Political Fragmentation, Forced Mobility, and Knowledge Accumulation in Europe before 1800

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Motivation

Mobility enhances investment in education and productivity

- For workers: Becker et al. 2020 (post WW2 Poland), Nakamura et al. 2022 (Iceland Volcano), Michalopoulos et al. 2025 (Greece-Turkey)
  + strong inter-generational cumulative effect
- For scholars: e.g. Franzoni et al. (2014): superior performance (impact factor) of migrant scientists + large correlational literature
- So far: Focus mainly on individual-level outcomes in specific contexts

$\Rightarrow$ What if you make a whole continent more mobile?

$\Rightarrow$ How big are the aggregate effects on knowledge growth?

Pre-modern Europe

- We look at this question in a fascinating setting: Pre-Modern Europe
  Renaissance, Scientific Revolution, Enlightenment
- $\exists$ integrated academic market then (de la Croix, Docquier, Fabre, Stelter, 2024)
- But also a world of repeated shocks, inducing scholars to move
- many examples in the historical literature (Burke (2017), Exiles and Expatriates in the History of Knowledge, 1500-2000)

Mechanisms

Exogenous Shocks $\Rightarrow$ **Forced Mobility** $\Rightarrow$ Knowledge Production

- Mobility allows to learn from more (sometimes better) people
- Context: political fragmentation creates both shocks (wars, ruler changes) and exit options for persecuted scholars

$\Rightarrow$ not simply "competition" but fragmentation-induced, shock-driven mobility.

- Provide causal evidence for this concrete mechanism within Europe, and
- back out its aggregate implications

This Paper: Empirics in a nutshell

- **Data:** 60k European scholars (ever at any university, 1000-1800)
  - Scholar-level measures of
    - productivity index (composite incl. wiki page, publications from VIAF, ...)
    - life trajectory (city-by-city moves because of new appointments)
  - Link with data on shocks to cities (and polities they belong to)
- **Core correlational result**: More/any moves $\Leftrightarrow$ More productive
- **Causal Identification**: Shocks to cities that force scholars to move
  - Three instruments: Nearby battles, plague outbreaks, new ruler coming to power

  $\Rightarrow$ **Scholars ever forced to move: productivity 40% $\uparrow$**

This Paper: Theory in a nutshell

Model captures the inter-generational externalities of documented effect:

- Young scholars learn from previous generation & decide how many moves to make
- Tradeoff: Meet possibly better scholar vs. losing time and utility by moving
- Externality: better old scholars benefit the future generation, etc.

Estimation of the structural parameters

$\Rightarrow$ **Aggregate level of European knowledge delayed by centuries**

Contribution to Related Literature

Needham: *"Why did modern science take its meteoric rise in the West?"*

Existing explanations emphasize

- Culture and beliefs (Weber, Landes, Mokyr, Tabellini, Henrich...)
- Institutions and incentives, e.g. property rights, corporations (North, Acemoglu et al., Greif,...)
- Political fragmentation and competition (Jones, Kennedy, Mokyr, Roeck...)

Our channel: scholarly mobility

- Cuts across these dimensions:
  - Requires individual autonomy (culture)
  - Is enabled by corporate bodies (institutions)
  - Is sustained by outside options (fragmentation)

Contribution to Related Literature (2)

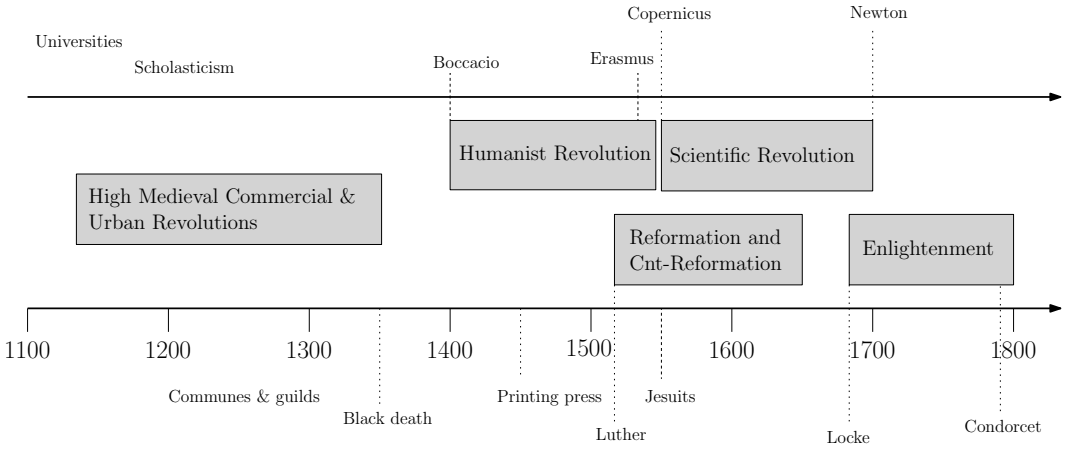
- Mobility of scientists
  - Today Moser et al. 2014, Catalini et al. 2020, ...
  - Historically Potrafke and Vaubel 2015, Link 2025, Dewitte et al. 2025, ...

