{City Growth})$

	(1)	(2)
$I_{\text{Subs}=0}$	0.414*** (0.091)	0.468*** (0.105)
$I_{\text{Subs}>0, \text{belowmedian}}$	0.635*** (0.114)	0.711*** (0.132)
$I_{\text{Subs}>0, \text{abovemedian}}$	0.792*** (0.134)	0.855*** (0.147)
Baseline Controls	✓	✓
Early Knowledge Controls		✓
R ²	0.73	0.73
Observations	193	193
P-values, test of difference in coefficients		
$I_{\text{Subs}=0} = I_{\text{Subs}>0, \text{b.m.}}$	[0.002]	[0.001]
$I_{\text{Subs}>0, \text{b.m.}} = I_{\text{Subs}>0, \text{a.m.}}$	[0.025]	[0.026]

Only cities with subscriptions > 0

Table: Dep. Var.: ln(City Growth), Only cities with subs > 0

	(1)	(2)	(3)	(4) [unweighted]	(5) 1700-1750
<i>SubsDensity</i>	0.090 (0.063)	0.135*** (0.051)	0.117** (0.045)	0.086* (0.044)	-0.069 (0.053)
<i>lnPop_{initial}</i>	0.051** (0.022)	-0.119*** (0.043)	-0.150*** (0.053)	-0.199*** (0.056)	-0.071 (0.043)
Atlantic Port		0.176* (0.099)	0.214* (0.120)	0.219 (0.192)	0.157* (0.093)
Mediterranean Port		0.845*** (0.082)	0.883*** (0.093)	0.920*** (0.065)	-0.284*** (0.094)
Navigable River		0.123 (0.084)	0.089 (0.090)	0.068 (0.088)	-0.064 (0.079)
Paris		0.614*** (0.143)	0.574*** (0.145)	0.657*** (0.168)	-0.059 (0.158)
Non French Speaking		0.257** (0.113)	0.184 (0.118)	0.079 (0.124)	0.041 (0.162)
University			-0.011 (0.073)	-0.064 (0.079)	0.087 (0.080)
Printing Press in 1500			-0.023 (0.106)	0.077 (0.112)	-0.091 (0.102)
ln(Books Printed 1500)			0.026 (0.022)	0.034 (0.024)	0.040* (0.022)
R ²	0.08	0.46	0.48	0.38	0.32
Observations	85	85	85	85	76
Magnitude: growth differential for cities from 0 to 75 percentile of <i>Subs.Density</i> (for subs > 0)					
	0.167*** (0.156)	0.255** (0.010)	0.221** (0.012)	0.161* (0.058)	-0.127 (0.204)

Cities with available data for the pre-1750 period

Table: Dep. Var.: $\ln(\text{City Growth})$

	(1)	(2)	(3)	(4)
Data on city size in	1700	1600	1500	1400
Panel A				
<i>Subs.Density</i>	0.154*** (0.036)	0.139*** (0.042)	0.157*** (0.037)	0.193*** (0.052)
Controls	✓	✓	✓	✓
R ²	0.39	0.57	0.55	0.57
Observations	148	58	62	50
Panel B				
<i>ScientSocMembDens</i>	0.269*** (0.071)	0.215*** (0.075)	0.202** (0.082)	0.242* (0.122)
Controls	✓	✓	✓	✓
R ²	0.36	0.53	0.49	0.48
Observations	148	58	62	50

Alternative subs density:

$$\text{Subs.Density}_n = \text{Subs}_n / \text{pop}_n^{1750}$$

Table: Dep. Var.: ln(City Growth)

	(1)	(2)	(3)	(4) [unweighted]	(5) 1700-1750
<i>SubDens</i>	0.021** (0.009)	0.040*** (0.009)	0.040*** (0.008)	0.048*** (0.008)	0.002 (0.009)
Baseline Controls		✓	✓	✓	✓
Early Knowledge Controls			✓	✓	✓
R ²	0.10	0.35	0.35	0.26	0.17
Observations	193	193	193	193	148
Magnitude: growth differential for cities from 0 to 75 percentile of <i>Subs.Density</i>					
	0.118** (0.026)	0.227*** (0.000)	0.226*** (0.000)	0.272*** (0.000)	0.008 (0.865)

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Alternative subs density:

$$\text{Subs.Density}_n = \text{Subs}_n / \text{pop}_n^{1750}$$

Table: Dep. Var.: ln(City Growth), Only cities with subs>0

	(1)	(2)	(3)	(4)	(5)
				[unweighted]	1700-1750
<i>SubsDensity</i>	0.016 (0.012)	0.032*** (0.010)	0.028*** (0.009)	0.022** (0.009)	-0.008 (0.011)
<i>lnPop_{initial}</i>	0.047** (0.020)	-0.132*** (0.045)	-0.158*** (0.058)	-0.192*** (0.058)	-0.064 (0.043)
Atlantic Port		0.203** (0.100)	0.233* (0.118)	0.228 (0.192)	0.149 (0.097)
Mediterranean Port		0.892*** (0.085)	0.920*** (0.103)	0.937*** (0.063)	-0.309*** (0.093)
Navigable River		0.133 (0.085)	0.102 (0.090)	0.075 (0.087)	-0.062 (0.079)
Paris		0.655*** (0.146)	0.614*** (0.141)	0.657*** (0.162)	-0.017 (0.155)
Non French Speaking		0.233** (0.103)	0.171 (0.108)	0.079 (0.118)	0.098 (0.150)
University			-0.008 (0.075)	-0.073 (0.080)	0.074 (0.076)
Printing Press in 1500			-0.021 (0.104)	0.073 (0.112)	-0.082 (0.101)
ln(Books Printed 1500)			0.023 (0.021)	0.032 (0.023)	0.034 (0.022)
R ²	0.06	0.47	0.48	0.39	0.30
Observations	85	85	85	85	76
Magnitude: growth differential for cities from 0 to 75 percentile of <i>Subs.Density</i> (for subs>0)					
	0.089	0.179***	0.157***	0.124**	-0.043

