Seeds of Knowledge: Premodern Scholarship, Academic Fields, and European Growth

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Context

- Human capital an engine of modern economic growth
- What about pre-modern academia?
- RETE: new data on European Academia 1000–1800

$\rightarrow$ Was pre-modern academia complementary with economic growth?

Contribution

- New way to measure and classify knowledge in the past
- Scholarship associated with higher GDP per capita in 1900
- Academics in general positive, but science and botany particularly
- Find evidence that suggests a role model mechanism

Literature

Growth, knowledge, and human capital

- Big picture (Cervellati and Sunde 2005; Mokyr, 2002; Mokyr, 2016; Galor 2022; Strulik 2014)
- By field: Science (Wooton, 2015), Institutions (Mitterauer, 2010), Theology (Henrich, 2020; Weber, 1930), Law (Cantoni et al., 2014), Medicine (Hill, 1915).

Measuring knowledge

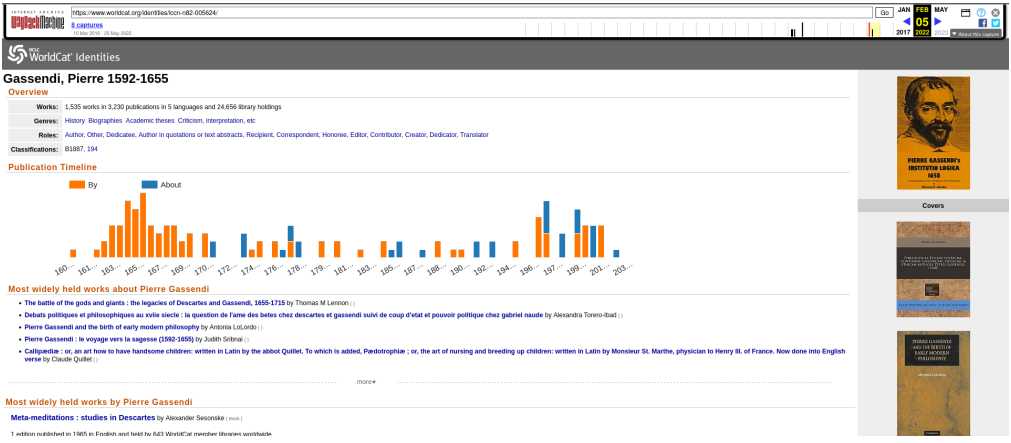
- Texts (Almelhem et al. 2023; Grajzl et al, 2023; Johnson et al., 2023; Li et al. 2023)
- Biographies: Courson et al. (2023)

RETE

Large sample of scholars working in academia in premodern Europe

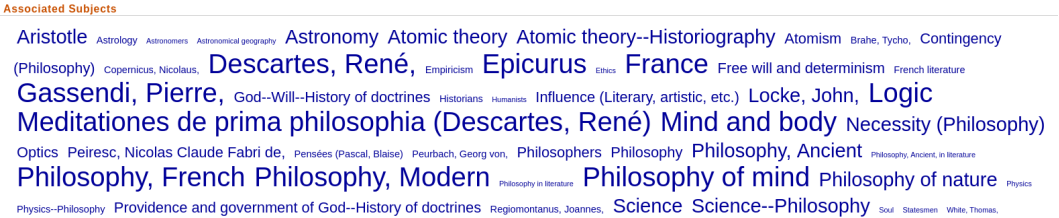
- European scope (from Evora to)
- Longue durée (1000-1800)
- Teachers, not students
- 60,001 scholars
- Appointed to universities or nominated to academies
- 535 secondary sources
- Manually linked to WorldCat

WorldCat Identities



- Discontinued in March 2023
- Provided data on productivity of scholar

WorldCat Identities



- Cloud of topics (mapping titles of works into FAST (Faceted Application of Subject Terminology) topics)
- Relative size, relative importance
- Exact methodology unclear
- 17,343 academics have topics

