Coffeehouses and the Rise of Science*

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(Job Market Paper)

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October 31, 2026

Abstract

Historians have long credited coffeehouses, venues for conversation where strangers met across social ranks, with fostering scientific contacts and activity during the Scientific Revolution. We test this claim in seventeenth-century London. Relying on newly geocoded records and a staggered event study across parishes, we find that the opening of the first coffeehouse in a parish is followed by a persistent increase in applied scientists and scientific instrument shops. Effects are concentrated among applied scientists with weak family ties to Oxford and Cambridge. Social connections that link craft skill to theory increase, and new shops turn toward experimental instruments. Across European cities in the seventeenth century, we similarly find that the numbers of applied mathematics titles and scientific instrument makers rise after a city's first coffeehouse, relative to cities of similar size and growth. In a quantitative urban model calibrated to our parish- and city-level estimates, coffeehouses account for 31 percent of London's applied scientists in the half century after the first one opened in 1652. These findings show that social institutions can raise the production and use of knowledge by broadening access to intellectual exchange beyond formal academic networks.

Keywords: Coffeehouses, Scientific Revolution, Knowledge Diffusion, Social Networks

JEL Codes: N33, N93, O31, O33, D83, R12

*We are grateful to Torsten Persson, David Schönholzer, and David Strömberg for their guidance. We thank Mehdi Amani, Alireza Azampour, Sascha O. Becker, Anne Sofie Beck Knudsen, Iacopo Bianchi, Tessa Bold, Konrad Burchardi, Marcel Caesmann, Gregory Clark, David de la Croix, Merve Demirel, Mitch Downey, Vitalia Eliseeva, Valentin Figueroa, Joseph Flavian Gomes, Simon Handreke, Duncan Hay, Brian Higgins, Rebekah Higgitt, Ruixue Jia, Mounir Karadja, Marie Kaul, Martin Koenen, Julius Koschnick, Lukas Leucht, Moritz Lubczyk, Andreas Madestam, Jaakko Meriläinen, Joel Mokyr, Arash Nekoei, J. Peter Nilsson, Artschil Okropiridse, Anders Olofsgård, Casey Petroff, Alessandro Pizzigolotto, Prashant Poddar, Luca Repetto, Jonatan Riberth, Veronica Salazar Restrepo, Theo Serlin, Lina Skoglund, Mara P. Squicciarini, Anna Tompsett, Karine van der Beek, Miriam Venturini, Noam Yuchtman, and Yves Zenou, as well as audiences at IIES, Oxford, Stockholm, Toulouse, the 15th Workshop on Growth, History and Development in Odense, the 4th Workshop in Economic History in Uppsala, SUDSWEC 2025, the EAYE 2026 Annual Meeting, the RIDGE Forum 2026, the SIOE 2026 Conference, the Applied Young Economists' Webinar 2026, and the 4th Yale-UB HPE Workshop for valuable feedback, help, and, not least, encouragement.

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1. INTRODUCTION

Producing new knowledge depends on how much of the existing knowledge stock researchers can access (Iaria et al., 2018; Mokyr, 2002). Though much of the existing knowledge is accessible in print or online, frontier knowledge often contains tacit elements that are difficult to articulate, making face-to-face interaction important for their transmission (Polanyi, 1966). Tacit knowledge is likely to be particularly important in periods when the scientific frontier changes rapidly (e.g., Shapin and Schaffer, 1985). Moreover, access to tacit knowledge depends on access to the relevant social networks, whose formation is shaped by culture, geography, education, family background, and wealth (e.g., Bourdieu, 1986; Glaeser et al., 1992; Jaffe et al., 1993).

Institutions shape who gains that access. On the one hand, institutions such as universities filter access to knowledge exchange to maintain quality and organize exchange within specialized, coordinated communities. On the other, such filtering narrows the pool of potential researchers. Broadening access could raise knowledge production and use by drawing in a reserve of talent that would otherwise be lost (e.g., Agarwal and Gaule, 2020; Bell et al., 2019; Husén, 1974; Stephan, 1996), especially when those outside filtering institutions possess valuable, tacit know-how. Yet, broadened access is seldom random, and we rarely have data to trace long-run effects.

This paper exploits the rise of a new social institution in English society, the coffeehouse, to overcome these difficulties. It was one of several such institutions during the seventeenth and eighteenth centuries, alongside French salons and German table societies, which are credited as transformative developments in early modern Europe (e.g., Clark, 2000; Cowan, 2005; Mokyr, 2016). Habermas (1991 [1962]) placed their introduction at the origin of the bourgeois "public sphere," and singled out the coffeehouse as a catalyst of Enlightenment thinking, a public, interactive, middle-class space where reason, rather than social rank, shaped debate. The coffeehouse "not merely made access to the relevant circles less formal and easier; it embraced the wider strata of the middle class, including craftsmen and shopkeepers" (Habermas, 1991 [1962], p. 33). Mokyr (2005) argues that coffeehouses, among other social institutions, reduced access costs to "useful knowledge" oriented toward progress at the intersection of science and technology. This paper asks whether coffeehouses fostered intellectual progress by broadening access and, if so, how.

We answer these questions by studying coffeehouses and science in seventeenth-century London, home to one of the first coffeehouses in Europe in 1652 and a center of the Scientific Revolution. In this context, much of the new experimental science relied on tacit knowledge. Its experiments ran on scientific instruments, and the skill to make them lay with craftsmen who learned it by apprenticeship and rarely wrote it down.

