The impact of the printing press in Europe

Ec 365

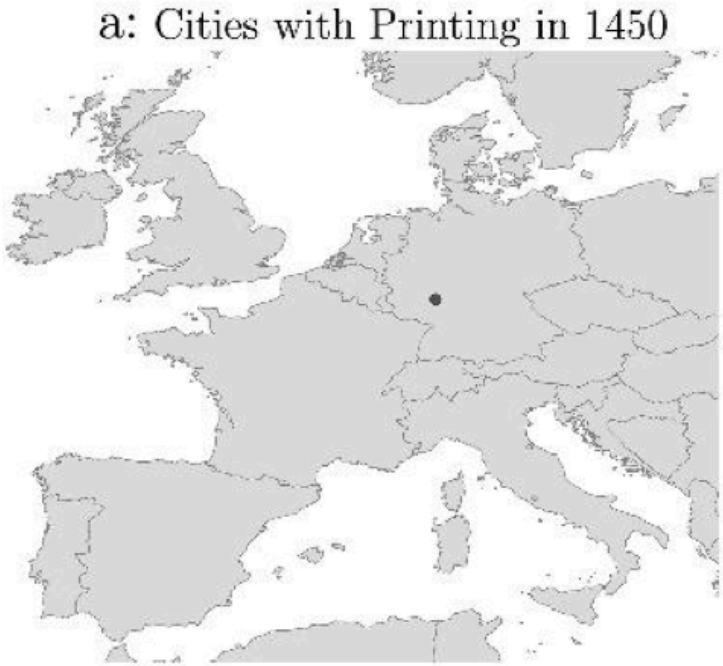
November 19, 2024

Argument

- References:
  - Eisenstein Elizabeth L. (1978). "In the Wake of the Printing Press," *The Quarterly Journal of the Library of Congress*, 35 (3). 183-197.
  - Dittmar, Jeremiah E. (2011). "Information Technology and Economic Change: the Impact of the Printing Press," *The Quarterly Journal of Economics*, 126 (3), 1133-1172.
- Question:
  - Did the printing press play a causal role in expanding economic activity?
- Events (Germany):
  - Spread of the printing press from the innovation in Mainz (Germany)
  - Commercial books!
- Test:
  - Impact on city growth.
  - Issue of causality

- Before 1450, one man's year to copy a bible.
- China: movable characters already around 1000 CE.
- Gutenberg
  - 1434-1445 in Strasbourg
  - Innovation in Mainz

After 1450

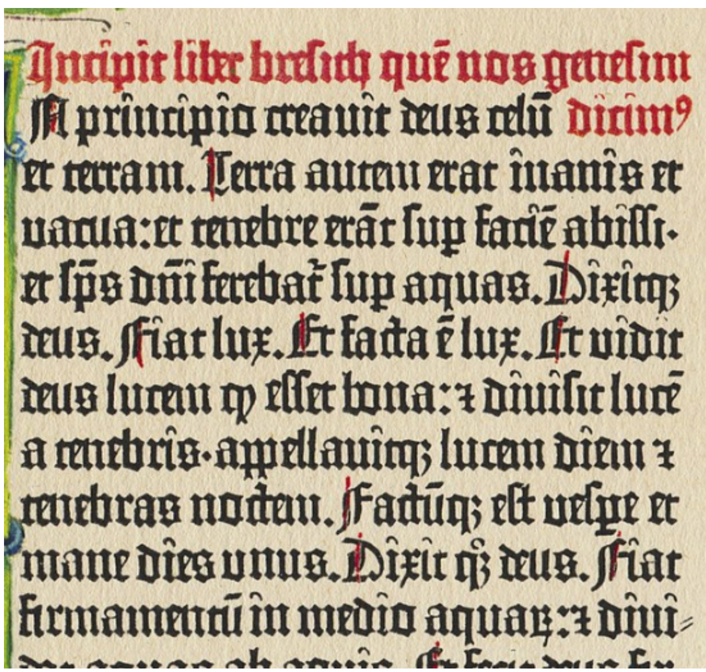


(Library of Congress)

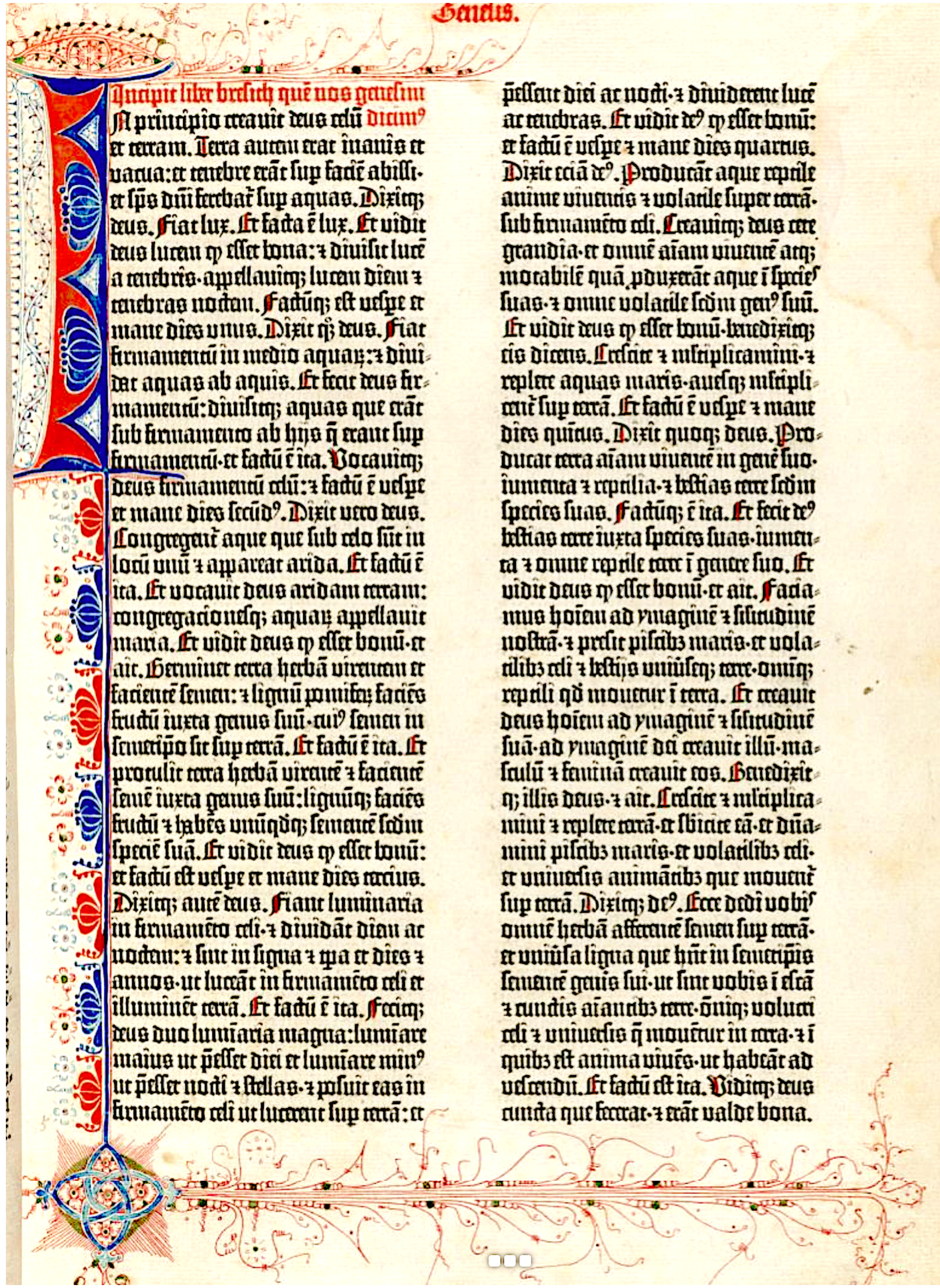
49 surviving Gutenberg bibles, 21 complete