City growth and literacy in the pre-1750 period

Table: Dep. Var.: $\ln(\text{City Growth})$ over the indicated period

	(1)	(2)	(3)	(4)	(5)	(6)
	1700-1750			1600-1700		
<i>Subs.Density</i>		0.021 (0.028)	0.004 (0.039)		0.024 (0.117)	0.080 (0.118)
Literacy 1686	0.334* (0.197)	0.358* (0.192)	0.327* (0.190)	-0.408 (0.397)	-0.362 (0.376)	-0.430 (0.413)
<i>lnPop_{initial}</i>	-0.018 (0.014)	-0.018 (0.014)	-0.043 (0.052)	0.118** (0.049)	0.121** (0.053)	-0.306 (0.183)
Baseline Controls			✓			✓
R ²	0.04	0.05	0.22	0.09	0.09	0.57
Observations	126	126	126	56	50	50

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Soldiers height before 1750

Table: Dep. var.: Soldiers height in cm (controlling for age and birth decade)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
							Weighted	
Literacy 1686	1.166** (0.539)		1.043* (0.525)	1.126** (0.557)		0.982* (0.549)	1.007** (0.433)	0.989** (0.441)
<i>InSubDens</i>		0.065 (0.107)	0.116 (0.115)		0.073 (0.108)	0.120 (0.116)	0.049 (0.112)	0.062 (0.111)
Baseline Controls				✓	✓	✓		✓
R ²	0.05	0.00	0.06	0.14	0.09	0.16	0.08	0.13
Observations	76	84	74	76	84	74	75	75

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Conscript Height 1819-1826

Soldier height as a proxy for income (at the department level)

Table: Dep. var.: Soldiers height in cm (controlling for age and birth decade)

	(1)	(2)	(3)	(4)
<i>SubDens</i>	0.092*** (0.031)	0.103*** (0.029)	0.069** (0.033)	0.084*** (0.031)
Literacy 1786	2.890*** (0.392)	3.156*** (0.350)		
Change in literacy 1686-1786			2.949*** (1.035)	3.999*** (0.813)
Literacy 1686			2.031** (0.882)	1.895** (0.850)
Height pre-1750			0.404* (0.217)	0.193 (0.158)
Baseline Controls		✓		✓
R ²	0.41	0.59	0.47	0.63
Observations	77	77	74	74

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Controlling for the effect of age and birth decade on soldier height, 1660-1740

Table: Dependent variable: Soldiers height in cm

Age	0.440*** (0.021)
Age ²	-0.006*** (0.000)
Birth Decade Dummy	Yes
R ²	0.07
Observations	29292

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Pre-Industrial Centers

Table: Pre-industrial centers and the two measures for human capital

	(1)	(2)	(3)
Dependent variable:	Pre-Industrial Density	Index	ln(Pre-Ind. Index)
<i>Subs.Density</i>	0.069 (0.201)	0.114 (0.209)	-0.006 (0.012)
Literacy 1686	2.914* (1.463)	2.834* (1.582)	0.116 (0.098)
Baseline Controls		✓	✓
R ²	0.06	0.12	0.07
Observations	75	75	73

Robustness check

Table: Subscriber density and firm wages in 1837

	(1)	(2)	(3)	(4)	(5)	(6)
					no log	
<i>SubsDensity</i>	0.021 (0.027)				0.007 (0.004)	-0.027 (0.019)
<i>SubsDensity</i> × <i>Modern</i>	0.060** (0.027)	0.028 (0.030)			0.018*** (0.005)	0.012** (0.006)
<i>I</i> _{Subs>0}	0.040 (0.049)		0.047* (0.028)			
<i>I</i> _{Subs>0} × <i>Modern</i>	0.017 (0.047)	0.070 (0.067)	0.109*** (0.026)	0.117*** (0.042)		
School Rate 1837	0.247*** (0.070)		0.264*** (0.069)		0.230** (0.100)	
<i>School</i> × <i>Modern</i>	-0.002 (0.069)	0.045 (0.097)	0.004 (0.066)	0.033 (0.095)	-0.042 (0.100)	0.130 (0.108)
Establishment Size	0.055*** (0.008)	0.039*** (0.010)	0.055*** (0.008)	0.038*** (0.010)	0.048*** (0.011)	0.030*** (0.010)
<i>Size</i> × <i>Modern</i>	-0.074*** (0.012)	-0.035** (0.016)	-0.078*** (0.012)	-0.034** (0.016)	-0.067*** (0.014)	-0.018 (0.017)
Modern Sector	0.129*** (0.036)		0.136*** (0.036)		0.147** (0.059)	
Sector FE		✓		✓		✓
Baseline Controls		✓		✓		✓
Additional Controls		✓		✓		✓
Department FE		(✓)		(✓)		(✓)
Arrondissement FE		✓		✓		✓
R ²	0.14	0.58	0.13	0.58	0.11	0.59