Coffeehouses spread suddenly and unevenly, parish by parish, from the first in 1652, and rich historical records track scientific activity over the subsequent decades. For the price of a cup of coffee, a penny or about one-tenth of a day's wage, strangers conversed across social ranks, earning coffeehouses their famous nickname, "penny universities" (Ellis, 1956). In the analysis to follow, we focus on their effects on mathematical practitioners, the applied scientists of the period, recorded as teaching mathematics, writing on it, or making instruments, and on the shops that made, repaired, and sold those instruments.[1] Their work, seeking understanding while shaped by use, is what

[1]Instead of counting applied scientists, several studies of institutions and knowledge measure

Stokes (1997) would call use-inspired basic research.

The idea that coffeehouses broadened access to knowledge dates to John Houghton (1645–1705), a Fellow of the Royal Society, who observed (1727 [1701], p. 132):

> Coffee-houses make all sorts of people sociable, the rich and the poor meet together, as also do the learned and unlearned: It improves arts, merchandize, and all other knowledge; for here an inquisitive man [. . .] may get more in an evening than he shall by Books in a month.

We take Houghton's thesis to the historical record. To do so, we hand-geocode every coffeehouse, mathematical practitioner workplace, and scientific instrument shop with a recorded address, using digitized seventeenth-century maps and gazetteers. This places these records within the 162 parishes of London and yields a parish-by-decade panel from the 1600s through the 1690s. We also use practitioners' biographies to reconstruct the social connections between them, from friendship and apprenticeship to correspondence and consultation. Coffeehouses, practitioners, and instrument shops come from three separate compilations assembled from different historical records by different authors, so our results are not merely an artifact of a single work or author.

We begin by estimating, in a staggered event study design, the effect of the first coffeehouse in a parish. We find that its opening is followed by a persistent increase in mathematical practitioners and scientific instrument shops. We then trace the channels. Effects are concentrated among practitioners with weak family ties to Oxford and Cambridge, connections increase between practitioners with craft skill and those with the knowledge to teach and develop theory, and new shops turn toward experimental instruments. Beyond London, applied mathematics titles and scientific instrument makers also rise after the first coffeehouse in European cities, relative to cities of similar size and growth. Finally, in a quantitative urban model, coffeehouses account for 31 percent of London's applied scientists between the 1650s and the 1690s. These results suggest that institutions need not codify knowledge or screen members to raise its production. An open venue for conversation could do so by broadening access to intellectual exchange beyond formal academic networks.

As Figure 1 shows, coffeehouses appeared when a sustained rise in the number of practitioners and instrument shops began. These trends coincided with a cultural shift toward quantification. Kelly and Ó Gráda (2022) show that the publication of applied mathematics titles more than doubled in the 1650s, interpreting this as a rise in demand as navigational and surveying technologies came into widespread use. In the same decade, language oriented toward progress began to rise (Almelhem et al., 2026).[2] Historians likewise document these shifts and emphasize coffeehouses as a central driver of them (e.g., Ellis, 2006; Jacob, 1997), but without providing quantitative evidence.

However, the staggered and incomplete distribution of coffeehouses within London helps separate the effect of these venues from rising aggregate demand. The parishes of

innovation with patents (e.g., Berkes and Nencka, 2026; Cinnirella et al., 2025; Hanlon et al., 2022). However, using patents is not feasible here. Of the 365 English patents of 1617–1699 in the data of Berkes et al. (2026), 34 name a patentee in London and five concern instruments or timekeepers, against 345 instrument shops in our London data. Instrument making relied on secrecy. Even at the Great Exhibition of 1851, only 10 percent of British instrument exhibits were patented (Moser, 2013).

[2] Appendix Figure D19 adds applied mathematics titles and the average progress score in England to Figure 1.