Incunables

- Incunable (plur. Incunabula)
  - "In the cradle"
  - Infant industry
  - Printed before 1500
- About 30,000 editions
  - Perhaps 20,000 lost
- (Bible at Widener Library)



Incipit liber bresith quē nos genesim
In principio creauit deus celū dicim⁹
et terram. Terra autem erat inanis et
uacua: et tenebre erāt sup faciē abissi.
et spūs dñi ferebat sup aquas. Dixitq;
deus. Fiat lux. Et facta ē lux. Et uidit
deus lucem q̄ esset bona: ⁊ diuisit lucē
a tenebris. appellauitq; lucem diem ⁊
tenebras noctem. Factūq; est uespe et
mane dies unus. Dixit q̄; deus. Fiat
firmamentū in medio aquaꝝ: ⁊ diui-



Genesis.

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deus. Fiat lux. Et facta ē lux. Et uidit
deus lucem q̄ esset bona: ⁊ diuisit lucē
a tenebris. appellauitq; lucem diem ⁊
tenebras noctem. Factūq; est uespe et
mane dies unus. Dixit q̄; deus. Fiat
firmamentū in medio aquaꝝ: ⁊ diui-
dat aquas ab aquis. Et fecit deus fir-
mamentū: diuisitq; aquas que erāt
sub firmamento ab hiis q̄ erant sup
firmamentū. et factū ē ita. Uocauitq;
deus firmamentū celū: ⁊ factū ē uespe
et mane dies secūd⁹. Dixit uero deus.
Congregent̄ aque que sub celo sūt in
locū unū ⁊ appareat arida. Et factū ē
ita. Et uocauit deus aridam terram:
congregationesq; aquaꝝ appellauit
maria. Et uidit deus q̄ esset bonū. et
ait. Germinet terra herbā uirentem et
facientē semen: ⁊ lignū pomiferū faciēs
fructū iuxta genus suū. cui⁹ semen in
semetipo sit sup terrā. Et factū ē ita. Et
protulit terra herbā uirentē ⁊ facientē
semē iuxta genus suū: lignūq; faciēs
fructū ⁊ habēs unūqdq; sementē sc̄dm
speciē suā. Et uidit deus q̄ esset bonū:
et factū est uespe et mane dies tercius.
Dixitq; autē deus. Fiant luminaria
in firmamēto celi. ⁊ diuidāt diem ac
noctem: ⁊ sint in signa ⁊ tpa et dies ⁊
annos. ut luceāt in firmamēto celi et
illuminēt terrā. Et factū ē ita. Fecitq;
deus duo luminaria magna: luminare
maius ut pesset diei et luminare min⁹
ut pesset nocti ⁊ stellas. ⁊ posuit eas in
firmamēto celi ut lucerent sup terrā: et
pessent diei ac nocti. ⁊ diuiderent lucē
ac tenebras. Et uidit de⁹ q̄ esset bonū:
et factū ē uespe ⁊ mane dies quartus.
Dixit etiā de⁹. Producāt aque reptile
anime uiuentis ⁊ uolatile super terrā.
sub firmamēto celi. Creauitq; deus cete
grandia. et omnē aīam uiuentē atq;
motabilē quā pduxerāt aque ī species
suas. ⁊ omne uolatile sc̄dm gen⁹ suū.
Et uidit deus q̄ esset bonū. benedixitq;
eis dicens. Crescite ⁊ multiplicamini. ⁊
replete aquas maris. auesq; multipli-
centur sup terrā. Et factū ē uespe ⁊ mane
dies quintus. Dixit quoq; deus. Pro-
ducat terra aīam uiuentē in genē suo.
iumenta ⁊ reptilia. ⁊ bestias terre sc̄dm
species suas. Factūq; ē ita. Et fecit de⁹
bestias terre iuxta species suas. iumen-
ta ⁊ omne reptile terre ī genere suo. Et
uidit deus q̄ esset bonū. et ait. Facia-
mus hoīem ad ymaginē ⁊ silitudinē
nostrā. ⁊ presit piscibȝ maris. et uola-
tilibȝ celi ⁊ bestiis uniuerseq; terre. omiq;
reptili qđ mouetur ī terra. Et creauit
deus hoīem ad ymaginē ⁊ silitudinē
suā. ad ymaginē dei creauit illū. ma-
sculū ⁊ feminā creauit eos. Benedixit-
q; illis deus. ⁊ ait. Crescite ⁊ multiplica-
mini ⁊ replete terrā. et subicite eā. et dña-
mini piscibȝ maris. et uolatilibȝ celi.
et uniuersis animātibȝ que mouent̄
sup terrā. Dixitq; de⁹. Ecce dedi uobis
omnē herbā afferentē semen sup terrā.
et uniuersa ligna que hñt in semetipis
sementē generis sui. ut sint uobis ī escā
⁊ cunctis aīantibȝ terre. omiq; uolucri
celi ⁊ uniuersis q̄ mouentur in terra. ⁊ i
quibȝ est anima uiuens. ut habeāt ad
uescendū. Et factū est ita. Uiditq; deus
cuncta que fecerat. ⁊ erāt ualde bona.

- Most revolutionary inventions in human history:
  - Economists have found no evidence of the technology's impact in measures of aggregate productivity or per capita income;
  - until the mid-1990s, they found no evidence of productivity gains associated with computer-based information technologies
- Historical research suggests that print media transformed the ways ideas were disseminated, promoted the accumulation of human capital, and played a key role in the evolution of business practices.
- Article examines these spillovers by exploiting new, city level data on the adoption of the movable type printing press in fifteenth-century Europe.
- Questions:
  - Was the new printing technology associated with city growth?
  - If so, how large was the association
- Historical evidence and instrumental variable techniques to identify the impact of printing on city growth

Entry restrictions

Over the period 1450–1500, entry was limited by the fact that the printing press was a quasi-proprietary technology. The key innovation in printing—the process used to cast movable metal type—was complex and semi-secret.[38] To produce suitable metal type, printers required a combination of alloys that was strong and ductile; hard and nonporous; noncorrosive and maintained the "plane-parallel" shape of the castings when cooled. These characteristics were obtained with a precise combination of lead, tin, and antimony that was a trade secret.[39] Although it proved impossible to maintain a strict monopoly on the intellectual property behind the printing press, the knowledge remained quasi-proprietary for almost a century. The first known "blueprint" manual on the production of movable type was only printed in 1540 (Biringuccio's *Pirotechnia*).

