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

Matthew Curtis[1] David de la Croix[2,3]

[1]Syddansk Universitet, [2]IRES/LIDAM, UCLouvain, [3]CEPR, Paris

February 2025

Context

- Human capital an engine of modern economic growth
- What about pre-modern human capital?
- RETE: new data on European Academia 1000–1800
- these data cover upper tail human capital involved in universities and academies ($\equiv$ "academia")
- propositional knowledge, and some knowledge-how

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

$\rightarrow$ Some fields in particular? **how to measure fields?**

Academic institutions

Universities: emergence during the Middle Ages.
Teach Arts (incl. sciences), Theology, Law, Medicine

▸ illustration ▸ map of universities ▸ birth places

Academies: informal clubs becoming formal institutions after 1650.
Mostly arts & sciences + applied (e.g. mechanics, navigation, cartography) –
Meetings, publications, letters, prizes

▸ illustration ▸ map of academies ▸ birth places

Contribution

- New way to measure and classify knowledge in the past
- Scholarship associated with higher regional 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; Galor 2022; Strulik 2014)
- Upper tail human capital (Squicciarini and Voigtlaender, 2015; Mokyr, 2016)
- By field: Science (Wootton, 2015), Institutions (Mitterauer, 2010), Theology (Henrich, 2020; Schultz et al, 2019; Weber, 1930), Law (Cantoni et al., 2014), Medicine (Hill, 1915).

Measuring knowledge

- Texts (Almelhem et al. 2023; Grajzl et al, 2023; Koschnick, 2023; Johnson and Taylor, 2023)
- Biographies (Courson et al. 2023; Borowiecki et al., 2024)

RETE

Large sample of scholars working in academia in premodern Europe

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

Assigning fields based on sources

For professors we often know in which faculty they belonged (Arts, Law, Medicine, Theology)
For academicians, field can be inferred from biographies

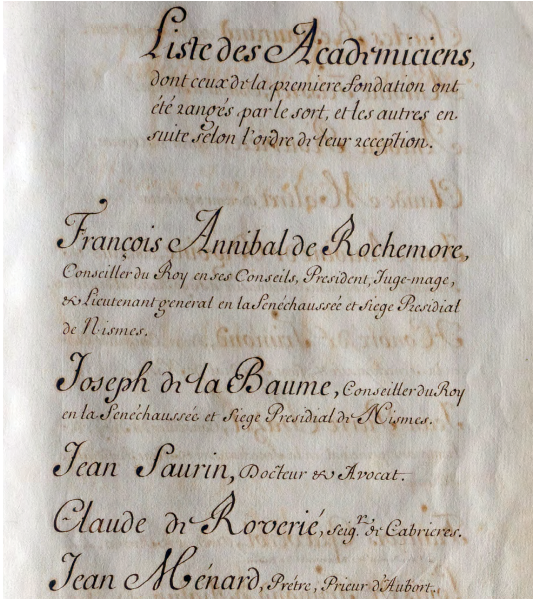
Difficulties:

- Optimal number of fields? Which degree of precision ? (ex. should be distinguish Canon law vs Civil law, vs French law)
- In many cases, hard to assign a field: many fellows in Oxford hold a D.D. (Doctor of Divinity) but may have pursued teaching and research in other fields, see "Early Science in Oxford - Oxford Colleges and their Men of Sciences" (Gunther 1937)

Example of primary source

Register of the Royal Academy of Nimes (France) established by patent letters issued by his Majesty in August 1682

"The 'juge-mage,' from the Latin 'judex major', is an ancient legal function
"Prieur" refers to a person who is the head of a priory, a small monastery.


Liste des Académiciens,
dont ceux de la premiere fondation ont
été rangés par le sort, et les autres en-
suite selon l'ordre de leur reception.

François Annibal de Rochemore,
Conseiller du Roy en ses Conseils, President, Juge-mage,
& Lieutenant general en la Sénéchaussée et Siege Presidial
de Nismes.

Joseph de la Baume, Conseiller du Roy
en la Sénéchaussée et Siege Presidial de Nismes.

Jean Saurin, Docteur & Avocat.

Claude de Roverié, Seig.r de Cabrieres.

Jean Ménard, Prêtre, Prieur d'Aubord.