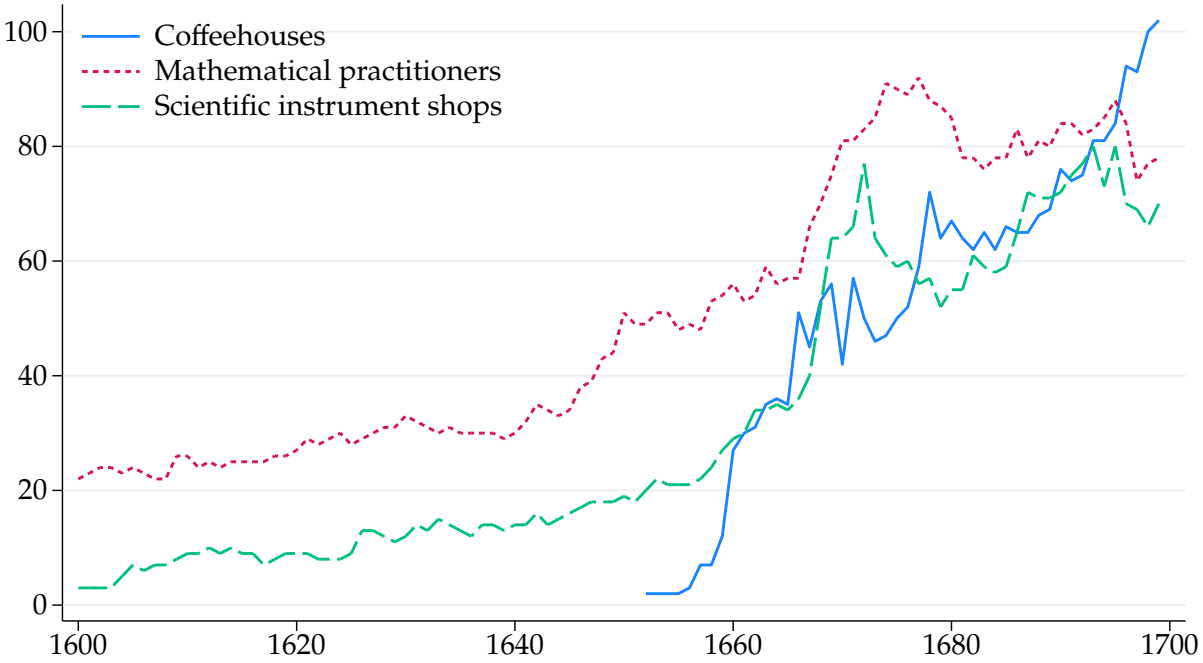


FIGURE 1. COFFEEHOUSES AND SCIENCE

Notes: Figure plots the number of coffeehouses, mathematical practitioners, and scientific instrument shops active in each year in seventeenth-century London. Coffeehouses are from Lillywhite (1963, 1972), practitioners from Taylor (1954), and instrument shops from Clifton (1995) and Hay et al. (2025). [Return to pages 2, OA-7, OA-81]

London are small units, and 97 of the 162 lie within the City walls alone, so a parish that received a coffeehouse and one that did not were often only a few streets apart. Of the 162 parishes, 101 have no coffeehouse recorded before 1700. We compare activity before and after the first recorded coffeehouse with changes in these never-treated parishes, using the staggered, heterogeneity-robust event study estimator of Wooldridge (2023).

We find large and persistent local effects on both measures of scientific activity. The 61 treated parishes averaged 0.62 mathematical practitioners in the decade before entry, and over the decade of entry and the four decades after, the number roughly doubles, to 1.30. Scientific instrument shops also rise, from 0.33 to 1.57, or nearly fivefold. Despite data scarcity, these effects are precisely estimated and significant. On growth, from the 1640s to the 1690s, London gained 68 practitioners and 136 instrument shops, and the estimated effects in the 1690s, summed over treated parishes, equal 49 percent of the first increase and 63 percent of the second. Relative to total activity, coffeehouse openings account for 20 percent of practitioner-decades and 46 percent of instrument shop-decades between the 1650s and the 1690s.

There are a number of threats to our identification strategy. Coffeehouse openings may coincide with other local shocks or anticipate local growth; change which practitioners enter the historical record; matter only as one more meeting place rather than through the characteristics of the coffeehouse; or have effects that spill over onto neighboring parishes or draw scientists away from them. We address each of them in turn.

One potential challenge to a causal interpretation of our results, then, is that, of course, coffeehouses did not open at random. The historical record suggests that entry followed commerce, as proprietors favored commercially active sites (Cowan, 2005,

pp. 156–161). Though coffeehouse keepers belonged to mercantile networks apart from the mathematical practitioners, treated parishes began with more commerce and more practitioners and instrument shops. Parish fixed effects absorb such differences in levels, but coffeehouses may also have opened where science was about to grow, or together with commercial or other local shocks. Before first openings, however, practitioners and instrument shops moved in parallel with those in parishes in which no coffeehouse opened, while commerce was rising faster. Looking at placebo outcomes, we find that population density, luxury shops, letters of non-scientific correspondents within the elite Republic of Letters, and taverns do not respond to entry, which weighs against a commercial or population boom, an inflow of the affluent or of established scholars, and a general rise in meeting places.

Survival in the historical record raises a separate concern, as coffeehouses could make existing practitioners more likely to appear in it, for instance through advertisements, imprints, and correspondence. However, the largest response appears among instrument shops, which are often recorded through signed instruments and guild records. In addition, the main estimates remain robust when we omit, in turn, coffeehouses first recorded in each type of historical source (e.g., diaries, trade tokens, and parish records), and when we allow separate trends for areas affected by the Great Fire, which speak to spatially differential record loss. Other robustness checks, including randomization inference, Conley standard errors, separate trends inside the London Wall, detrending within cohorts, leave-one-parish-out estimates, and alternative treatment timing, geographic units, control groups, and estimators, all yield similar conclusions.

As a placebo treatment, earlier tavern openings produce no comparable increase, which speaks against the idea that the coffeehouse was just another meeting place. Coffeehouses also did not matter for lack of other venues, as coffeehouse parishes already had 3.0 taverns on average before 1652, against 0.5 elsewhere. In addition, a textual analysis of our transcription of the diary, written 1672–1683, of the most connected practitioner, Robert Hooke (1635–1703), shows that the words he wrote after naming a coffeehouse are about discourse, and those after naming a tavern are about claret and payment.

Coffeehouses could also raise activity in neighboring control parishes, which would bias our estimates downward. Comparing changes from the 1640s to the 1690s on a grid of hexagons 200 meters across, we find positive spillover effects of an opening and that these effects are concentrated in its own hexagon and the adjacent ones.[3] Another concern is that the parish estimates do not show whether London as a whole gained scientists, since coffeehouses might simply have drawn scientists from control parishes or from outside London. Three patterns weigh against this interpretation. First, London's share of England's practitioners rose, but their number elsewhere in England rose too, so London did not grow only at the expense of the rest of the country. Second, the immediate neighborhood of an opening gained scientists, whereas moves from nearby parishes would leave the neighborhood with fewer scientists, not more. Third, separating practitioners and instrument shops first recorded in our data from those that moved from elsewhere in London, we find that moves account for 16 percent

[3]The short range might seem surprising. However, most adjacent hexagons lie in treated parishes, so the parish estimates already contain most of their gain, and the distance is not far off the habits of Hooke, as about three-quarters of the located coffeehouse mentions in his diary lie within 400 meters of his lodgings.

of the local effect for practitioners and 38 percent for instrument shops.