- No guild, but financial barriers to entry

I have often been asked by certain youths. . . who look forward to mercantile pursuits, to put into writing the fundamental principles of arithmetic. . . Here beginneth a Practica, very helpful to all who have to do with that commercial art. (Reproduced in Swetz 1987)

Books for commercial arithmetics

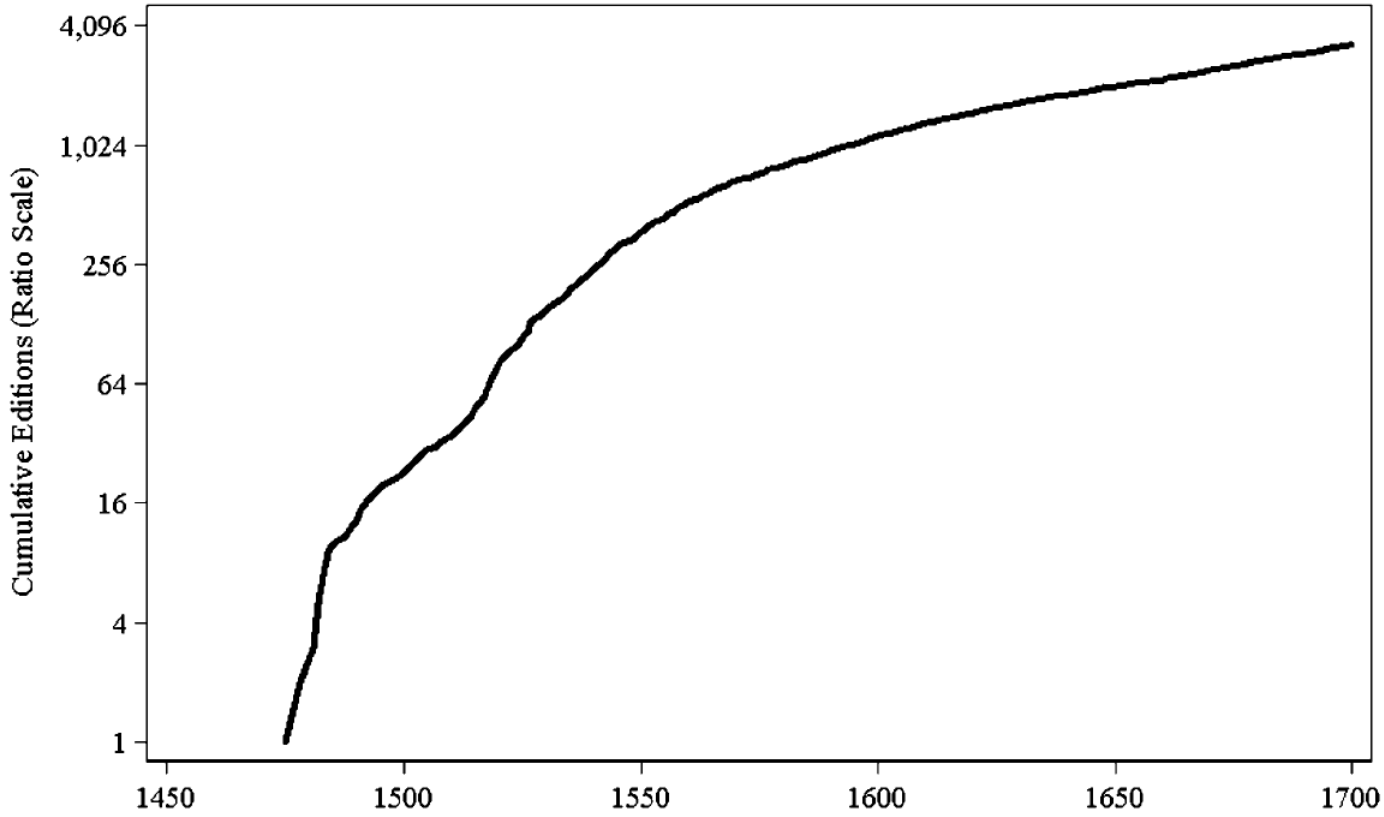


FIGURE I

Cumulative Output of Merchants' Manuals in Europe

Cumulative output (editions) of printed merchants' manuals in Europe, including commercial arithmetics, treatises on bookkeeping, guides to commercial law and business practice. Data from Hoock and Jeannin (1991, 2001, 2007).

Transport costs

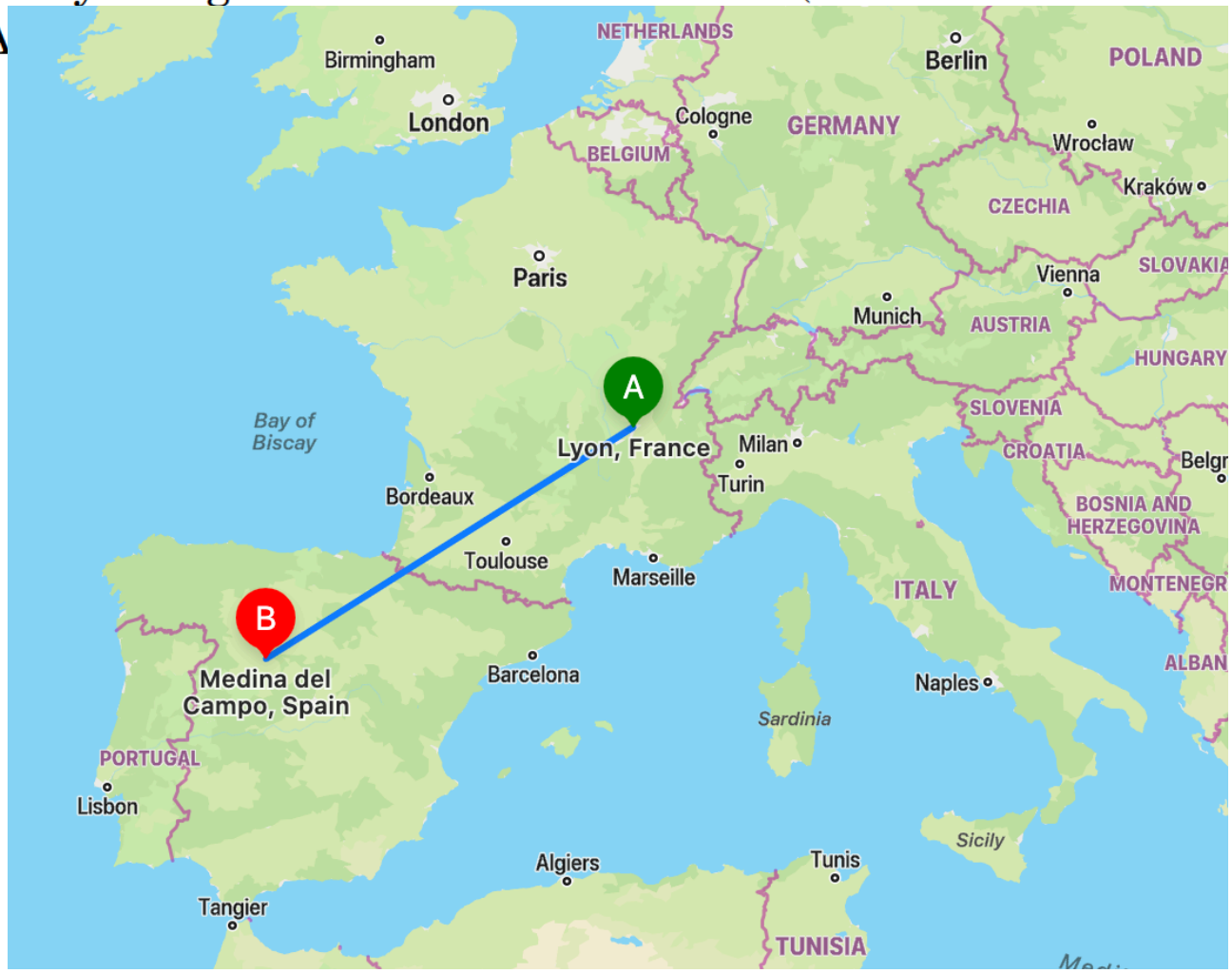
- Starting in the 1480s, European presses produced a stream of "commercial arithmetics.
- First published description of double-entry bookkeeping appeared in 1494.
- The availability of inexpensive texts was a key prerequisite for the spread of literacy in Renaissance Europe
  - Print media were costly to transport because they were heavy and fragile commodities, sensitive to damp.
  - Transport costs in early modern Europe were sufficiently high that print media often spread through reprinting rather than intercity trade