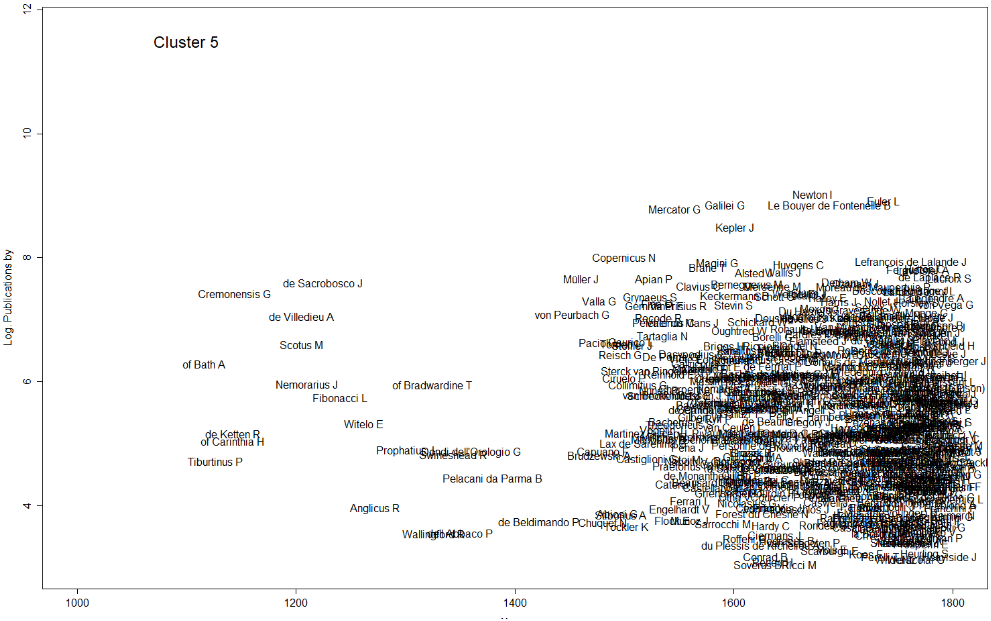
k-means clustering

Group scholars into academic fields (clusters) using their topics

- $1,360$-dimension space, one axis per topic
- Each scholar is a point in the space
- Pick k centroids and assign each scholar to a centroid
- Compute the TWSS: total within-cluster sum of squares
- No closed-form solution, use numerical algorithm
- Optimal k: minimize $BIC = TWSS_k + \log(I)Jk$

Clusters of WorldCat Topics

Cluster Field	N. Scholars	Top 3 Names	Median N. Publ.	Earliest Year	Median Year
Theology 1	1581	Aquinas, Bossuet, Pascal	143	975	1615
Theology 2	940	Luther, Melanchthon, Wesley	315	1039	1671
Politics	990	Swift, Machiavelli, Corneille	184	1043	1756
Law	727	Stryk, Bentham, Bohmer	156	1090	1593
Science	661	Newton, Euler, Galilei	177	1116	1714
Classics	7317	Schiller, Erasmus, Pope	54	970	1712
Philosophy	653	Rousseau, Kant, Diderot	258	980	1700
Botany	543	Linnaeus, Bernardin, Trew	189	1176	1753
Culture	1086	Arouet, Humboldt, Homman	211	1140	1749
Medicine	1651	Haller, Hohenheim, Gessner	125	1025	1698


Cluster 5
Log. Publications by
Newton I
Euler L
Mercator G
Galilei G
Le Bouyer de Fontenelle B
Kepler J
Copernicus N
Magini G
Huygens C
Lefrançois de Lalande J
Müller J
Apian P
Alsted J
de Sacrobosco J
Cremonensis G
Valla G
Stevin S
Keckermann B
von Peurbach G
de Villedieu A
Tartaglia N
Scotus M
Reisch G
of Bath A
Nemorarius J
of Bradwardine T
Fibonacci L
Witelo E
de Beaune F
de Ketten R
of Carinthia H
Prophatius J
Dondi dell'Orologio G
Swineshead R
Tiburtinus P
Pelacani da Parma B
Anglicus R
Engelhardt V
de Beldimando P
Wallingford R
Sarrocchi M
Hardy C
Ricci M
1000
1200
1400
1600
1800
12
10
8
6
4

Measurement

How do we aggregate scholarly output?