Example of secondary source

Series professorum qui in academia rheno-traiectina publice aut docuerunt aut etiamnunc docent (1861)

(The series of professors who have either taught or are currently teaching at the University of Utrecht)

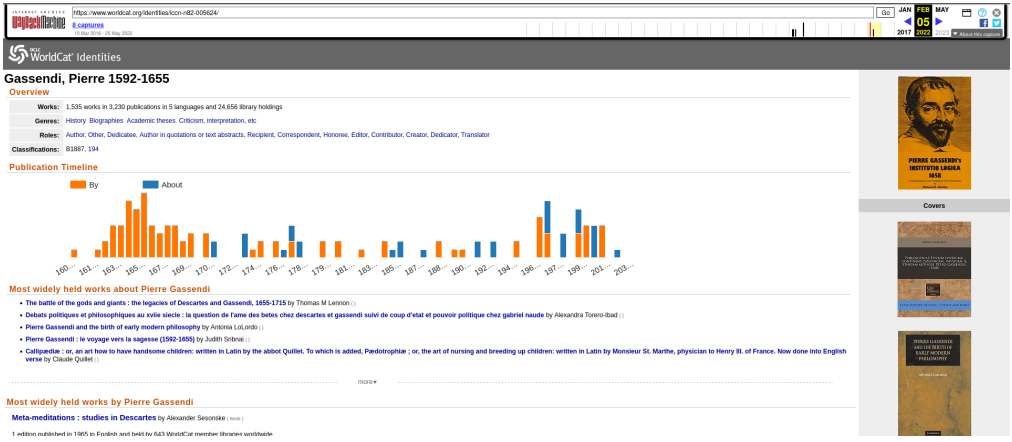
Matheseos: of Mathematics
Iuris: law

55. Hermannus Alexander Roëll, *Marco-Westphalus*, nat. a. 1653. Ex academia Franequerana evocatus, Prof. *Theologiae* d. 22 Sept. 1704. Ob. d. 12 Iulii 1718. *
56. Iosephus Serrurier, *Amstelaedamensis*, Prof. *Philosophiae et Matheseos* d. 3 Febr. 1706, *Medicinae et Botanices* d. 18 Maii 1716, *Institutionum Medicarum* d. 7 Iunii 1723. Ob. d. 15 April. 1742. *
57. Iohannes Iacobus Vitriarius, *Genevensis*, nat. a. 1679. Ex academia Heidelbergensi huc evocatus, *Iuris civilis et publici* Prof. d. 17 Sept. 1708. In academiam Lugduno-Batavam profectus exeunte a. 1719. Obiit d. 11 Dec. 1745. *
58. Hieronymus van Alphen, *Hanoviensis*, nat. d. 12 Maii 1665. In ecclesia Amstelaedamensi Euangelii interpres, huc evocatus, Prof. *Theologiae* d. 26 Febr. 1715. Ob. d. 7 Nov. 1742. *
59. Franciscus Burmannus, Franc. F. *Rheno-Traiectinus*, nat. d. 15 Maii 1671. In ecclesia Amstelaedamensi Euangelii interpres, huc evocatus, Prof. *Theologiae* d. 26 Febr. 1715. Ob. d. 22 Sept. 1719. *
60. Arnoldus Drakenborch, *Rheno-Traiectinus*, nat. d. 31 Dec. 1684. *Historiarum et Eloquentiae* Prof. d. 25 Maii 1716. Ob. d. 16 Ian. 1748. *

Example scholar: Pierre Gassendi (1592–1655)

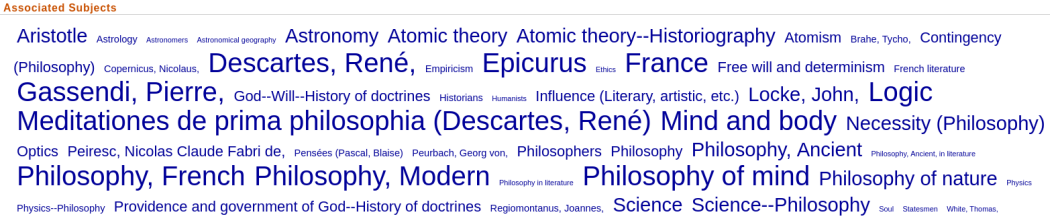
- Doctor in theology, Philosopher, priest, astronomer, and mathematician.
- University of Aix-en-Provence (course on Aristotelian philosophy), Collège Royal in Paris (course on Mathematics), + two informal academies (Investiganti, Mersenne)
- Key figure of Scientific Revolution: he redefined the goal of empirical science as determining probable, rather than certain, results (Applebaum, 2003)
- "The precise place of Gassendi in the history of early modern philosophy and science is only partly articulated by recent scholarship" — Stanford Plato

WorldCat Identities



- Discontinued in March 2023
- Provided data on productivity of scholar and data on "topics"

WorldCat Identities



- Cloud of topics: mapping titles of works into FAST (Faceted Application of Subject Terminology) topics
- Relative size, relative importance
- Exact methodology unclear (translations?)
- 17,343 academics have topics
- after dropping topics with fewer than 30 scholars, 16,149 scholars have at least one remaining topic "Mind and Body" concerns 100 scholars

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 (centre point of field k)
- 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

▸ topics ▸ clusters over time

Mapping between Clusters of WorldCat Topics and Fields from sources

	Field from source							
Cluster	Theology	Law	Humanities	Medicine	Sciences	Applied Sc.	Social Sc.	unknown
Theology 1	**45%**	13%	33%	2%	4%	0%	0%	3%
Theology 2	**53%**	3%	39%	2%	3%	0%	0%	1%
Politics	11%	27%	**39%**	6%	8%	3%	**5%**	3%
Law	3%	**83%**	11%	1%	1%	0%	0%	1%
Science	4%	1%	18%	5%	**68%**	3%	1%	1%
Classics	16%	14%	**40%**	11%	13%	3%	1%	3%
Philosophy	16%	5%	**59%**	4%	13%	0%	1%	1%
Botany	3%	0%	10%	**39%**	**44%**	2%	1%	1%
Culture	8%	8%	**45%**	7%	22%	4%	3%	3%
Medicine	2%	2%	12%	**70%**	12%	0%	0%	2%

Application: a growth regression. Measurement

How do we aggregate scholarly output?