  $\Rightarrow$ We combine causal identification and *aggregate* (Europe-wide) effects

- Shocks forcing mobility
  - Nakamura et al. 2022, Becker et al. 2024, Waldinger 2010, 2012 ...

  $\Rightarrow$ We focus on scientists and trace the aggregate effects of forced mobility

Europe, 1000–1800 CE: A Hub of Innovations



Europe, 1000–1800 CE: Academia

- Over >**100,000 academic scholars** across Europe during this period.
  among whom 30% have a footprint in today's libraries
- Scholars did not work in isolation: they were part of a **vast academic community** connected through **universities and other institutions.**
- By 1800:
  - **200 universities** established (1000–1800, e.g. Bologna, Paris, Oxford, Louvain, Cracow, Salamanca).

Key features of universities

Many are bottom-up. Recognized *ex post* by a charter (e.g. Papal Bull)

Variety of subjects are taught

Diplomas follow exams. Given by institutions (hence by community of masters)
Some dose of meritocracy (disputatio, exams)

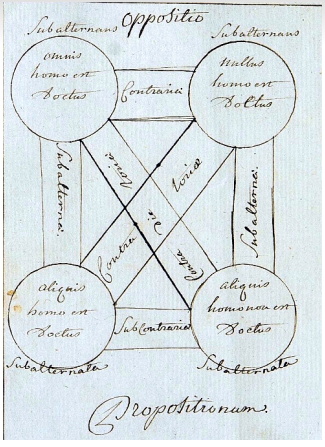
Very unique feature: they are *persona ficta* ($\approx$ legal persons/corporations)
Origin: Roman law (*universitas, societas*) + Theology (church as *corpus mysticum* of Christ) + Canon law

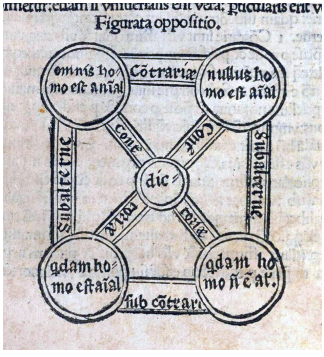
In corporations, professors act collectively. + **one can leave a corporation**.
The institution persists beyond the existence of its members (universities more persistent than States)

Universities across Europe shared remarkable similarities

- Latin (until late in the 18th century)
- *licentia ubique docendi*
- similar curricula
- Charters and Bulls (giving autonomy)
- ritual: sceptres, gowns, etc..

$\rightarrow$ fragmented but homogeneous: needed for mobility to be possible





Square of opposition. Source: on the left, student notes from the course *Logica*, 1776-1777, KU Leuven Libraries, Special Collections, Ms. 251. On the right, Thomas Murner (Cracow, Basel, Trier). *Logica memorativa: Chartiludium logicae*. 1509.

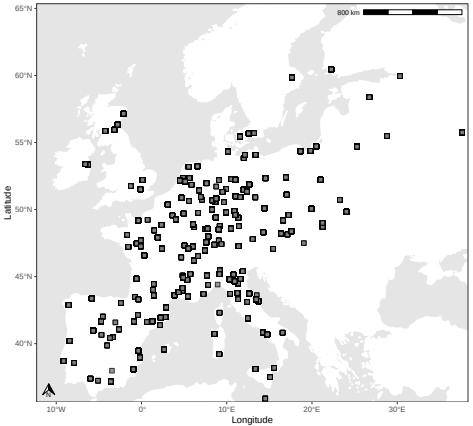
International comparison

Type of institution	Period	Bottom-up	*Persona ficta*	Gave diplomas
European Universities	c. 1100–	yes	legally autonomous corporate entity	granted by the collective authority of the faculty
Nalanda monastery–university	427–1197	?	?	no
Madrasas	c. 800–	yes	no, charitable endowment	issuance of ijazahs based on attendance
Imperial academies (Guozijian)	c. 700–1905	no	no	central examination system

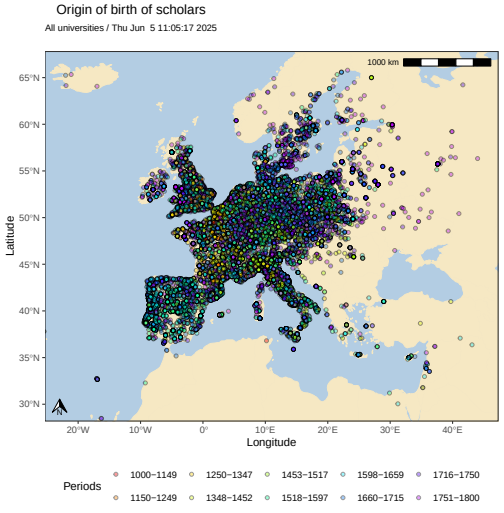
A Data set of Scholars, Cities, and Shocks (1)

- time range: 1000-1800. Latin Europe
- 221 universities and higher education institutions ← c. 600 secondary sources
- 66000 scholars professors at these institutions
- RETE also includes academies (17000 scholars) but not included here

Universities:



Scholars by birthplace



Core outcome: scholar's productivity (Curtis, de la Croix, Manfredini, Vitale, EEH, 2026)