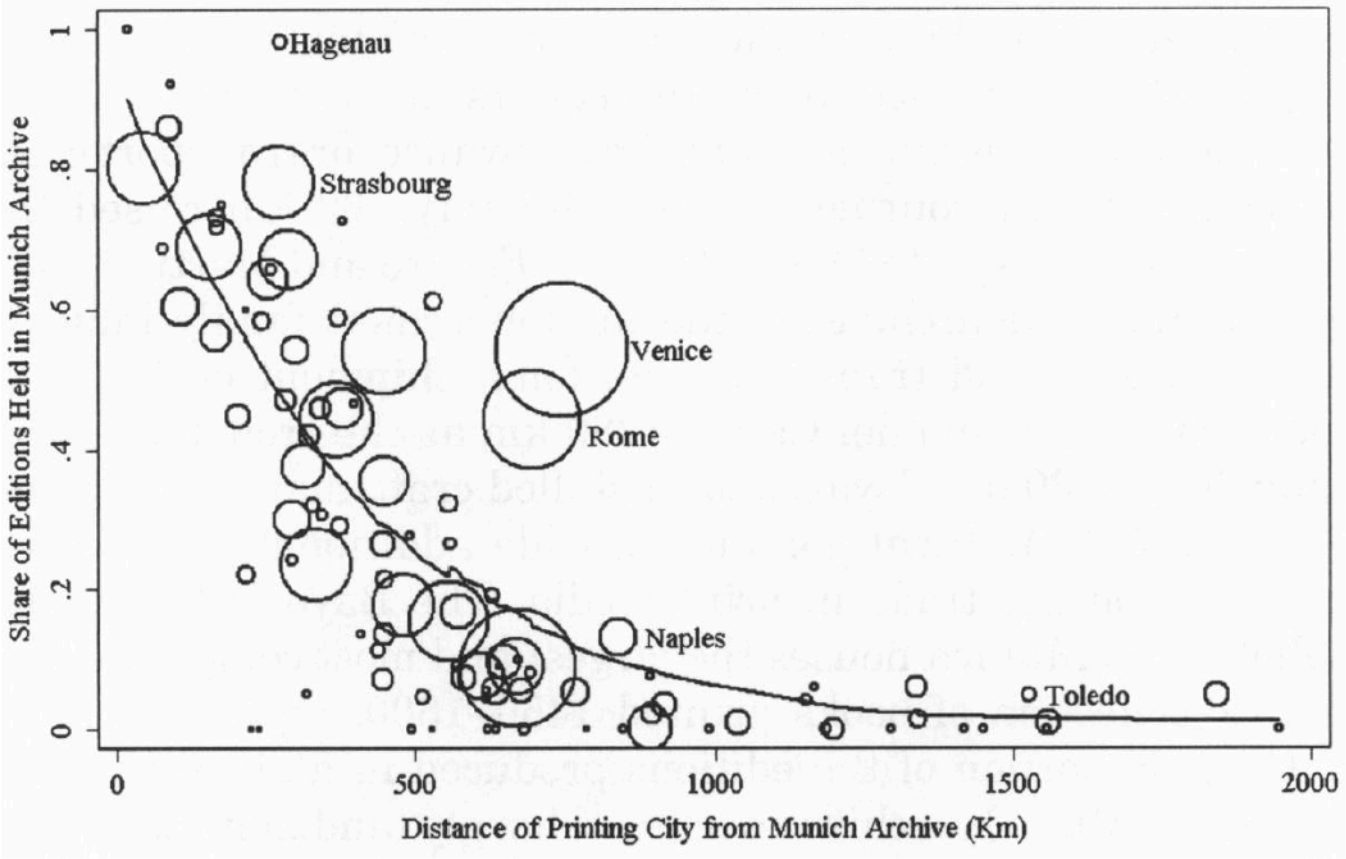
Transportation costs

- High costs: implies that local printing press is important

Records from the archives of the Ruiz merchant family indicate that insurance and transport costs for a shipment of 21 books from Lyon to Medina del Campo (280 km as the crow flies) were equivalent to 30 days' wages for a skilled craftsman (Febvre and Martin 1958). A