- Aggregate by birth/activity/death NUTS2 region
- weighted by f(no. of publications)

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

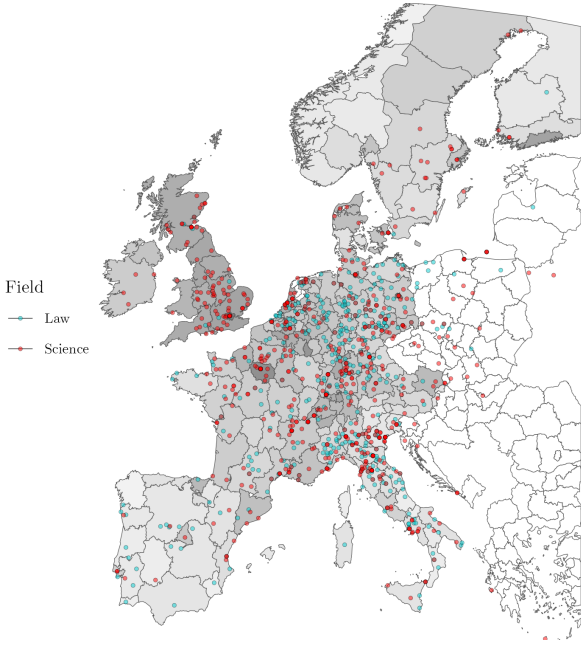
- Methodology based on Geary and Stark (2002)
- Combine national GDP and value added by sector with regional wages by sector
- Key assumption is that wages are good proxy for productivity

Controlling for

- Area of NUTS2 region
- Ruggedness from Nunn and Puga (2012)
- Land productivity (post-1500 calorie suitability index, Galor and Özak 2015)

Regression

	log GDP per capita, 1900				2015
	(1)	(2)	(3)	(4)	(5)
Local scholarship (birth) (1000-1800)	0.187** (0.086)	0.135** (0.060)	0.171*** (0.043)	0.129* (0.067)	0.166*** (0.046)
Share Theology 1			0.215 (0.222)	0.028 (0.173)	0.151 (0.178)
Share Theology 2			1.440*** (0.415)	0.381 (0.501)	0.163 (0.224)
Share Politics			0.417 (0.321)	0.049 (0.131)	-0.065 (0.209)
Share Law			-0.850*** (0.255)	-0.427* (0.208)	-0.081 (0.157)
Share Science			1.451*** (0.470)	1.215*** (0.312)	0.631* (0.323)
Share Philosophy			-0.029 (0.265)	-0.107 (0.126)	0.230* (0.111)
Share Botany			0.856** (0.353)	0.649*** (0.199)	0.677*** (0.143)
Share Culture			0.102 (0.277)	-0.108 (0.358)	-0.162 (0.205)
Share Medicine			0.075 (0.371)	-0.425 (0.525)	-0.055 (0.270)
N	172	172	172	172	165
Country FEs		X		X	X



Science and law across place

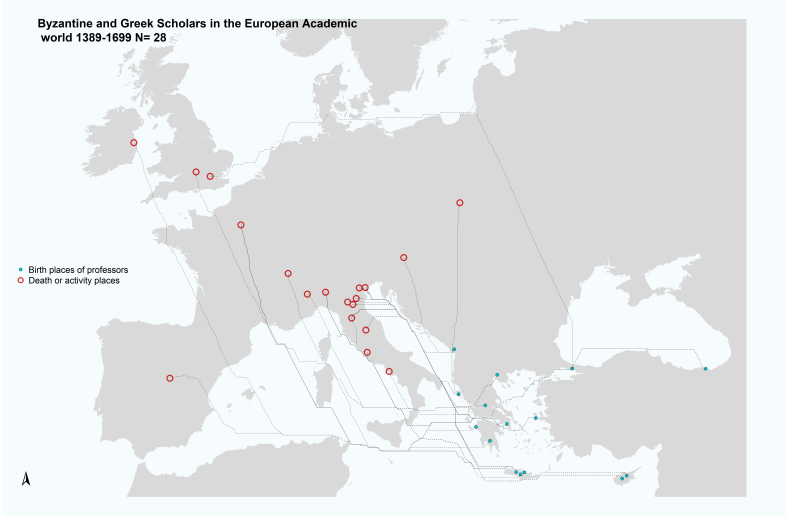
Endogeneity

Both Human capital and GDP per capita in 1900 may depend on common unobserved variables (a cultural variable perhaps)
Or attenuation bias from measurement error? If WorldCat has random errors in the publications