Combining 11 indicators to reduce bias present in each indicator

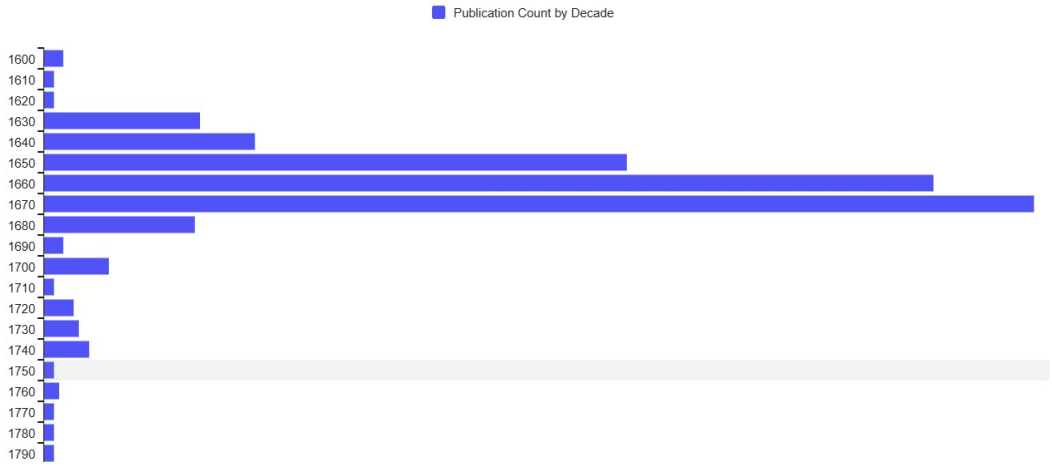
Variable (in asinh)	PC1	PC2
Wikipedia: No. characters of longest page (*LengthWikiN*)	0.29	-0.02
Wikipedia: No. pages in different languages (*NWikiLanguage*)	0.26	-0.46
VIAF: No. publication countries (*countries*)	0.32	0.04
VIAF: No. different publishers (*publishers*)	0.32	0.24
VIAF: No. titles (*titles*)	0.33	0.20
VIAF: No. coauthors (*coauthors*)	0.32	0.27
VIAF: No. isbn (*isbn*)	0.23	-0.66
VIAF: No. publications before 1900 (*pubbef1900*)	0.32	0.18
VIAF: No. publications after 1900 (*pubaft1900*)	0.29	-0.34
Wikidata: No. of identities / external ids (*nidentities*)	0.32	0.17
Wikidata: No. of occupations (*noccupations*)	0.30	0.10
Eigenvalue	8.49	0.91
Proportion of Variance explained	0.77	0.08

Example: VIAF page for Attanasio Kircher: titles

VIAF: Virtual International Authority File
unique page per author (disambiguation done by libraries)

and many more

VIAF page for Attanasio Kircher: some temporal data



Properties, strengths and weaknesses

- constant term chosen to give $q_i = 0$ for someone with neither a Wikipedia page, nor a VIAF page, nor a Wikidata page
- Top university scholar: Martin Luther ($q = 19.7$)
- Seen from the point of view of today $\rightarrow$ lifetime perspective
- Includes both output and citations
- Measurement errors, mitigated by combining 11 variables
- Based on digitally-native sources, hence subject to updates
- Bias: printing press, non academic works (von Schiller, Rabelais, Swift)
- Temporal dimension: per decade only, + methodology not transparent

Endogenous treatment: Scholar mobility

- we trace scholars appointments and consider moves any change between institutions

An example: Michelangelo Fardella (1646-1618), $q = 8.2$

Professor of philosophy in Messina (1670-6)

Left when Messina rebelled against Spanish rule and experienced military conflict

Moved to the Universities of Modena (1683-93) and Padua (1693-1711)

His Modena period is where he became best known internationally, especially for his correspondence with Leibniz

Main works:

1. Universae philosophiae systema . . . , Venezia, 1691
2. Universae usualis mathematicae theoria, Venezia, 1691.

An example: Attanasio Kircher (1603-1680), $q = 15.4$

Professor of Mathematics in Würzburg (1629-31)

Thirty Years' War, Protestant forces captured Würzburg in 1631; the college was dissolved and Kircher fled

Moved to the Universities of Avignon (1631-32) and Collegio Romano (1635-1660)

Large number of works, from *Musurgia Universalis* (1650) to *Mundus Subterraneus* (1665)

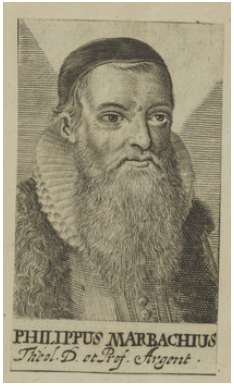
An example: Philipp Marbach (1650-1611), $q = 5.9$

Professor of Lutheran theology in Heidelberg (1679-84)

After the Elector's death in 1583, he was unable to stay in Heidelberg as a Lutheran theologian.