Turning to mechanisms, we find evidence consistent with three channels. Effects are strongest among practitioners whose surnames were least represented at Oxford and Cambridge, which points to wider access to science. Connections among makers, and between makers and theorists, rise, linking craft skill to the development and dissemination of theory. Relatedly, Hooke's diary records meetings with 2 more people on days he visited a coffeehouse than on other days in the same year and on the same weekday (against a mean of 3 on days without a coffeehouse), about two-thirds of them from outside the elite correspondence network of the Republic of Letters. Shops producing experimental instruments such as microscopes and air pumps rise too, and proportionally faster than shops producing practical instruments for measurement and navigation, from a smaller base, consistent with makers learning what the new experimental science demanded. Beyond these three channels, we find evidence that coffeehouses put practitioners into circulation within a wider ecology of applied science. Coffeehouse parishes see more works, more instrument-maker apprentices, and more Fellows of the Royal Society.

The London pattern also appears elsewhere in Europe. Taking the first coffeehouse in a city as marking a shift toward open sociability and cheaper access to knowledge exchange, we construct new data on the first coffeehouses in 200 European cities. We find that applied mathematics titles and scientific instrument makers rise after the first coffeehouse, relative to cities of similar size and growth. In the 37 cities with a coffeehouse before 1700, titles rise by 4.97 on a pre-entry mean of 5.95, and makers by 4.89 on a mean of 3.73. We read these as conditional correlations, not causal effects. Nevertheless, they neither exhibit pre-trends nor rest on London, and they reduce concerns about relocation, since activity shifting between London parishes is easy to imagine, but between London, Paris, and Munich it is not.

To quantify the aggregate implications of coffeehouses for science in London, we build a quantitative urban model with two blocks. The first formalizes the coffeehouse as a meeting technology. Applied scientists in two parishes meet at a rate that falls with the distance between them and rises with a coffeehouse at either end. In the second, potential entrants to science choose whether to practice it and, if they enter, in which parish, given the returns to science each parish offers, which rise with access to coffeehouses through the first block. We prove that the first block yields an estimable gravity equation for the practitioners' connections documented between parishes. The second block gives two elasticities, of location and of entry into science. We calibrate the elasticity of location by indirect inference, chosen so that the model reproduces the parish event study, and the elasticity of entry, which we cannot identify within London, to the rise after a first coffeehouse in European cities, assuming that scientists did not move between cities. The model then implies that coffeehouses account for 31 percent of London's applied scientists from the 1650s to the 1690s, and that 23 percent of the gain in parishes with a coffeehouse came from elsewhere in London, the rest from new entrants.

Contribution to the Literature. This paper contributes to several strands of literature. First, whether coffeehouses changed who did science has been debated since Houghton (1699). Historians often associate the coffeehouse with London science. Cowan (2005, p. 260) calls it "the product of the cultural world forged by the virtuosi," while Stewart

(1999) describes particular coffeehouses as "other centres of calculation" alongside the Royal Society. We provide, to our knowledge, the first causal quantitative evidence that coffeehouses increased scientific activity, using novel data. We also show that, by drawing more people from outside formal academic networks into science, coffeehouses broadened participation in applied science. This parallels evidence that childhood exposure to innovation affects who becomes an inventor (Bell et al., 2019).

Second, recent work places the onset of sustained productivity growth in England most likely in the first half of the seventeenth century (Bouscasse et al., 2025) and the rise of progress-oriented language in its second half, which reached the nexus of science and political economy during the Enlightenment (Almelhem et al., 2026). We add to this work the coffeehouse, a social institution that arrived in London in 1652, at the onset of modern growth, and raised applied science where it opened.

Third, institutions that widened access to useful knowledge, and reduced the frictions in producing it, come in two kinds (e.g., Dowey, 2017; Galofré-Vilà, 2023). Some codify knowledge and carry it across distance (e.g., Mokyr, 2002): the printing press (Dittmar, 2011, 2019), the postal networks of the Republic of Letters (Cervellati et al., 2026; Melillo et al., 2026), the encyclopedias of arts and trades (Squicciarini and Voigtländer, 2015), the Uniform Penny Post of 1840 (Hanlon et al., 2022), the Carnegie libraries (Berkes and Nencka, 2026), and the state translation programs of Meiji Japan (Juhász et al., 2026). Others organize exchange within a bounded membership: universities and academies (de la Croix et al., 2025; Koschnick, 2025b), and economic societies (Cinnirella et al., 2025). Coffeehouses did neither. Instead, they lowered the cost of repeated face-to-face contact across segmented communities that otherwise met only in specialized settings of their own. Modern evidence finds high returns to contact of this kind (e.g., Andrews, 2026; Andrews and Lensing, 2024; Atkin et al., 2022; Boudreau et al., 2017; Campos et al., 2018; Catalini, 2018), and network evidence documents spillovers beyond the people directly exposed (Fluegge and Bailey, 2024). The rise in connections we document gives one way that urban density could raise knowledge production (Carlino and Kerr, 2015; Glaeser, 1999), at the scale of streets and parishes rather than towns (Cox and Figueroa, 2025), much as the gains from networking among advertising agencies decay within southern Manhattan (Arzaghi and Henderson, 2008) and academic research spills over into the R&D of nearby firms (Bergeaud et al., 2025). Our results thus offer empirical support for, and color to, the view of Fleck (1979) and Mokyr (2016) that scientific knowledge is produced in interaction among people, not by individuals alone.