930 km



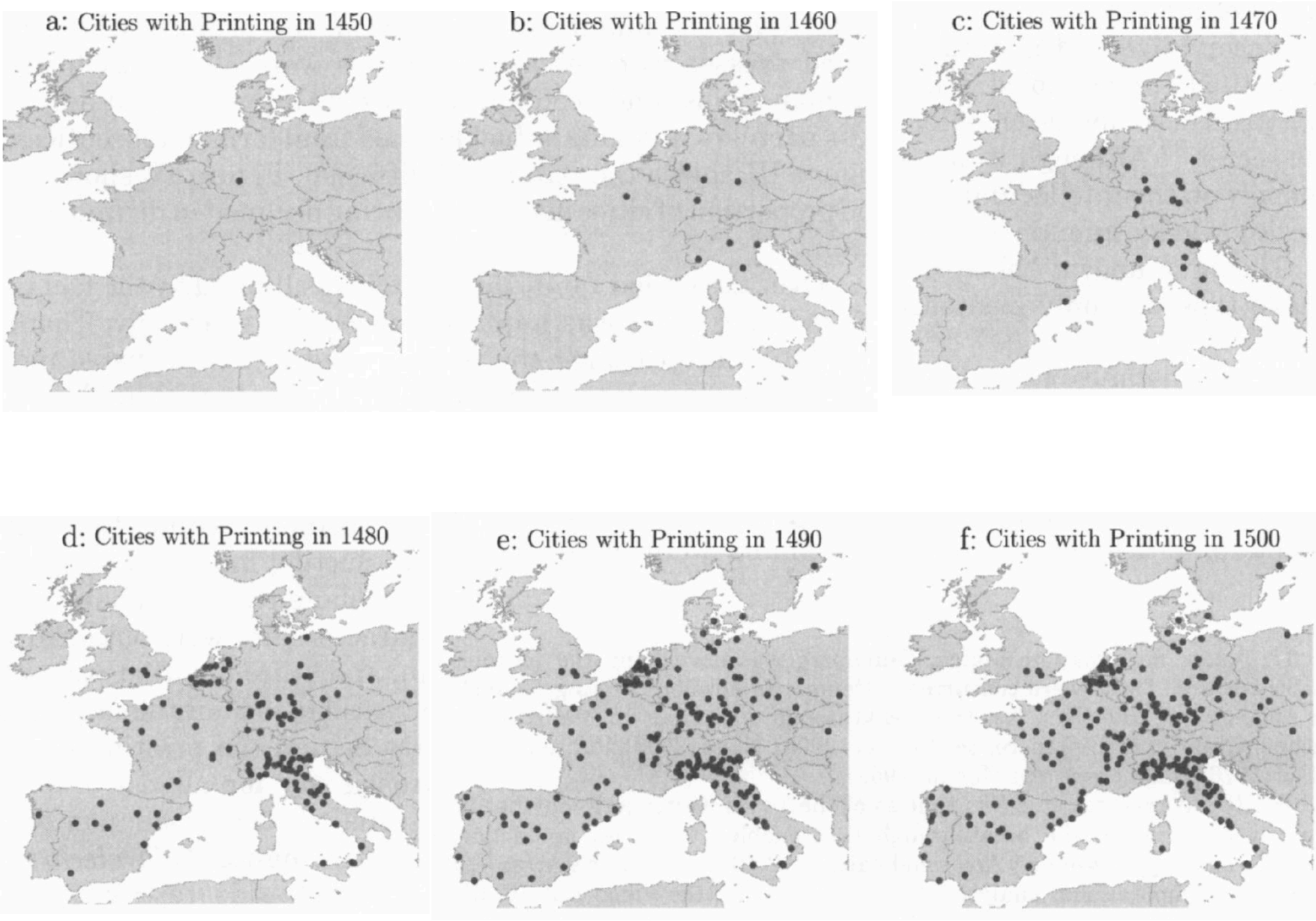


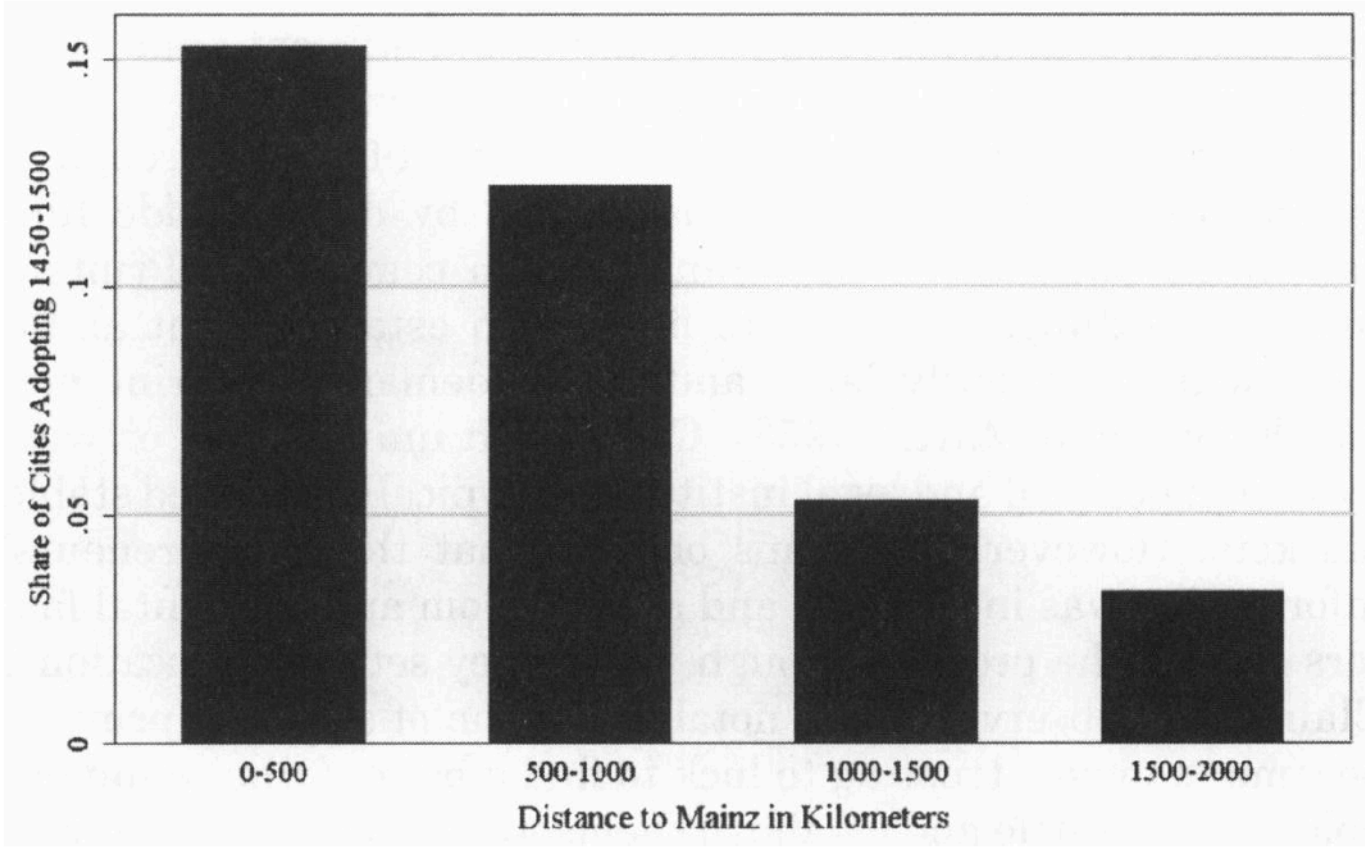
Archive Holdings and Distance from Point of Production

This figure presents data for the 100 cities with the highest output of incunabula editions 1450–1500. For each city it shows what share of its editions are held in the Bayerische Staatsbibliothek in Munich and how far the city is from Munich.

THE DIFFUSION OF THE PRINTING PRESS 1450–1500

(1) 20th-Century Polity	(2) Cities Adopting Printing Press	(3) Total Number of Historic Cities	(4) Share Adopting (%)
Austria	1	17	6
Belgium	9	72	13
Czechoslovakia	5	36	14
Denmark	2	10	20
England	3	165	2
France	39	341	11
Germany	40	245	16
Hungary	1	47	2
Italy	56	406	14
Netherlands	11	60	18
Poland	3	55	5
Portugal	6	53	11
Spain	24	265	9
Sweden	1	20	5
Switzerland	4	19	21
Total	205	1,811	11


a: Cities with Printing in 1450
b: Cities with Printing in 1460
c: Cities with Printing in 1470
d: Cities with Printing in 1480
e: Cities with Printing in 1490
f: Cities with Printing in 1500


Share of Cities Adopting 1450-1500
0
.05
.1
.15
0-500
500-1000
1000-1500
1500-2000
Distance to Mainz in Kilometers