he took up a rector position in Klagenfurt and took over a chair at the Strasbourg University (1593-1611)

best known in the 1590s, when he was teaching philosophy at Strasbourg

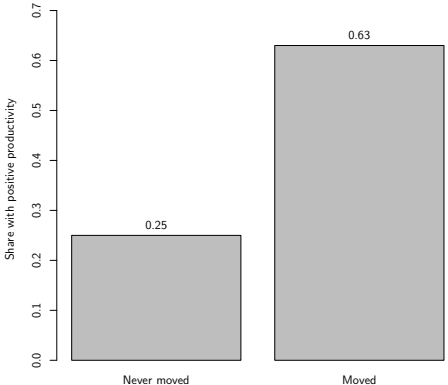


His surviving publications are polemical theological works (1585, 1593, 1603):

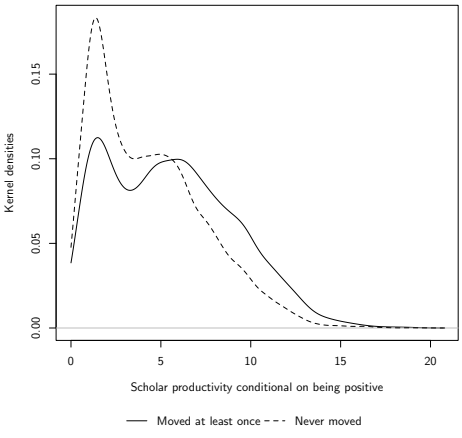
1. Solida refutatio tractatus Christophori Pezelii ..., Tübingen 1593.

Moving is correlated with higher productivity across scholars

Extensive margin: Movers are more often productive



Intensive margin: More moves ↔ More productivity



Descriptive statistics

	mean	sd	min	max	No. obs
Productivity	1.261	2.635	0	19.672 (Luther)	69810
Dummy: Productivity > 0	0.277	0.448	0	1	69810
log(1+ no. Moves)	0.063	0.238	0	2.400	69810
Dummy: Moved Min. Once	0.073	0.261	0	1	69810
Dummy: Ruler Change	0.190	0.393	0	1	69810
Dummy: Nearby Battle	0.026	0.159	0	1	69810
Dummy: Nearby Plague	0.153	0.360	0	1	69810
Known longevity					22781
Known place of birth					45269

OLS: Documenting a strong relationship between productivity and mobility

Dep. Var.			*Productivity*		*Dummy: Prod.*>0
Sample:	All Scholars		Scholars with birthplace	Scholars with non-zero productivity	Scholars with birthplace
	(1)	(2)	(3)	(4)	(5)
log(1+ no. Moves)	2.661***	2.508***	2.014**	1.095***	
	(0.510)	(0.514)	(0.624)	(0.299)	
Dummy: Moved Min. Once					0.253***
					(0.065)
Century FE		✓	✓	✓	✓
Field FE		✓	✓	✓	✓
Birth State FE			✓	✓	✓
Mean dep. var.	1.261	1.261	1.838	4.815	0.382
R^2	0.06	0.12	0.18	0.07	0.23
Observations	69,810	69,810	45,269	17,280	45,269

Note: Standard errors clustered at the century level in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Data: Instruments for Scholar Mobility

- Core endogeneity concern: Scholars who move are inherently different, in ways that relate to their productivity. Direction of bias not clear cut.
  - E.g. worse scholars have to move more often $\Rightarrow$ OLS underestimates causal effect
    best scholars receive more offers, move more $\Rightarrow$ OLS overestimates causal effect
- We address this with a set of instrumental variables
- Idea: shocks to locations that force scholars to leave
  1. A dummy of whether a plague outbreak occurred within 20km of the city in which the scholar resides (Ginzler, Digitizing historical plague)
  2. A dummy of whether a battle took place within 20km of the city in which the scholar resides (Miller and Bakar, Conflict Events Worldwide Since 1468BC)
  3. A dummy of whether a new ruler came to power in while the scholar resides in a city (Ottinger and Voigländer, The Effect of European Monarchs on State Performance)

Scholar-Level IV Regressions: Shocks to Mobility and Productivity

First Stage: log(1 + # moves)		Second Stage: Productivity			
		All	Ruler Change	Nearby Battle	Nearby Plague
Instrument (Dummies):	(1)	(2)	(3)	(4)	(5)
Dummy: Ruler Change	0.060***				
	(0.009)				
Dummy: Nearby Battle	0.055**				
	(0.017)				
Dummy: Nearby Plague	0.087***				
	(0.010)				
log(1+ no. Moves)		9.108***	11.886***	9.229***	7.156***
		(1.025)	(1.711)	(1.580)	(1.003)
Century FE	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓
Field FE	✓	✓	✓	✓	✓
First-Stage F-Statistic		130.6	40.0	17.7	123.2
Observations	45,269	45,269	45,269	45,269	45,269

Interpretation

why IV>OLS ?

OLS: average effect among all movers, mixed with selection.

IV: local average treatment effect for compliers — scholars who moved only because the mobility shock changed their opportunity set.

These compliers may be precisely the scholars for whom moving unlocks the most: better matches, stronger networks, or access to more productive environments.

Interpretation: IV $>$ OLS suggests mobility has especially large productivity returns for scholars whose moves are induced by external shocks.