Fourth, better information technology does not retire the tacit margin. Today, access to codified knowledge has grown steadily cheaper, most recently through the internet (Goldfarb and Tucker, 2019) and frontier AI (Stanford Institute for Human-Centered Artificial Intelligence, 2026), but these advances do less for tacit knowledge, which travels with people rather than with texts (Storper and Venables, 2004). Seventeenth-century London had the printed book, yet the coffeehouse still changed how many and who did science. The gap between what academic publishing carries and what researchers know is rapidly increasing with AI. As Tao (2026, p. 7) argues, a mathematical proof polished by an AI can be "easy to read and hard to learn from," because the friction a human author leaves on the page carries part of the tacit knowledge of a field. Hence, with AI-driven codification, venues for tacit exchange may matter more, not less.

Finally, what enlarged the number of people who translated scientific knowledge into practice is unsettled. Zilsel (1942) attributed the rise of the early modern mathematical

practitioner to a weakening separation between university scholars and artisans, Taylor (1954) to demand from navigation, warfare, and surveying, and Kelly and Ó Gráda (2022) document how far practical mathematics spread. Related work traces tacit skill through apprenticeship (de la Croix et al., 2018), the skilled implementers behind industrial technological change (Meisenzahl and Mokyr, 2012), and the later emergence of professional engineers (Hanlon, 2025). Much of this learning by apprenticeship took place in guilds that guarded member skills as the "mystery" of a trade (Ogilvie, 2019, pp. 571–572). Some see in such skill a link between the Scientific and the First Industrial Revolutions (Jacob, 1997; Kelly et al., 2023; Kelly and Ó Gráda, 2022), and Ó Gráda (2016, p. 235) argues that the human capital behind the Industrial Revolution lay mainly in the skills of craftsmen rather than in Newtonian science. Focusing on London between 1550 and 1630, Cormack (2017) documents a vibrant practical mathematical community in shops, in lectures, and among merchants, and treats the later coffeehouse as one more venue for a sociability that was already there. We provide causal evidence that the coffeehouse did more for science than just rehouse that sociability. Coffeehouses connected established centers of knowledge to a wider body of skilled men, giving institutional content to accounts that link the associational world of Britain to the diffusion of useful knowledge (Habermas, 1991 [1962]; Clark, 2000; Iliffe, 1995; Jacob, 1997; Mokyr, 2016; Squicciarini and Voigtländer, 2015). The practitioners and makers whose numbers rose are among those that accounts of Britain's later technological change partly credit for it (Meisenzahl and Mokyr, 2012; Mokyr, 2016). Their price of entry was a penny rather than a university place.

Roadmap. The paper proceeds as follows. Section 2 provides the historical background. Section 3 describes the data. Section 4 estimates the local effects of coffeehouses on science in London. Section 5 examines the mechanisms underlying these effects. Section 6 extends the analysis to Europe to document the rise in science in cities with coffeehouses relative to other cities of similar size and growth. Section 7 builds a quantitative urban model to quantify the coffeehouse effect on London as a whole. Section 8 concludes.

2. BACKGROUND

This section describes seventeenth-century London and then traces the history of its coffeehouses and their relationship to science.

2.1. Seventeenth-Century London

In the early 1600s, London was a booming commercial hub with dense trade networks, skilled artisans, and a vibrant community of merchants and instrument makers closely connected to practical science (Cormack, 2017; Harkness, 2007; Shaw-Taylor et al., 2024). The population surged from 200,000 in 1600 to 475,000 by 1670 (Wrigley, 2010, p. 61) while England shifted from centuries of stagnation to sustained productivity growth (Bouscasse et al., 2025). Urbanization and the rise of wage labor increased disposable incomes, expanding demand for new consumer goods and exotic imports (Lake and Pincus, 2006). Coffee was one such import, reaching the city through contact with the Ottoman Empire, where a coffeehouse culture had flourished since the 1500s (Hattox,

2014). English travelers described the drink from 1600, and coffee consumption in England is first recorded in the late 1630s (Cowan, 2005, pp. 5, 25). Merchants of overseas trading companies, such as the Levant Company, founded in 1592, encountered coffee abroad but were slow to sell it at home. Natural philosophers and other curious gentlemen, who counted Francis Bacon (1561–1626) among their intellectual forebears, were the first in England to write about coffee, drink it, and promote it (Cowan, 2005, pp. 11, 14, 55–56).

2.2. Coffeehouses



Figure 2. A seventeenth-century London coffeehouse

Notes: Drawing by an unknown artist, c. 1690–1700, showing the interior of a London coffeehouse. Customers sit at communal tables, reading, conversing, and drinking, while a maid keeps the bar and coffee boys serve. British Museum, 1931,0613.2. [Return to page 8]