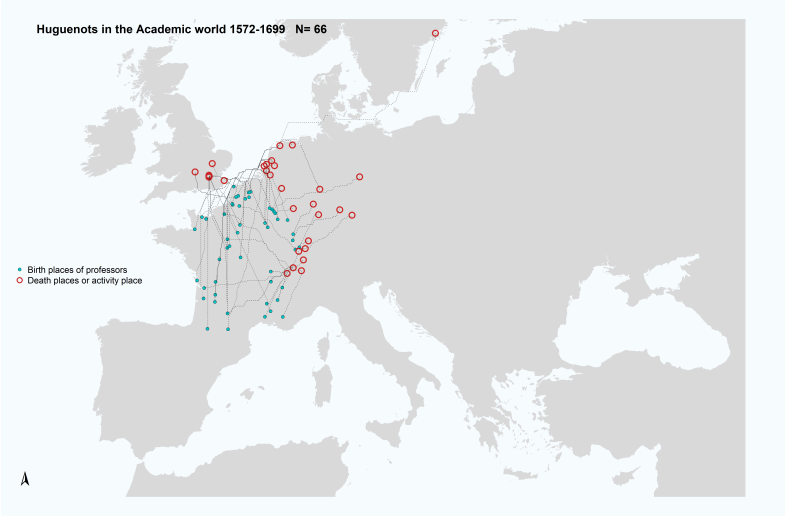
Use episodes of forced migration to suscitate exogenous changes in human capital

- Byzantine scholars and Greeks born between 1389 (the battle of Kosovo) and 1699 (end of Seventh Ottoman–Venetian War)
- French Huguenots born in France between 1572 (the Bartholomew's Day massacre) and 1699 who worked or died in a Protestant region
- British Catholics after the Reformation. All scholars born in Britain between 1558 (the coronation of Queen Elizabeth I) and 1699 who worked or died in a Catholic region

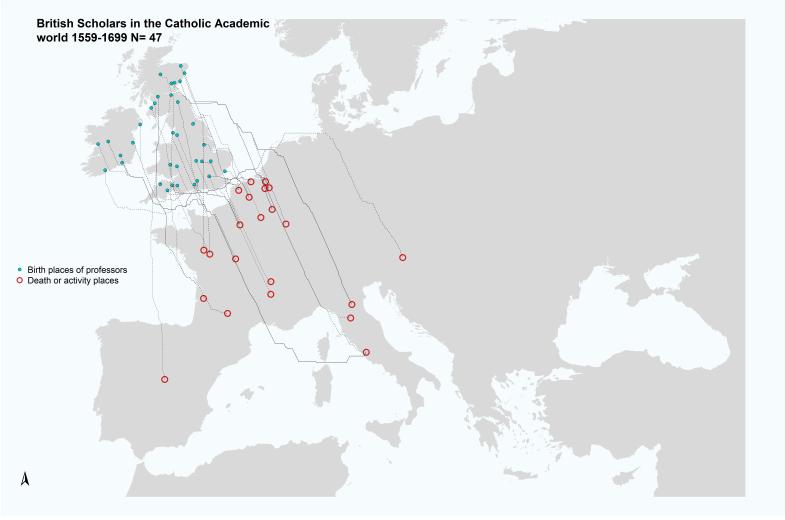
Byzantines


Byzantine and Greek Scholars in the European Academic world 1389-1699 N= 28
Birth places of professors
Death or activity places

Huguenots


Huguenots in the Academic world 1572-1699 N= 66
Birth places of professors
Death places or activity place

British Catholics

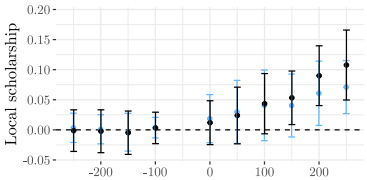


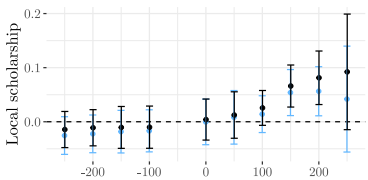
IV results

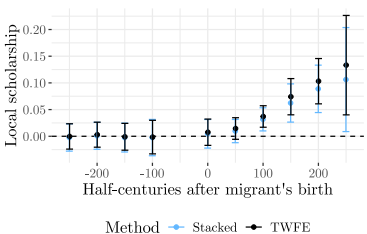
	log GDP per capita, 1900				
Panel A: IV	(1)	(2)	(3)	(4)	(5)
Local scholarship aft. 1700	0.135**	0.274***	0.168***	0.336***	0.315***
	(0.060)	(0.056)	(0.034)	(0.052)	(0.066)
N	172	172	172	172	172
	Local scholarship				
Panel B: 1st-stage	(1)	(2)	(3)	(4)	(5)
N Refugees		0.158***			
		(0.024)			
N Byzantines			0.491***		
			(0.086)		
N Huguenots				0.171***	
				(0.043)	
N British Catholics					0.273***
					(0.057)
N		172	172	172	172
Country FEs		X	X	X	X
1st stage F-stat.		95.39	99.29	28.42	38.28