- Aggregate by birth NUTS2 region
- Number of publications (includes new editions and translations)
- $pubs^{1/4}$: Luther would be worth 18 obscure Theologians (Results are robust to weighting)

Measuring regional development in 1900: GDP per capita from Rosés-Wolf database on regional GDP (2023)

- Methodology based on Geary and Stark (2002)
- Combine national GDP and value added by sector with regional wages by sector
- Key assumption is that wages are good proxy for productivity

Measuring regional development in 1800

Proxy with urbanization

- Urban populations from Buringh (2021)
- Area of NUTS2 region
- Ruggedness from Nunn and Puga (2012)

Regression

We estimate the following regression model:

$$y_{r,s} = \alpha_0 + \alpha_1 log(n_{r,s}) + \sum_{c=1}^{10} \beta_c share_{r,s}^c + \beta X_{r,s} + \phi_s + \epsilon_{r,s}$$

- $y_{r,s}$ is the GDP per capita in 1800
- $n_{r,s}$ is the weighted sum of output of scholars born in r
- $share_{r,s}^c$ is the share of $n_{r,s}$ that belong to field c
- ϕ_s is a country fixed effect
- $X_{r,s}$ are controls: log total urban population in 1800, log ruggedness, log area.

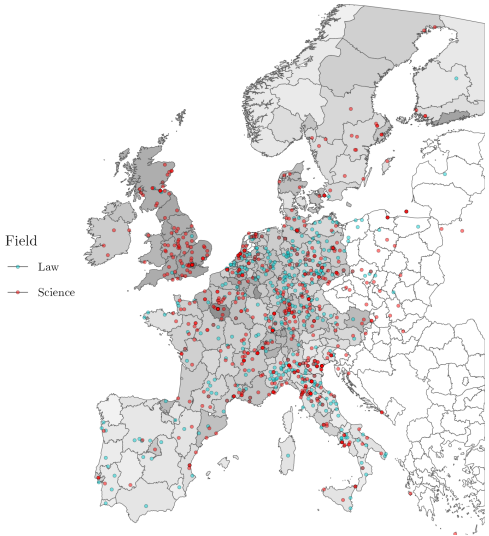
	log GDP per capita, 1900				2015
	(1)	(2)	(3)	(4)	(5)
$\log(n_{r,s})$	0.14***	0.10***	0.10***	0.09***	0.07***
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Share Theology 1			0.08	-0.08	-0.13
			(0.26)	(0.21)	(0.10)
Share Theology 2			0.85*	-0.10	-0.29
			(0.44)	(0.43)	(0.21)
Share Politics			0.32	0.01	-0.05
			(0.33)	(0.23)	(0.15)
Share Law			-0.78**	-0.31*	0.00
			(0.35)	(0.19)	(0.16)
Share Science			1.07***	0.81**	-0.11
			(0.34)	(0.39)	(0.18)
Share Philosophy			-0.05	-0.07	-0.13
			(0.19)	(0.16)	(0.13)
Share Botany			0.78***	0.56**	0.13
			(0.26)	(0.23)	(0.18)
Share Culture			0.03	-0.16	-0.07
			(0.23)	(0.20)	(0.14)
Share Medicine			-0.15	-0.56	-0.03
			(0.39)	(0.41)	(0.24)
N	172	172	172	172	221
Country FE		X		X	X

Every column controls for log urban pop in 1800, log area, and log ruggedness.

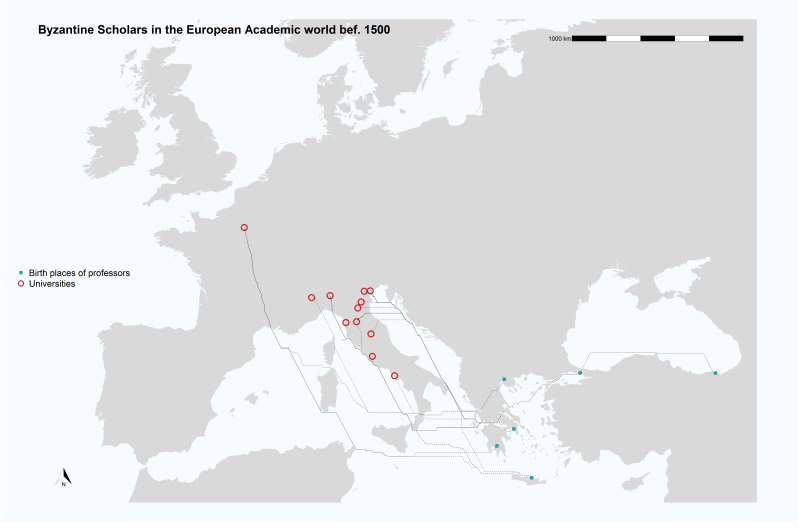
Interpreting results

- Baseline: Weighted output of scholars +10% associated w. +1.4% GDP pc
- Adding control and shares reduces magnitude, but always significant
- Interpretation: all scholarship good for growth
- Law and Theology 2 correlated with national factors (legal origins, Weber hypothesis)
- Science and Botany particularly important for regional development
- +10*pp* compared to Classics:
  - Science associated w. +8.1% GDP pc
  - Botany associated w. +5.6% GDP pc

Science and law across place



Exploiting mobility to build an instrumental strategy?