Coffeehouses emerged in England in the 1650s as a novel kind of public house, similar to taverns, inns, and alehouses, where people could converse, exchange ideas, and build trust (Figure 2). In his *Ephemerides* (1654), Samuel Hartlib (c. 1600–1662), a noted promoter of science, recorded the opening of "a cuphye-house or a Turkish, as it were ale-house" near the Old Exchange (quoted in Cowan, 2005, pp. 25–26). Although other social institutions, such as taverns, bookshops, and artisanal workshops, already provided settings for conversation and exchange, what set the coffeehouse apart was its combination of familiar sociability with coffee. Like wine and ale, coffee encouraged conviviality, but in contrast to them, coffee spared customers the fog of intoxication. Travelers to the Orient, and natural philosophers inspired by them, had credited it with sharpening the wits since before the 1650s, and as it spread in London, physicians,

writers, and politicians began to praise it as a sober stimulant that increased productivity, while increasingly associating alcohol with disorder. Coffeehouses prospered on this promise of a social beverage suited to clear thought (Cowan, 2005, pp. 18–21, 44–46).[4]

That appeal first took physical shape in 1652, when Pasqua Rosée, a Greek servant of the Levant Company merchant Daniel Edwards, opened the first coffeehouse in London.[5] To attract customers, Rosée (1652) circulated a handbill advertising the virtues of coffee, claiming the beverage "quickens the Spirits, and makes the Heart Lightsome" and "is excellent to prevent and cure the Dropsy, Gout, and Scurvy." The idea spread quickly. By 1663, there were 82 coffeehouses in the City of London (City of London Magistrates, 1663). One penny, about £1.10 or $1.45 in 2025 prices, bought a cup of coffee; two pence could cover a longer visit (Peacham, 1677).[6] At these prices, men below the elite could afford a seat, and coffeehouses became sober public rooms for news and knowledge exchange (Cowan, 2005, pp. 52, 87).

On his first visit to a coffeehouse in Cornhill, on 10 December 1660, Samuel Pepys (1633–1703) found "much pleasure in it, through the diversity of company and discourse" (Pepys, 1660–1669). Over the course of the 1660s, coffeehouses became part of everyday urban life, as Fellows of the Royal Society gathered at Garraway's Coffee House and merchants met at coffeehouses near the Royal Exchange. In 1666, the growing influence of coffeehouses so alarmed Charles II that he considered banning them (Cowan, 2005, pp. 194–195). Their blend of low cost and lively discussion earned them the nickname "penny universities," as is vividly echoed in the London broadside *The Triumphs of London* by poet Thomas Jordan (1675):

> So great an university,
>
> I think there ne'er was any;
>
> In which you may a scholar be,
>
> For spending of a penny.

Habermas (1991 [1962]) expands on this view by presenting English coffeehouses as the embodiment of an emerging "public sphere" in early modern Europe, where debate ranged from literature to politics to philosophy. Mokyr (2005, p. 312) strikes a similar note, portraying the coffeehouse as a natural gathering point for polymaths and practical men alike, a site of learning and literary and political discussion. "Much of the improved access to useful knowledge," he writes, "took place through informal meetings [. . .], in coffee houses and pubs, improvised lectures, and private salons."

[4]Some contemporaries doubted that coffeehouses served learning. The Oxford antiquary Anthony Wood (1632–1695) asked in 1678 why "solid and serious learning" declined at the university, and answered: "because of coffey houses where they spend all their time" (Wood, 1892, vol. 2, p. 429).

[5]Pasqua Rosée's Coffee House is often described as the first coffeehouse in London, and sometimes as the first coffeehouse in Christian Europe. The latter claim is contested by sources that credit an Oxford establishment as the first coffeehouse. These sources cite Anthony Wood's diary, which in a revision made in 1671 reports that a Jewish man named Jacob opened a coffeehouse near the Angel in Oxford, a claim that a later editor dated to 1651. Coffeehouse historian Ellis (2004, p. 30) disputes this attribution and argues that Wood's entries show that coffee was sold in Oxford but do not establish the existence of a public coffeehouse.

[6]Price conversion uses the retail-price series from Clark (2026). Assuming 300 paid workdays per year, the average-earnings series from the same source implies that one penny was roughly 10 percent of a day's earnings. It was a meaningful unit of everyday spending, enough for the weekly news-books or a cucumber (Peacham, 1677).

The social impact of coffeehouse culture shows most clearly when juxtaposed with earlier social norms. As Cowan (2005, pp. 101–105, 112) explains, coffeehouses, rather than alcohol-centered public houses, became key venues for elite exchange. In early seventeenth-century England, the virtuosi (natural philosophers and scholars) tended to gather in aristocratic great houses, where interactions were formal and exclusive. Coffeehouses, by contrast, encouraged informal, cross-class dialogue and, as such, challenged traditional pathways to intellectual recognition. For less wealthy aspiring virtuosi, coffeehouses provided unprecedented access to information and social networks.

That access mattered more than the drink. Though coffee was consumed mainly in coffeehouses rather than at home (Withington, 2020, p. 59), there was no abundance of it. In the mid-1680s, English imports could have supplied at most about 50,000 people with half a liter a day, some 1.5 percent of the population in England aged fifteen or over (Smith, 2001, pp. 252–253). In any case, what the coffeehouses supplied, beyond the physiological effects of coffee, was an institutional setting: accessible and predictable venues that lowered the cost of communication between theorists, craftsmen, and entrepreneurs from different social backgrounds, and that diffused new norms of civility and intellectual openness (Klein, 1996).

2.3. Diffusion, Reception, and Clientele

The spatial diffusion of coffeehouses followed the commercial and institutional geography of London (Cowan, 2005, pp. 156–161). Early coffeehouses clustered near the Royal Exchange, Fleet Street, and the Inns of Court, just beyond the western wall of the City, where merchants, printers, and lawyers worked. Coffeehouses then expanded from these areas into nearby neighborhoods as proprietors captured foot traffic and repeat customers.