Result: difference between OLS and IV suggests endogeneity bias barely significant and, if any, of the attenuation type

Refugees and future scholarly output: Byzantines, Huguenots and British Catholics





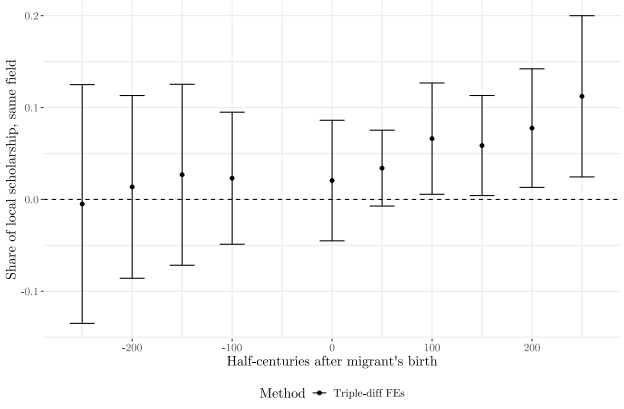


Event study, analyzing the effect of the arrival of a refugee on academic output of the region

→ no pre-trend in hosting places and a significant effect on future knowledge

Effect of refugees in their specific field

When a refugee arrives, is there a disproportionate increase in scholarship in their particular field in their destination?



The inspiration mechanism

Occupational choice: army vs church vs . . . vs academia

Hypothesis: successful scholars inspire fellow natives to choose academia

Finds support through indirect evidence:

1. regional development better understood when scholars are aggregated by birthplace rather than their activity location
2. scholars who stay closer to their roots demonstrate a stronger correlation with development compared to those who relocate or face an untimely demise
3. regions boasting a higher number of scholars born within them exhibited elevated levels of general population numeracy in the late 19th century

+ strong anecdotal evidence

1. Birth place vs activity place vs death place

All three ways of aggregating scholars lead to significant results
But stronger results obtained with aggregation by birthplace

	log GDP per capita, 1900					
	(1)	(2)	(3)	(4)	(5)	(6)
Local scholarship by						
birthplace	0.187**	0.135**				
	(0.086)	(0.060)				
activity place			0.040**	0.035**		
			(0.017)	(0.012)		
death place					0.111***	0.096***
					(0.028)	(0.019)
N	172	172	172	172	172	172
Adj. R^2	0.33	0.63	0.30	0.63	0.32	0.64
Country FEs		X		X		X

2. Groups less likely to inspire

	log GDP per capita, 1900				
	(1)	(3)	(4)	(5)	(6)
Local scholarship (1000-1800)	0.135**				
	(0.059)				
×died in other place			0.085		
			(0.097)		
×died in same place			0.236***		
			(0.068)		
×died before age 40				-1.959*	
				(0.998)	
×died after age 40				0.214**	
				(0.071)	
×born before 1600					0.175
					(0.150)
×born after 1600					0.127
					(0.127)
N	172	172	172	172	172
Country FEs		X	X	X	X

Example: Pierre Gassendi

- Born in Champtercier (pop. 856 in 2020)
- Gassendi primary school
- Digne-les-Bains has a Gassendi road, museum, statue, and secondary school
- The moon has a Gassendi crater

▸ Another example: Fermat

1989 - Ecole maternelle - Ecole pierre gassendi

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

Extension

- the 2 million pages of the WorldCat Identities project were suddenly retired in March, 2023.
- the RETE database keeps growing with now 79,000 scholars (January 2025)
- to pursue this line of research we found a viable alternative using statistics drawn from the VIAF platform
- VIAF provides a list of titles, but no word clouds
- in the future: infer the field from the titles. Main challenge: translations
- languages in VIAF: Latin (39%), French (15%), English (12%), German (11%), Italian (7%), Dutch (3%), Spanish (2%)