Byzantine Greek refugees as an instrument for total scholarly output

	log GDP per capita, 1900		$\log(n_{r,s})$
	OLS	IV	1st-stage
$\log(n_{r,s})$	0.11***	0.18***	
	(0.03)	(0.05)	
1+ Byzantine scholars			1.68***
			(0.36)
N	172	172	172
Country FE	X	X	X
IV F-stat.		29.52	

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Robust standard errors in parentheses. The unit of observation is a NUTS2 region.

Suggested mechanism: Important scholars inspire locals to accumulate human capital

Find groups less likely to inspire:

- Death place was in a foreign country
- Death place of different denomination (post-1555)
- Death place different than birth place
- Died before age 40

Regression

We estimate the following regression model:

$$y_{r,s} = \alpha_0 + \alpha_1 \log(n_{r,s,i}) + \log(n_{r,s,!i}) + \phi_s + \beta X_{r,s} + \varepsilon_{r,s}$$

- $y_{r,s}$ is the GDP per capita in 1800
- $n_{r,s,i}$ is the weighted sum of output of scholars in the group i
- $n_{r,s,!i}$ is the weighted sum of output of scholars **not** in i
- ϕ_s is a country fixed effect
- $X_{r,s}$ are controls: log total urban population in 1800, log ruggedness, log area.

	log GDP per capita, 1900				
	(1)	(2)	(3)	(4)	(5)
$\log(n_{r,s,i})$, all scholars	0.10***				
	(0.03)				
$\log(n_{r,s,i})$,					
died in other country		0.01			
		(0.02)			
died in same country		0.09***			
		(0.03)			
émigré			-0.01		
			(0.03)		
not émigré			0.11***		
			(0.03)		
died in other place				0.04	
				(0.04)	
died in same place				0.05**	
				(0.02)	
died before age 40					-0.00
					(0.02)
died after age 40					0.10**
					(0.04)
N	172	172	172	172	172
Country FE	X	X	X	X	X
Every column controls for log urban pop in 1800, log area, and log ruggedness.					

Example: Fermat

Born in Beamont-de-Lomagne in 1605
Member of the informal academy of Mersenne in Paris (1636)

- Working life spent in Toulouse at the Parliament
- Beamont-de-Lomagne's pop. in 2020: 3,778
- It has a statue of him, street named after him, a tourism office in his house, and the yearly *fête des maths*

Inspiration mechanism: model

$$
\begin{aligned}
U &= \int_0^\infty u(C)\exp(-\rho t)\mathrm{d}t && \textbf{Utility}\\
Y &= AK^\alpha H^{1-\alpha} && \textbf{Production}\\
Y &= C + I_K + I_H && \textbf{Resource constraint}\\
\dot{K} &= I_K - \delta_K K && \textbf{Capital accumulation}\\
\dot{H} &= I_H - \bar{\delta}_H H && \textbf{Human capital accumulation}\\
\bar{\delta}_H &= \delta_H \left(\frac{S}{H}\right)^{-\eta} && \textbf{Depreciation of human capital}\\
\dot{S} &= I_H - \delta_S S && \textbf{Inspiration}
\end{aligned}
$$

Short-run:

$$Y = AK^\alpha \left(K\, g\left[\frac{S}{H}\right]\right)^{1-\alpha} = AK\left(g\left[\frac{S}{H}\right]\right)^{1-\alpha}$$

Along a balanced growth path:

$$\frac{S}{H} = \left(\frac{\delta_H}{\delta_S}\right)^{\frac{1}{1+\eta}}$$

Conclusion

- New data on premodern academics grouped into academic fields
- Premodern European scholarship associated economic development
- All scholarship positive, but science and botany more important
- Evidence for an inspiration mechanism