Public reception reflected both the coffeehouse's role as a site of collective discussion and its positioning as a sober alternative to traditional public houses (Cowan, 2005, pp. 45–46). By promoting coffee as a means of fostering sober, rational discourse, proprietors shaped customers' expectations of the coffeehouse. The news, opinion, and rumor that coffeehouses concentrated also drew the attention of authorities in periods of political instability, and regulatory efforts to curb coffeehouse culture focused on publicity rather than consumption (Cowan, 2005, pp. 193–224).

Coffeehouse clientele was broad, reaching beyond natural philosophers and merchants to a wider urban audience, but bounded (Cowan, 2005, pp. 255–256). Participation required modest means, literacy, and conversational competence, excluding much of the urban poor. Women were largely absent as customers, though present as proprietors or workers (Cowan, 2001). Before the 1650s, scientists had limited ties to merchants, and historical evidence suggests that the emergence of coffeehouses was not driven by changes in scientific or intellectual life.[7] Coffeehouses thus connected commercial, intellectual, and technical communities.

[7]Among the 31 mathematical practitioners of Taylor (1954) whose recorded flourishing ends before 1650 and whose connections Warren et al. (2016) infer from the Oxford Dictionary of National Biography (2025), only 18 of 562 recorded connections are commercial, and only 9 practitioners had any such connection (Appendix Table A4). The same dictionary places the early coffeehouse keepers in mercantile networks, and none of its biographies connects them to science (Appendix A.1).

2.4. Relation to Science

In January 1684, at a London coffeehouse, Robert Hooke, Christopher Wren (1632–1723), and Edmond Halley (1656–1742), all Fellows of the Royal Society, met to discuss the nature of the force that keeps planets in orbit (Mount, 2021, pp. 145–146).[8] Hooke claimed to have discovered the inverse-square law but did not provide a demonstration. Wren offered a prize for a proof, which Hooke failed to deliver. Halley, seeking a resolution, visited Isaac Newton (1643–1727) in Cambridge later that year. Newton replied that he had already solved the problem, and later sent Halley a manuscript that became the foundation for his *Principia* (1687).

Coffeehouses gave such conversations a setting alongside the Royal Society, and one that was easier to enter. Hooke's diary is filled with references to London coffeehouses, which he visited on nearly two of every three days. As Iliffe (1995) demonstrates, Hooke used these spaces to build networks, exchange technical information, examine machines and instruments, and conduct business. After one such meeting with Wren at Man's Coffee House, on 21 August 1678, Hooke sketched in his diary the four devices the two had described to each other, among them a "poysd weather glasse" and his own "philosophicall spring scales" (Robinson and Adams, 1935, pp. 372–373). Two of the four were Wren's. Another example is Hooke's relationship with the cartographer John Ogilby (1600–1676), for whom he "designd sheets for London" at Garraway's Coffee House on 14 August 1673. Two months later, he "[s]hewd him the way of Letters for marking his map and also the way of shadowing" there (Robinson and Adams, 1935, pp. 55, 65).

Coffeehouses complemented rather than replaced print. Though books carried mathematical and technological insights, those insights reached readers slowly. In contrast, in coffeehouses, news and claims spread daily through repeated conversation, where they could be discussed, demonstrated, and combined with hands-on expertise (Higgitt et al., 2024; Johns, 2006), while repeated meetings built the trust and social capital on which such exchange depended (Shapin, 1994). Coffeehouses became places where information was gathered and compared, what Stewart (1999) calls "other centres of calculation." This expertise was spread across overlapping networks of natural philosophers, mathematical practitioners, and artisans, who worked in coffeehouses, workshops, shops, and institutions (Higgitt et al., 2024, pp. 8–9, 19–20). Since all of them were now incentivized to enter the same room for a penny, a coffeehouse could connect what each network held.

Instrument production remained largely commission based: guild apprenticeships transmitted craft and commercial knowledge, while advertising connected makers with professional users (Bryden, 1992; Crawforth, 1987; Stewart, 2005). The guild itself met in coffeehouses. The Clockmakers' Company held its Feast at the George in Ironmonger Lane in 1672 and its ordinary meetings there until 1698, and its Search Court sat at the Angel and Crown in Threadneedle Street and at the Crown in West Smithfield (Lillywhite, 1963, entries 44, 317, 1751).[9] Whether or not coffeehouses created skill, they broadened who took part. This was especially so for craftsmen whose skill

[8] It is an open question where the three met. Mount (2021, pp. 145–146) places the meeting at Garraway's Coffee House.

[9] Other companies met in coffeehouses too, among them the Pewterers at Kiftell's in Cheapside in 1677–1678 and the Ironmongers and the Basket Makers at North's in King Street (Lillywhite, 1963, entries 670 and 914).

passed by demonstration rather than through books. The clockmaker Thomas Tompion (1639–1713), the son of a Bedfordshire blacksmith, illustrates this point clearly. He had skill but no place in scholarly networks when he began working with Hooke. At Child's Coffee House on 27 June 1674, Hooke described new dividing compasses and other mechanisms to him. At Garraway's Coffee House on 8 March 1675, Hooke showed Tompion how to fix double springs inside a balance wheel. Tompion brought clockwork to Hooke six days later, and on 7 April they showed Hooke's new spring watch to Charles II (Robinson and Adams, 1935, pp. 109, 151–157; Appendix Figure A2). While Hooke brought scientific problems and designs, Tompion built, tested, and revised them. The collaboration became a mutual exchange of techniques and skills (Iliffe, 1995, p. 311), and it carried Tompion into science: in 1676 he made the two year-going clocks for the new Royal Observatory at Greenwich. The episode attests to how coffeehouse meetings could combine insights held by people with different skills and backgrounds and, more broadly, how they could raise the chance that craftsmen, who had the skill to make the instruments the new experimental science needed, would meet the scholars who brought its questions.