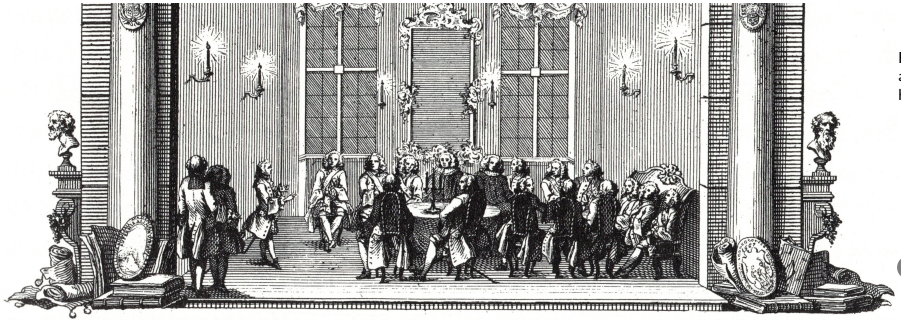
Universities

Handwritten lecture notes of George Licton

who studied in Louvain in 1467

Back

Academies



First meeting of the academy in Copenhagen

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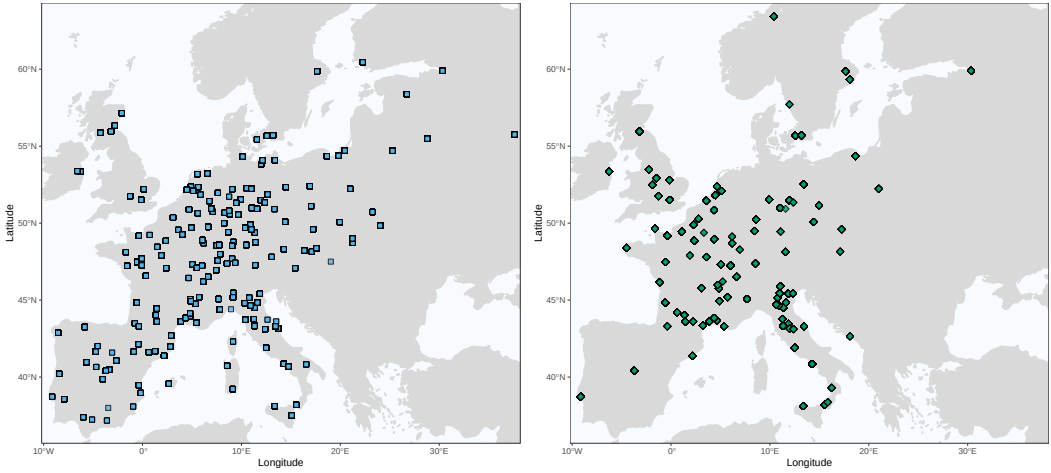
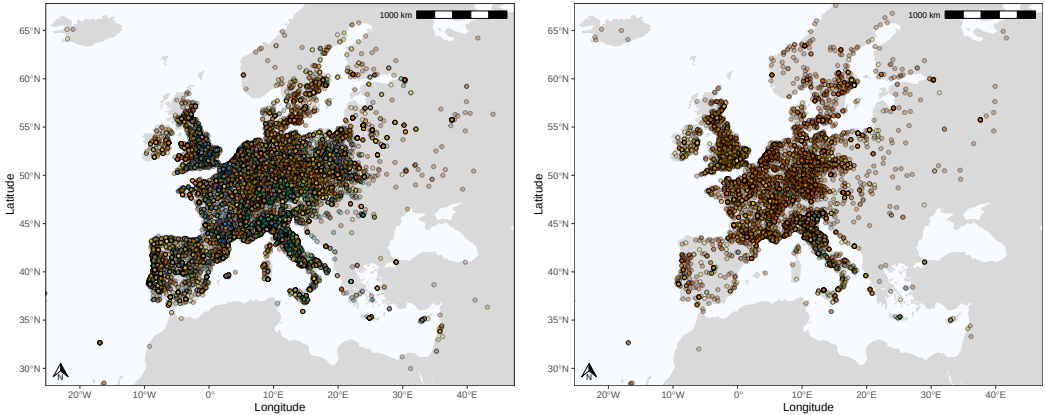
Location of Universities (left) and Academies (right)



Back

Birth places of scholars. Universities (left) and Academies (right)



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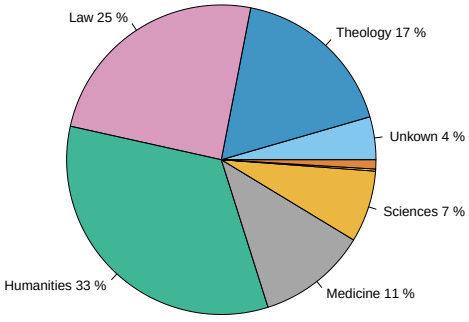
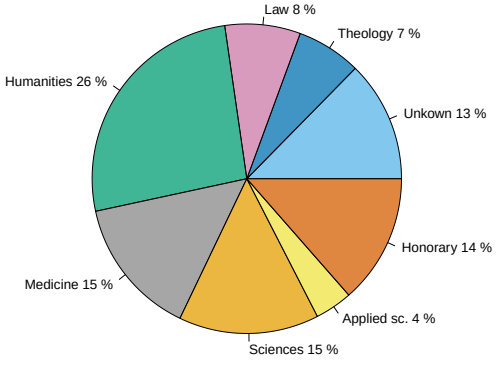
Fields from sources. Universities (left) and Academies (right)