Size of the effect (for battles)

mean productivity is 1.261

one more person affected by nearby battles implies 0.055 log number of moves (from first stage)

one more log number of moves implies 9.229 more productivity (from second stage)

hence we get 0.055 x 9.229 / 1.261 = 40 %

Large correlational literature finds that for today's scientists, moving increases citations between 17 % (26,170 physicists from 1980–2009) - 63% (Swedish researchers)

Beyond lifetime effects: event studies

Above, we claim forced migration at some point in life → higher lifetime academic performance

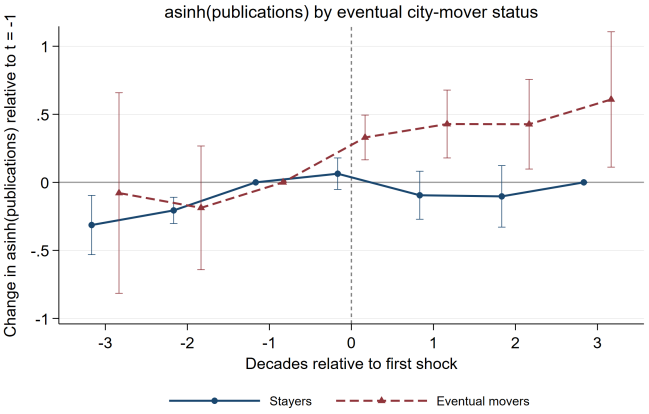
VIAF provides data on publications at the decade level

- decade-level event-study timing
- measure whether a scholar is in a different city at the start of the next decade.
- includes city-decade and age-decade fixed effects
- includes scholar fixed effects

→ allows to discuss the remaining threats to causal identification

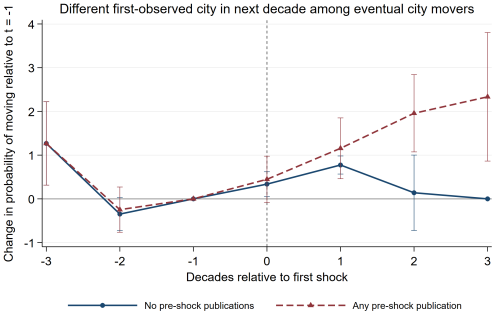
Exclusion Restriction: Did shocks affect productivity directly?

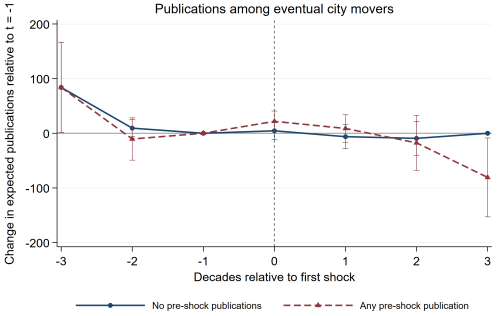
those who move after the first shock they experience (red dashed line) publish more in the decades after the shock than those who stayed behind



Selective survival of younger or better scholars?

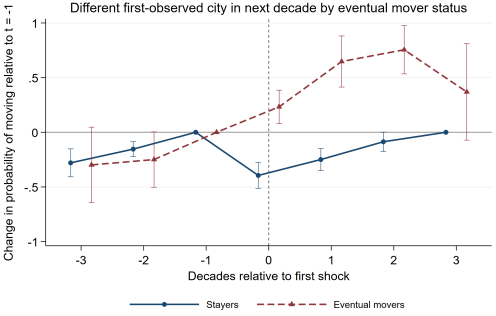
- Event-study heterogeneity: Not driven by scholars who published more before shock

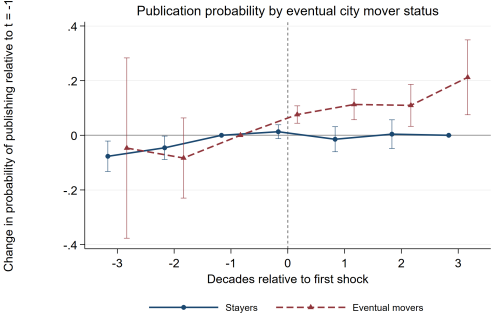




Endogenous exposure of more mobile/better scholars to shocks

- Event-study: No evidence of increased pre-shock mobility of shock-movers





Left: Shock-movers not more mobile before – Right: More likely to publish after move

Model

Aim: map micro data into aggregate measure of the effect of shocks on productivity including externalities

Young scholars - old scholars

Young decide how many academic positions to fill during their life

The more they move, the better they become (private return)

But moving implies a fixed cost (time), and disutility

There is a social return to moving $>$ private return
better teachers induce cumulative effects on subsequent generations

Having shocks forcing scholars to move brings closer to the optimum

Technology (1)

Time is discrete and goes from 0 to ∞.

Two generations of scholars. Young acquire knowledge from old by meeting them.

Starting from an empty location, the young decides how many moves to make, n_{it}, each move corresponding to a new old scholar they will learn from.

Disutility m_t for each move. m_t is time varying reflecting that mobility conditions.

When old, they enjoy their productivity which depends on the no. of moves when young.

Old scholars *ex ante* identical but (unobserved) heterogeneous productivity when old.