Main results

	Dependent Variable Is Log City Growth			
	Pre-Adoption	Post-Adoption		
(1)	(2)	(3)	(4)	(5)
Independent Variable	Growth 1400–1500	Growth 1500–1600	Growth 1500–1700	Growth 1500–1800
Print Adoption 1450–1500	0.07	0.19***	0.26***	0.30***
	(0.08)	(0.06)	(0.08)	(0.09)
Editions Per Capita	0.03	0.03*	0.04	0.05
	(0.03)	(0.02)	(0.03)	(0.03)
University	−0.12	0.02	0.17*	0.17*
	(0.11)	(0.07)	(0.09)	(0.09)
Roman Site	0.08	−0.01	0.09	0.04
	(0.06)	(0.05)	(0.08)	(0.07)
Capital	0.31**	0.95***	1.46***	1.98***
	(0.13)	(0.16)	(0.20)	(0.27)
Freedom Index	−0.23	0.27***	0.29**	−0.07
	(0.14)	(0.10)	(0.13)	(0.14)
Atlantic Port	0.16	0.34***	0.64***	0.76***
	(0.18)	(0.09)	(0.14)	(0.12)
Mediterranean Port	0.21*	0.15	0.57***	0.65***
	(0.13)	(0.12)	(0.15)	(0.17)
Baltic Port	−0.16	0.25**	0.55**	0.37
	(0.18)	(0.12)	(0.22)	(0.24)
Navigable River	0.14*	0.18***	0.23***	0.39***
	(0.08)	(0.06)	(0.09)	(0.09)
Log Population	−0.22***	−0.30***	−0.42***	−0.64***
	(0.04)	(0.04)	(0.05)	(0.05)
Country FE	Yes	Yes	Yes	Yes
Observations	291	495	515	622
R Squared	0.33	0.32	0.35	0.47

TABLE V

LOG CITY GROWTH: THE TIMING OF THE PRINT ADVANTAGE

(1) Variable	(2) All Cities Balanced Sample	(3) Exclude German Cities	(4) Exclude Italian & Dutch Cities	(5) Exclude If East of Elbe River	(6) Only Port Cities	(7) Only Cities Without Ports
Print × Yr1400	0.09	0.10	0.09	0.11	0.27	−0.04
	(0.16)	(0.18)	(0.20)	(0.17)	(0.38)	(0.16)
Print × Yr1500	0.34**	0.39**	0.41**	0.34**	1.39***	0.10
	(0.15)	(0.17)	(0.18)	(0.16)	(0.42)	(0.15)
Print × Yr1600	0.13	0.22	0.08	0.16	0.73**	−0.01
	(0.16)	(0.17)	(0.20)	(0.16)	(0.34)	(0.17)
Print × Yr1700	0.19	0.25	0.16	0.22	0.84**	0.00
	(0.14)	(0.16)	(0.17)	(0.14)	(0.42)	(0.15)
Atlantic × Yr1400	0.12	0.27	0.13	0.12	−0.32	—
	(0.31)	(0.33)	(0.37)	(0.31)	(0.52)	—
Atlantic × Yr1500	0.43*	0.55**	0.38	0.44*	−0.24	—
	(0.25)	(0.28)	(0.28)	(0.25)	(0.52)	—
Atlantic × Yr1600	0.42*	0.49*	0.33	0.45**	0.47	—
	(0.22)	(0.25)	(0.24)	(0.22)	(0.38)	—
Atlantic × Yr1700	0.60***	0.73***	0.64***	0.62***	0.32	—
	(0.19)	(0.20)	(0.21)	(0.19)	(0.38)	—
R squared	0.55	0.57	0.58	0.54	0.77	0.53
Observations	1,010	875	710	850	225	785
Adopting Cities	83	71	53	78	16	67
Nonadopting Cities	119	104	89	92	29	90

	Dependent Variable Is Log City Growth			
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	(0.11)	(0.07)	(0.09)	(0.09)
Roman Site	0.08	−0.01	0.09	0.04
	(0.06)	(0.05)	(0.08)	(0.07)
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	(0.13)	(0.16)	(0.20)	(0.27)
Freedom Index	−0.23	0.27***	0.29**	−0.07
	(0.14)	(0.10)	(0.13)	(0.14)
Atlantic Port	0.16	0.34***	0.64***	0.76***
	(0.18)	(0.09)	(0.14)	(0.12)
Mediterranean Port	0.21*	0.15	0.57***	0.65***
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Baltic Port	−0.16	0.25**	0.55**	0.37
	(0.18)	(0.12)	(0.22)	(0.24)
Navigable River	0.14*	0.18***	0.23***	0.39***
	(0.08)	(0.06)	(0.09)	(0.09)
Log Population	−0.22***	−0.30***	−0.42***	−0.64***
	(0.04)	(0.04)	(0.05)	(0.05)
Country FE	Yes	Yes	Yes	Yes
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	(0.16)	(0.18)	(0.20)	(0.17)	(0.38)	(0.16)
Print × Yr1500	0.34**	0.39**	0.41**	0.34**	1.39***	0.10
	(0.15)	(0.17)	(0.18)	(0.16)	(0.42)	(0.15)
Print × Yr1600	0.13	0.22	0.08	0.16	0.73**	−0.01
	(0.16)	(0.17)	(0.20)	(0.16)	(0.34)	(0.17)
Print × Yr1700	0.19	0.25	0.16	0.22	0.84**	0.00
	(0.14)	(0.16)	(0.17)	(0.14)	(0.42)	(0.15)
Atlantic × Yr1400	0.12	0.27	0.13	0.12	−0.32	—
	(0.31)	(0.33)	(0.37)	(0.31)	(0.52)	—
Atlantic × Yr1500	0.43*	0.55**	0.38	0.44*	−0.24	—
	(0.25)	(0.28)	(0.28)	(0.25)	(0.52)	—
Atlantic × Yr1600	0.42*	0.49*	0.33	0.45**	0.47	—
	(0.22)	(0.25)	(0.24)	(0.22)	(0.38)	—
Atlantic × Yr1700	0.60***	0.73***	0.64***	0.62***	0.32	—
	(0.19)	(0.20)	(0.21)	(0.19)	(0.38)	—
R squared	0.55	0.57	0.58	0.54	0.77	0.53
Observations	1,010	875	710	850	225	785
Adopting Cities	83	71	53	78	16	67
Nonadopting Cities	119	104	89	92	29	90

Causality

- Given the observed positive association between the adoption of print technology and city growth, the natural question is whether printers selected cities that were already bound to grow quickly.
- Distance from Mainz as an instrument for print adoption.
  - It confirms that distance from Mainz was a significant determinant of technology adoption.
  - It documents that there was no statistically significant relationship between distance from Mainz and city growth before the diffusion of the printing press,
  - a highly significant relationship emerged after Gutenberg, and that distance from Mainz was not correlated with other determinants of growth

Causality

No statistically significant relationship between distance from Mainz and city growth before the diffusion of the printing press,

DISTANCE FROM MAINZ AND ECONOMIC OUTCOMES BEFORE AND AFTER GUTENBERG

(1) Regression Model	(2) Log Growth 1400–1500	(3) University in 1450	(4) Log Size in 1500	(5) Log Growth 1500–1600
Log Distance to Mainz	−0.05	0.00	−0.11	−0.03***
	(0.04)	(0.01)	(0.08)	(0.01)
Observations	269	410	410	410
R Squared	0.23	0.12	0.31	0.22

IV

- Distance from Mainz was a significant determinant of technology adoption.
- A highly significant relationship emerged after Gutenberg, and that distance from Mainz was not correlated with other determinants of growth

INSTRUMENTAL VARIABLE ANALYSIS OF PRINTING AND LOG CITY GROWTH

(1)	(2)	(3)
	1st Stage	2nd Stage
	Adopt Print	City Growth
Regression Model	1450–1500	1500–1600
Log Distance to Mainz	−0.06***	
	(0.01)	
Adopt Print 1450–1500		0.58**
		(0.29)
Observations	410	410

Max Weber (1864-1920)

- Founder of sociology
- Most famous work:

  The Protestant Ethic and the Spirit of Capitalism

- Ethics of work and saving
  - Religious foundation unclear
- "Max Weber, in his seminal work, proposed what might be the most famous theory about the impact of cultural factors, namely beliefs about religion and afterlife, on economic growth. Despite its renown, this theory has rarely been tested quantitatively with historical data" (Cantoni 2015).
- Cantoni, Davide. (2015). "The Economic Effects of the Protestant Reformation: Testing the Weber Hypothesis in the German Lands." *Journal of the European Economic Association* 13 (4): 561–98.