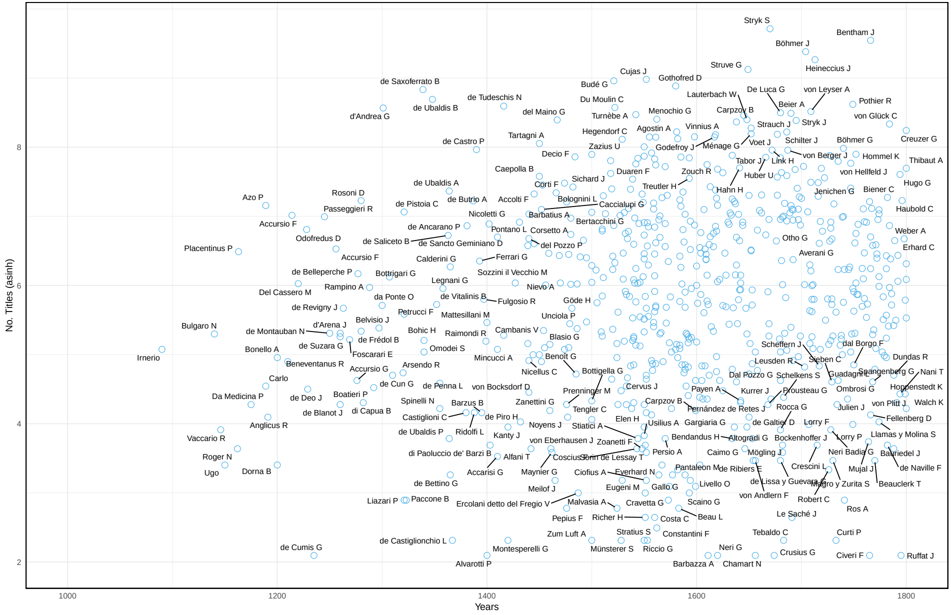




Clusters of WorldCat Topics

Clusters	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
Theology 1	Catholic Church	Theology, Doctrinal	Theology	Clergy	Reformation
Theology 2	Bible	Theology	Theology, Doctrinal	Jesus Christ	Bible.–Old Testament
Politics	Politics and government	Political science	Diplomatic relations	Economics	Catholic Church
Law	Roman law	Law	Canon law	Civil law	Digesta
Science	Mathematics	Astronomy	Geometry	Science	Physics
Classics	Rome (Empire)	Intellectual life	Law	Jesus Christ	Antiquities
Philosophy	Philosophy	Ethics	Logic	Science	Metaphysics
Botany	Botany	Plants	Natural history	Medicine	Botany, Medical
Culture	Travel	Antiquities	Manners and customs	Natural history	Voyages and travels
Medicine	Medicine	Physicians	Human anatomy	Materia medica	Surgery