Technology (2)

Each young has a time endowment λ.
Going from one old professor to another takes some time δ.
Assuming the same length of stay in each place, the duration of a stay is

$$v_{it} = \frac{\lambda - \delta n_{it}}{n_{it}}.$$

The young learns a fraction $\ell(v)$ of the productivity of the old depending on the length of the stay v:

$$\ell(v), \quad \ell'(v) > 0, \quad \ell''(v) < 0, \quad \ell(0) = 0, \quad \ell(\lambda) \leq 1.$$

The learning process

At time t, old professors' productivity x_{it} is distributed according to:

$$x_{it} \sim \text{Fréchet}(\alpha_t, s_t, 0), \quad \alpha_t > 0, s_t > 0,$$

where α_t is the shape parameter, and s_t is the scale parameters.

Meeting one old scholar with productivity x_{it}, the knowledge a young professor will learn is $y_{it} = \ell(v_t)x_{it}$. This acquired knowledge is distributed according to

$$y_{it} \sim \text{Fréchet}(\alpha_t, \ell(v_t)s_t, 0)$$

The young will learn from n_t old, with learned productivity $\{y_{1t}, \ldots, y_{n_t t}\}$. His final productivity will be the best of those learned:

$$\max(y_{1t}, \ldots, y_{n_t t}) \sim \text{Fréchet}(\alpha_t, n_t^{\frac{1}{\alpha_t}} \ \ell(v_t) \ s_t, 0)$$

(max stability property)

Distribution dynamics

$$x_{it+1} \sim \text{Fréchet}(\alpha_{t+1}, s_{t+1}, 0)$$

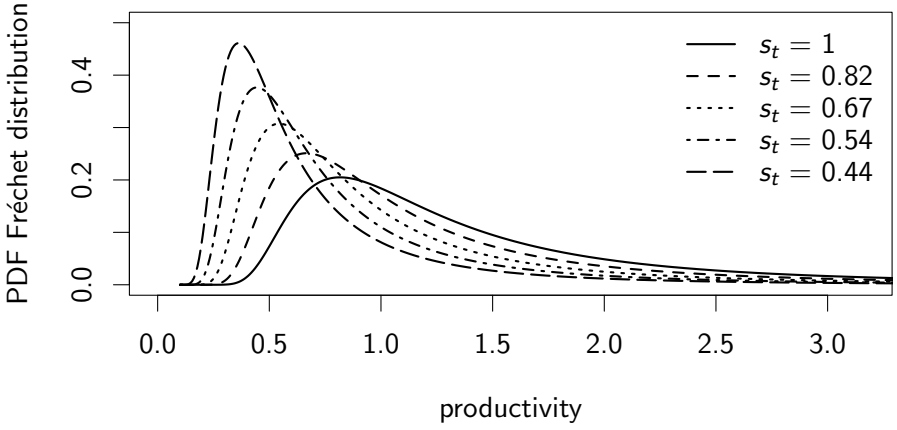
$$\begin{aligned} \text{with} \quad \alpha_{t+1} &= \alpha_t \ (= \alpha) \\ s_{t+1} &= \varphi(n_t)\, s_t \end{aligned}$$

The function

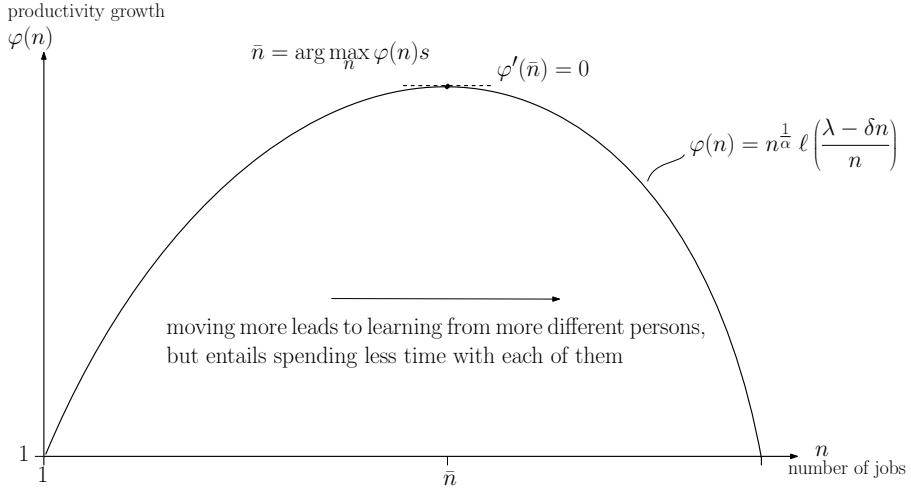
$$\varphi(n_t) = n_t^{\frac{1}{\alpha}}\, \ell((\lambda - \delta n_t)/n_t)$$

describes how knowledge growth is affected by the number of moves n_t.