Weber in 1918

The economic impact of the Reformation in Germany

- "Following Max Weber, many theories have hypothesized that Protestantism should have favored economic development. With its religious heterogeneity, the Holy Roman Empire presents an ideal testing ground for this hypothesis. Using population figures of 272 cities in the years 1300-1900, I find no effects of Protestantism on economic growth."
- "The finding is precisely estimated, robust to the inclusion of various controls, and does not depend on data selection or small sample size. Denominational differences in fertility behavior and literacy are unlikely to be major confounding factors."
  - Protestantism has no effect when interacted with other likely determinants of economic development.(Instrumental variables estimates, considering the potential endogeneity of religious choice, are similar to the OLS).

Beginning of Reformation

- Sales of indulgences by the Church
  - Financial intermediation by the Fugger family (richest man)
- Martin Luther, monk, lecturer at the University of Wittenberg, posted his objections 95 theses on 31 October 1517 on the door of the local church.
- Objections in previous centuries, but this time:
  - power struggles between the Emperor, the Pope, and the territorial lords;
  - contemporary intellectual networks;
  - technological breakthroughs such as Gutenberg's printing press;
  - ongoing fight against the Turks in Austria.
- First reaction was “benign neglect,” and Luther's pamphlets could spread rapidly.

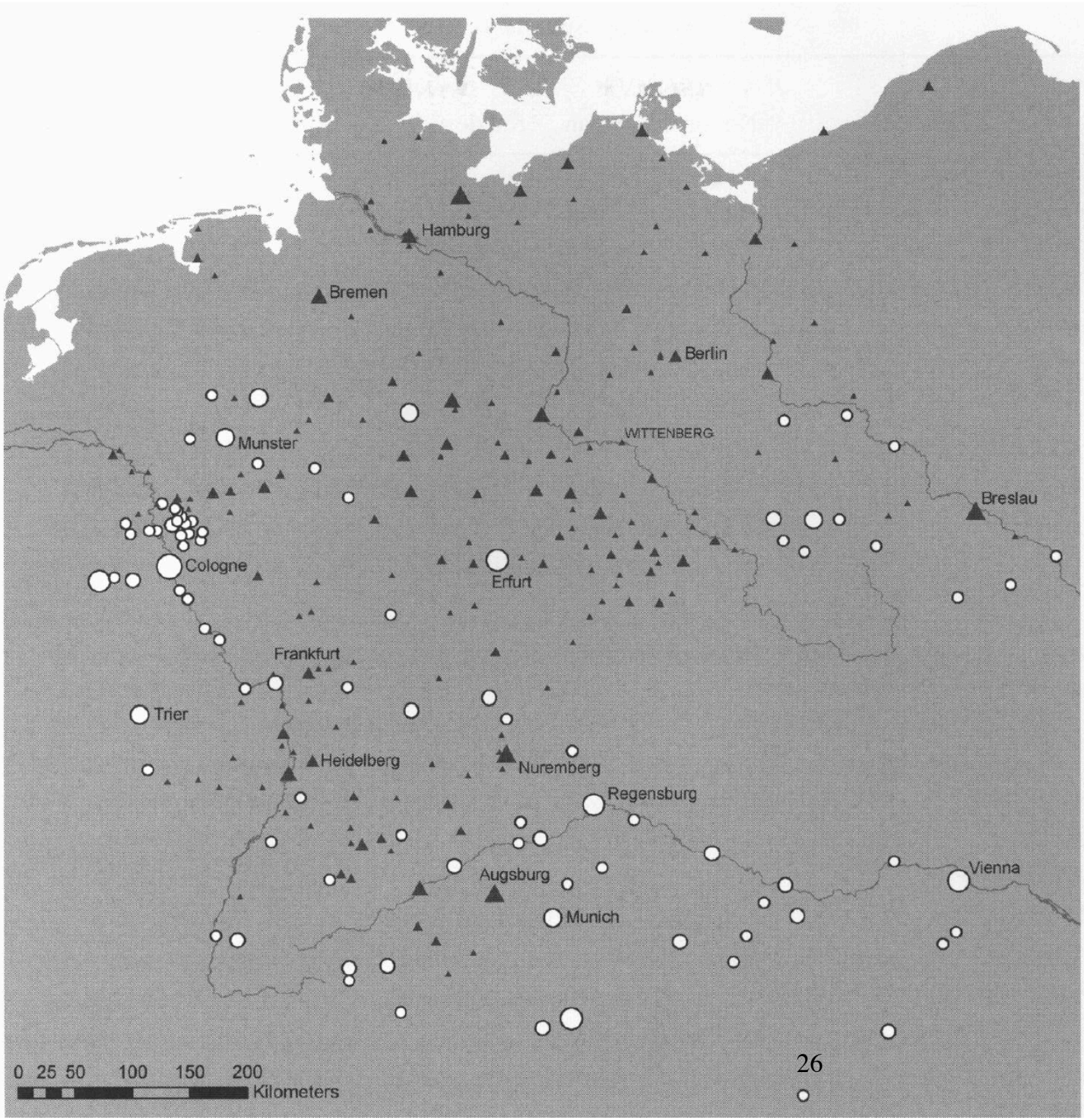
Evolution 1517-1624

- Eventually, sort of a civil war in central Europe: *The Thiry Years War* (1618-1648)
- Treaty of Westphalia (1648):
  - The religion of a region is the religion of its prince: *Cujus Regio ejus religio*
    - (recall the fragmentation of Germany in the Holy Roman Empire)
  - Religions set as of 1624
- Durable separation

TABLE 1. Homogeneity of religious affiliation after 1624.