◂ Back


Stryk S
Bentham J
Böhmer J
Heineccius J
Struve G
Cujas J
Gothofred D
Budé G
de Saxoferrato B
Lauterbach W
De Luca G
von Leyser A
de Tudeschis N
Du Moulin C
Beier A
Pothier R
de Ubaldis B
del Maino G
Menochio G
Carpzov B
d'Andrea G
Turnèbe A
von Glück C
Strauch J
Stryk J
Agostin A
Vinnius A
Hegendorf C
Tartagni A
Creuzer G
Schilter J
Böhmer G
de Castro P
Zazius U
Godefroy J
Ménage G
Voet J
Decio F
von Berger J
Hommel K
Tabor J
Link H
Thibaut A
Caepolla B
Duaren F
Zouch R
Huber U
von Hellfeld J
Sichard J
de Ubaldis A
Corti F
Treutler H
Hugo G
Rosoni D
Hahn H
Jenichen G
Biener C
Azo P
de Butrio A
Accolti F
Bolognini L
de Pistoia C
Caccialupi G
Haubold C
Passeggieri R
Nicoletti G
Barbatius A
Accursio F
Bertacchini G
de Ancarano P
Pontano L
Corsetto A
Weber A
Odofredus D
de Saliceto B
de Sancto Geminiano D
Otho G
del Pozzo P
Erhard C
Placentinus P
Averani G
Accursio F
Calderini G
Ferrari G
de Belleperche P
Bottrigari G
Sozzini il Vecchio M
Legnani G
Rampino A
Nievo A
Del Cassero M
da Ponte O
de Vitalinis B
Fulgosio R
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de Revigny J
Petrucci F
Mattesillani M
Unciola P
Belvisio J
Bulgaro N
d'Arena J
de Montauban N
Bohic H
Raimondi R
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Blasio G
de Frédol B
de Suzara G
Omodei S
Scheffern J
dal Borgo F
Bonello A
Foscarari E
Mincucci A
Benoît G
Sieben C
Dundas R
Irnerio
Leusden R
Beneventanus R
Arsendo R
Accursio G
Nicellus C
Bottigella G
Guadagni L
Spangenberg G
Nani T
Carlo
de Cun G
Dal Pozzo G
Schelkens S
de Penna L
von Bocksdorf D
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Prenninger M
Kurrer J
Prousteau G
Ombrosi G
Da Medicina P
de Deo J
Boatieri P
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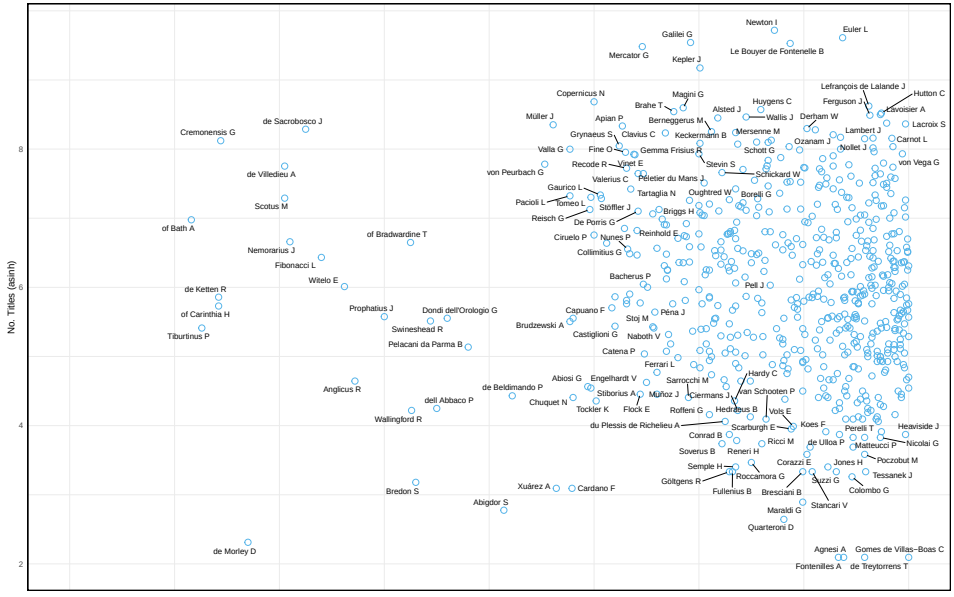
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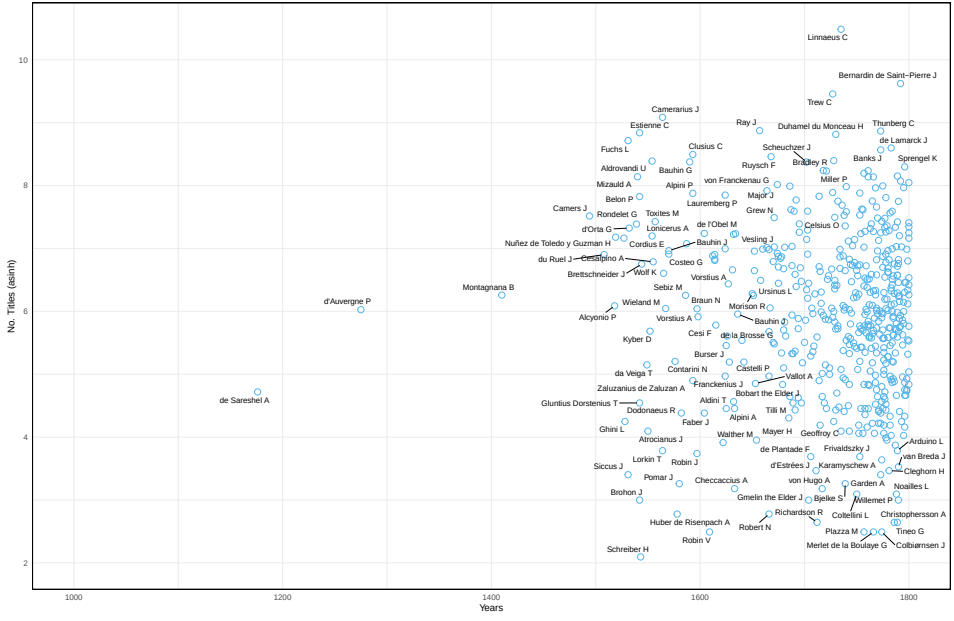
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Back

3. Human capital and general population numeracy in 1900

	Numeracy index c. 1900	
	(1)	(2)
Local scholarship	3.297*	3.085*
(1000-1800)	(1.881)	(1.659)
N	62	102
Country FEs	X	X

Note: Numeracy is the ABCC index from Baten and Hippe (2018): $125(1-s)$, where s is the share of reported ages ending in 0 or 5. Imputed numeracy assigns a value of 1 to Germany and Scandinavia in 1900.

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* Back

Inspiration mechanism: general equilibrium 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:

$$Y = AK\left(g\left[\frac{S}{H}\right]\right)^{1-\alpha}, \quad g'[\cdot] > 0$$

Along a balanced growth path:

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