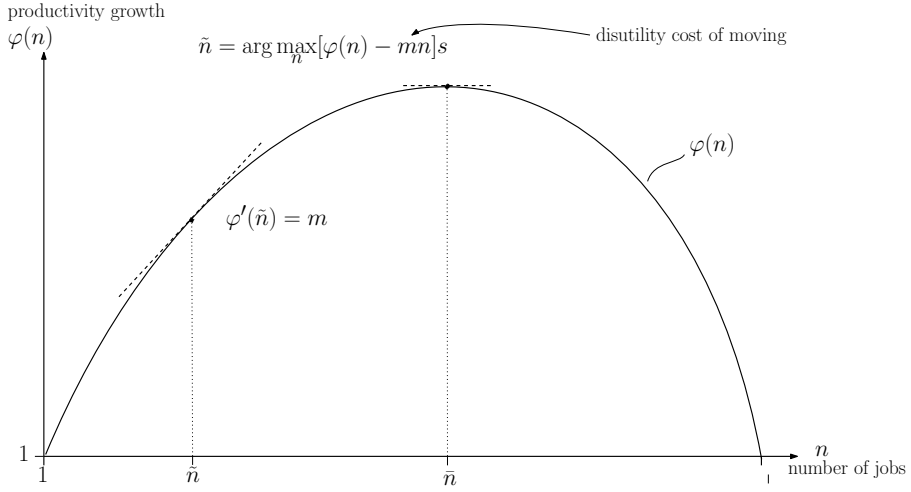
Distribution dynamics



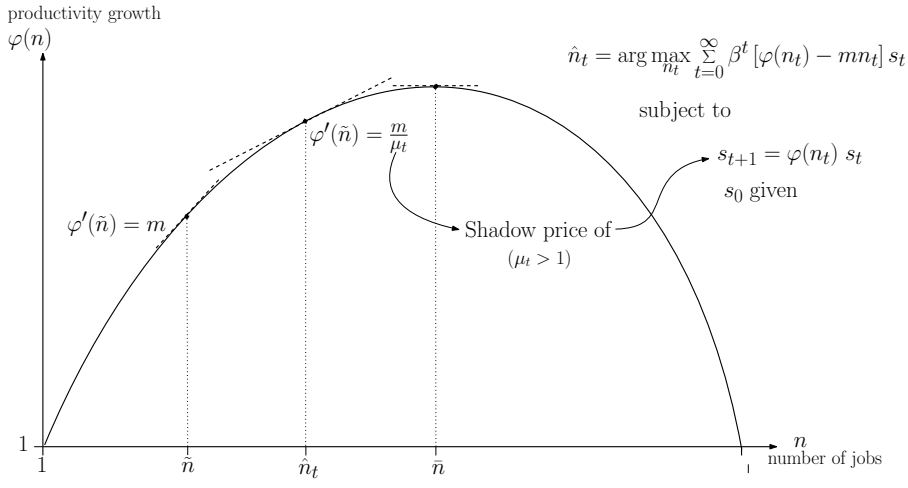
Static productive efficiency



Individual Choice



A Benevolent Planner to see the *positive externalities*



Quantitative analysis

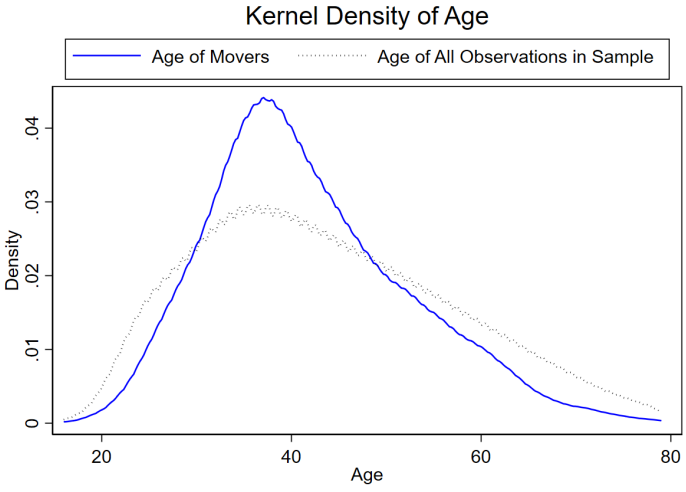
infer the effect of scholars' mobility on growth, not only through the immediate effect of moving on individual productivity, but also including the dynamic effects through the inter-generational externality

1. estimate the deep parameters of the model

2. using the first stage of the IV regression, predict the number of moves in the absence of shocks

3. simulate knowledge growth with this counter-factual number of moves

Demography



→ Young (movers): 25-55

Old: 55+

Structural estimation (1)

We assume a concave form $\ell(v) = \tau v^{\kappa}$.

The expected productivity can be written as:

$$\mathrm{E}[x_{it+1}] = n_t^{\frac{1}{\alpha}}\ \ell(v_t)\ s_t\ \Gamma(1 - 1/\alpha) \tag{1}$$