Territory	Population (1849)	Religion (after 1624)	% Prot. (1849)	% Cath. (1849)
Prince-Bishopric of Münster	329 081	Cat	4.3	94.9
Duchy of Westphalia	191 425	Cat	8.7	90.0
Prince-Bishoprics of Paderborn and Corvey Abbey	160 404	Cat	4.7	92.9
Vest Recklinghausen	46 940	Cat	1.3	98.2
County of Mark	305 182	Pro	78.1	21.0
Principality of Minden and County of Ravensberg	260 096	Pro	97.2	2.1
Principality of Siegen	44 885	Pro	82.3	17.5
Counties of Wittgenstein-Berleburg and W.-Hohenstein	21 463	Pro	94.1	3.9
Free Imperial city of Dortmund	10 515	Pro	71.1	27.1
Lippstadt	4 845	Pro	40.5	58.0
Counties of Tecklenburg and Lingen	42 123	Pro/Cat	55.8	43.6

Circles: Catholic cities
Triangles: Protestant



Determinants of adoption of

	City Protestant in 1600			
Dependent variable	(1)	(2)	(3)	(4)
Distance to Wittenberg	−0.158***	−0.179***	−0.183***	−0.140***
	[0.029]	[0.036]	[0.032]	[0.037]
Distance to Geneva		0.058		
		[0.170]		
Distance to Zurich		−0.100		
		[0.162]		

	ln(City size)			
Dependent variable	(1)	(2)	(3)	(4)
Panel A: Differences-in-differences				
Protestant × Post-1517	0.621*	0.075	0.636	0.611
	[0.361]	[0.408]	[0.520]	[0.567]
Panel B: Structured setup				
Protestant × Post-1517	0.468	−0.110	0.642	0.681
	[0.372]	[0.388]	[0.528]	[0.573]
Protestant × Post-1517 × trend	0.054	0.065	−0.002	−0.024
	[0.145]	[0.150]	[0.240]	[0.256]
p-value for joint significance Protestant	0.182	0.908	0.273	0.337
Panel C: Fully flexible setup				
Protestant × Year 1300	−0.580	−0.335	−0.059	−0.067
	[0.411]	[0.532]	[0.504]	[0.587]
Protestant × Year 1400	−0.481	−0.614	−1.046	−1.038
	[0.414]	[0.491]	[1.166]	[1.245]
Protestant × Year 1600	0.221	−0.461	0.182	0.176
	[0.290]	[0.446]	[0.573]	[0.583]
Protestant × Year 1700	0.364	−0.224	0.739	0.902
	[0.369]	[0.484]	[0.580]	[0.702]
Protestant × Year 1750	0.486	0.213	0.791	0.772
	[0.352]	[0.470]	[0.527]	[0.543]
Protestant × Year 1800	0.234	−0.253	0.259	0.138
	[0.337]	[0.490]	[0.502]	[0.527]
Protestant × Year 1850	0.286	−0.213	0.316	0.276
	[0.356]	[0.479]	[0.527]	[0.548]
Protestant × Year 1875	0.418	−0.195	0.426	0.390
	[0.397]	[0.518]	[0.586]	[0.616]
Protestant × Year 1900	0.482	−0.035	0.419	0.378
	[0.432]	[0.568]	[0.637]	[0.676]

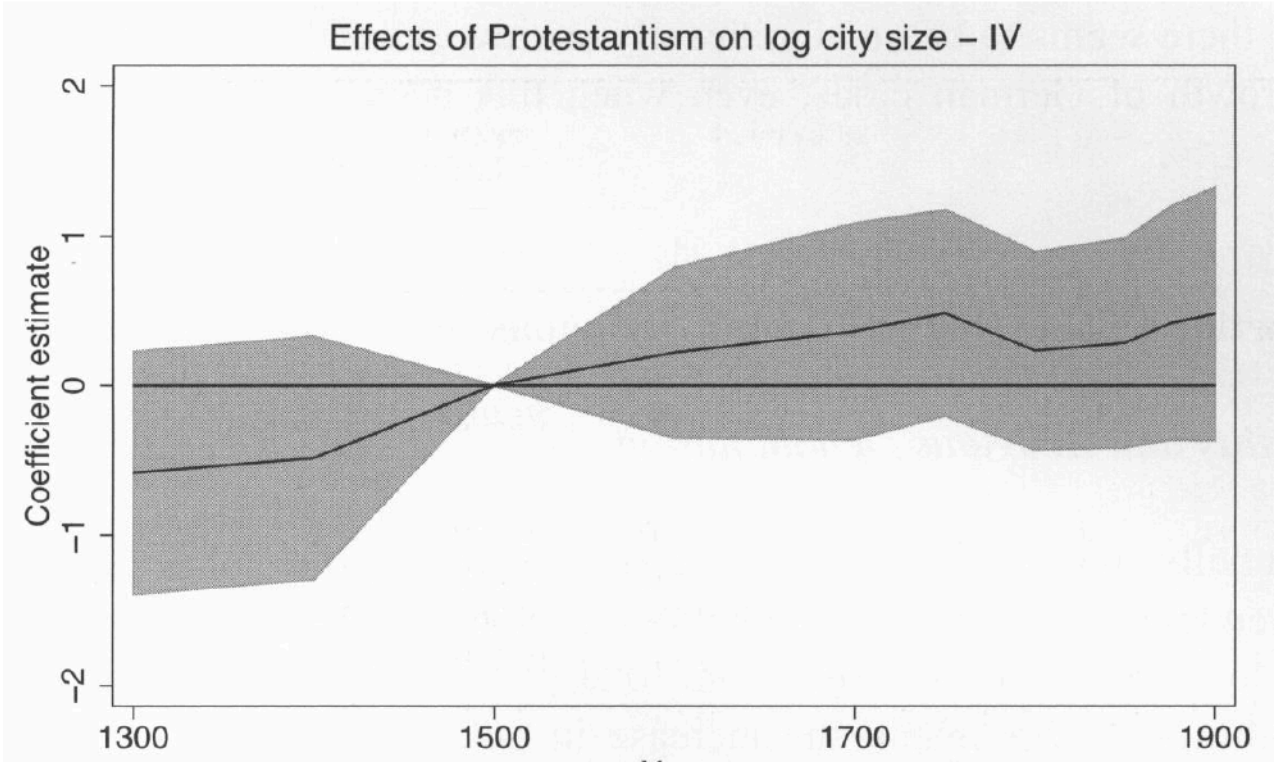

Effects of Protestantism on log city size – IV
Coefficient estimate
2
1
0
−1
−2
1300
1500
1700
1900

TABLE 2. City size and economic outcomes, Prussia 1821.

Dependent Variable	Teacher-student ratio (1)	Fire Insurance p.c. (2)	Business Tax p.c. (3)	Looms p.c. (4)	Merchants p.c. (5)	% houses with stonework (6)	% houses with shingled roofs (7)
Panel A: All cities in the Prussian manufacturing census of 1816–1821							
ln(City size)	0.380***	19.226***	0.153***	–0.041	0.078	0.093***	0.082***
	[0.127]	[2.413]	[0.023]	[0.259]	[0.054]	[0.027]	[0.027]
	0.211	*0.260*	*0.619*	*–0.013*	*0.060*	*0.220*	*0.176*
Observations	157	999	66	168	941	162	162
R-squared	0.044	0.068	0.383	0.000	0.004	0.048	0.031
Panel B: Subset of cities also present in the Bairoch, Batou, and Chèvre (1988) *data set*							
ln(City size)	0.341**	22.289**	0.117***	0.096	0.147	0.082**	0.022
	[0.150]	[9.641]	[0.032]	[0.348]	[0.116]	[0.035]	[0.030]
	0.226	*0.271*	*0.509*	*0.026*	*0.115*	*0.181*	*0.062*
Observations	83	100	29	90	98	87	87
R-squared	0.051	0.073	0.259	0.001	0.013	0.033	0.004

Notes: Robust standard errors are in brackets. Standardized beta coefficient is in italics. A constant term is included in all regressions. Variable definitions: see Appendix A.1; p.c., per capita.
*Significant at 10%; **significant at 5%.
Source: Krug and Mützell (1825).