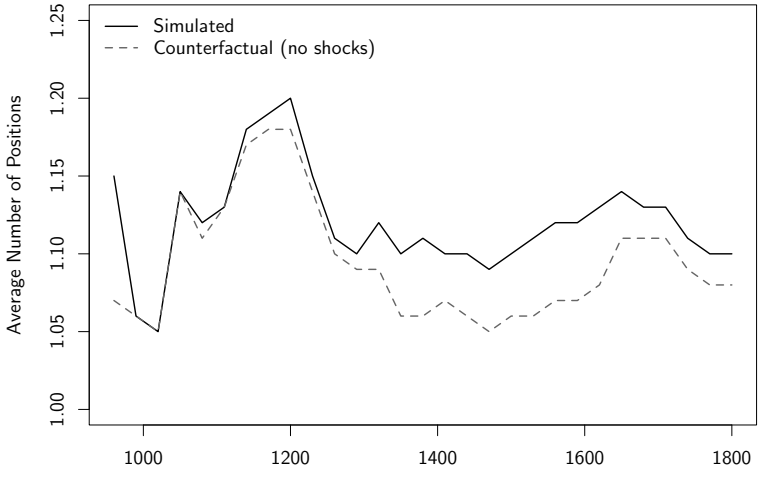
We use Equation (1) in logarithms to estimate δ and κ by non linear least squares, applying it to individual data, hence exploiting the individual variation in the number of employers (n_i) and the length of life (λ) (in the model, all scholars have the same λ and n, which is not true in reality):

$$\ln E[x_i] = \frac{1}{\alpha} \ln n_i + \kappa \ln(\lambda_i / n_i - \delta) + C \tag{2}$$

Structural estimation (2)

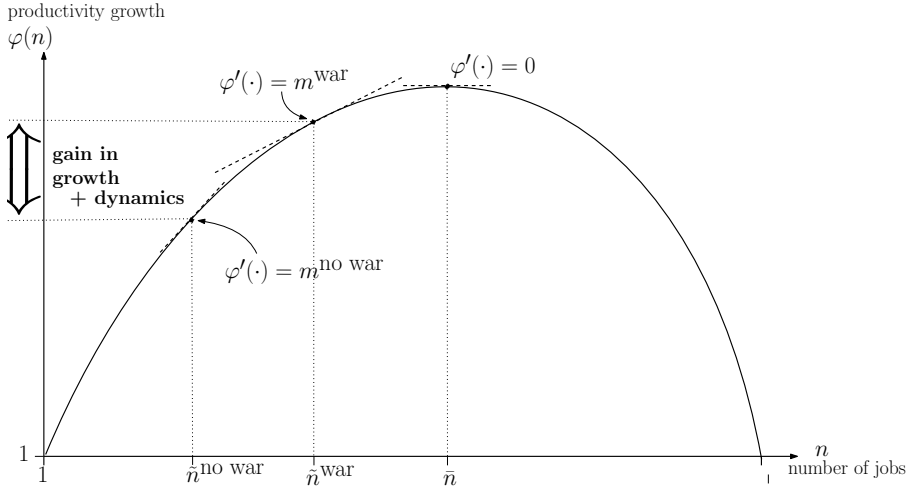
Parameter	value	target
time endowment λ	28.42 years	observed survival between 25 and 55
shape parameter α	1.538 (0.008)	estimation of Fréchet distribution of publications
time cost of moving δ	1.088 (1.66) years	non linear estimation of (2)
elasticity of productivity to length of stay κ	0.343 (0.041)	non linear estimation of (2)
scale parameter τ	0.322	implies stagnation if nobody moves ($n = 1$)

Simulated and Counter-factual (no shocks) number of jobs

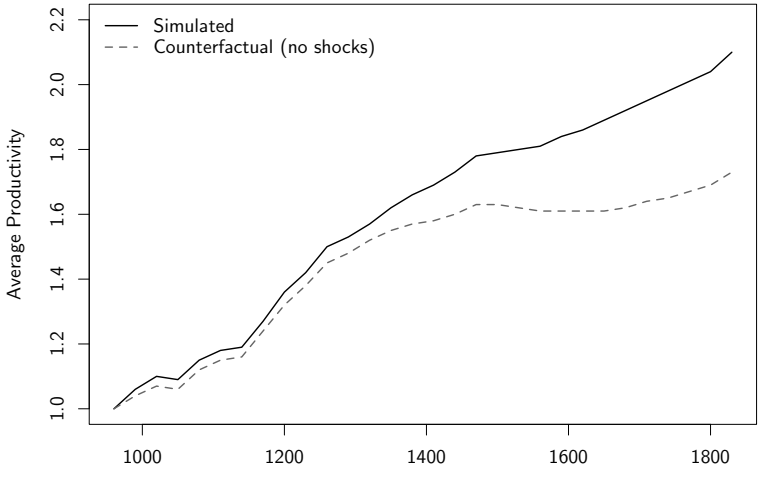


Using first-stage regression with shocks dummies = 0

Computing effect on productivity



Simulated and Counter-factual (no shocks) productivity



Note: Longevity at its observed values

Next step: Europe vs China

Above, we simulate knowledge with European type shocks and no shocks at all

We could attempt a simulation for "Chinese shocks":

- keep plagues as in Europe (to be discussed, related to wars?)
- cut war shocks by 75%, as
  - Voitgänder and Voth (2013): China had markedly less warfare, no more than one quarter of the European frequency
- ruler changes much less frequent in China (self-evident), with no outside option

Conclusions

- Medieval and Early modern professors moved across Europe
- Some of these moves are the consequence of shocks (war, plague, rulers)
- These extra moves were critical to exploit spill-overs between scholars and enhance knowledge accumulation
- Without them, the Scientific Revolution would have been delayed by centuries