Coffeehouses also hosted disputes over experimental philosophy. Shapin and Schaffer (1985, pp. 292–293) document that Tillyard's Coffee House in Oxford served as a venue for an experimental group and chemistry lectures, and that a dispute over barometric phenomena at a London coffeehouse was discussed in a 1662 pamphlet. Read within their account of experimental knowledge as a product of instruments, credible witnessing, and communication, the coffeehouse is a social setting that extends the institutionalization of science into the public sphere, beyond laboratories and the Royal Society, rather than replacing them.

This exchange rested on the broader knowledge economy of London. Beeley (2019, p. 225) describes London's mathematical practitioners as an interdependent community spanning teachers, instrument makers, printers, booksellers, merchants, and even mathematical clubs, known contemporaneously as "the London mathematicians" in distinction to their academic counterparts at Oxford and Cambridge. One of these London mathematicians was John Collins (1625–1683), who exemplifies the brokers within this community. He circulated manuscripts, arranged publication, identified relevant expertise, and connected practical problems with mathematicians and instrument makers (Beeley, 2017). Though Collins held no university position, he and others like him could repeatedly interact through coffeehouses with those more closely tied to elite intellectual networks. Hooke's diary places Collins in coffeehouse company throughout the 1670s. At the Spanish Coffee House on 18 April 1674, Hooke noted, "Collins shewd me the 3rd book of Kerseys algebra," the treatise the London teacher John Kersey had just published (Robinson and Adams, 1935, pp. 67, 98, 392). The printer Joseph Moxon (1627–1691) stood further outside the academic establishment. Hooke met him at Man's, Garraway's, and Child's Coffee Houses from 1674 to 1680, and Moxon moved from printing into globes, instruments, and mathematical books. In 1678 he was elected to the Royal Society, an exceptional election for a tradesman (Robinson and Adams, 1935, pp. 90, 286–287, 383, 401, 436; Appendix Table A1).

Stewart (1999) more broadly documents that coffeehouses, while circulating print materials, set aside rooms for meetings, lectures, and discussions, serving as important sites for debate of recent news and general exchange of knowledge. Some hosted lectures and demonstrations in natural philosophy, sometimes with a formality comparable

to that of schools, the Royal Society, or Gresham College. Unlike those institutions, coffeehouses were spread across the city, a decentralized, face-to-face infrastructure for exchange.[10]

London was not closed to science before coffeehouses: Gresham College offered public lectures; St. Paul's Churchyard supported an open book trade; workshops transmitted craft skills; and aristocratic great houses connected established scholars. However, these channels were often much narrower than a coffeehouse, where one penny bought news and a seat in a shared room for conversation, without a credential, charter, or patron. Historical accounts give such institutions a role in the exchange of useful knowledge and Europe's transition to modern economic growth (Broman, 1998; Jacob, 1997; Mokyr, 2002, 2005, 2016; Stewart, 1992).

The scholarly networks were also harder to enter before the coffeehouse era. The closest precedents to the coffeehouse as places to exchange knowledge were the "invisible college" of Robert Boyle (1627–1691) in the 1640s and the wider Republic of Letters, networks of scholars that, despite having no building or charter, were closed to outsiders, since joining required correspondence, introductions, and learned standing (Mokyr, 2016, p. 186). Similarly, research depended on patronage from wealthy sponsors or on personal fortunes (Mokyr, 2016, pp. 181, 205–206). As science shifted from Renaissance secrecy toward a public, competitive enterprise of discovery (Wootton, 2015), natural philosophers, instrument makers, artisans, merchants, and the middling sort met in coffeehouses repeatedly, and repeated contact built the reputation and trust that made exchange possible (Johns, 1999; Shapin, 1994; Sunderland, 2007).

3. DATA

For London, we assemble records of coffeehouses, mathematical practitioners, and scientific instrument shops, each with an address and dates. We geocode every address and assign it to one of the 162 parishes into which London was divided in 1660.[11] We count records by parish and decade from the 1600s through the 1690s. Two further sources complement this panel. European cities, observed by decade in the seventeenth century, carry measures similar to those for London, including the dates of their first coffeehouses. We also transcribe the diary of Robert Hooke, who wrote about science, coffeehouse visits, and much else almost daily from 1672 to 1683.[12]

Coffeehouses. To determine where and when coffeehouses opened in London, we compile data from *London Signs* (Lillywhite, 1972). The work draws on primary and secondary sources at the Guildhall Library in London, covering coffeehouses and other establishments from the seventeenth through the nineteenth centuries. These include tokens, records of house signs, reward notices, business directories, newspapers, advertisements, letters, reference works, and diaries. Lillywhite (1972) reports the names and years of mention of each coffeehouse and provides addresses for 2,124 of the 2,254 coffeehouses.

[10] Appendix A.2 sets these episodes in a chronology of coffee, coffeehouses, and science in England.

[11] These are 113 City of London parishes, 97 within the walls; 9 Westminster parishes; 20 parishes in Middlesex and Surrey; and 20 liberties or extra-parochial areas, which were separate jurisdictions rather than parishes but which we also call parishes for simplicity.

[12] Summary statistics can be found in Appendix D.1.

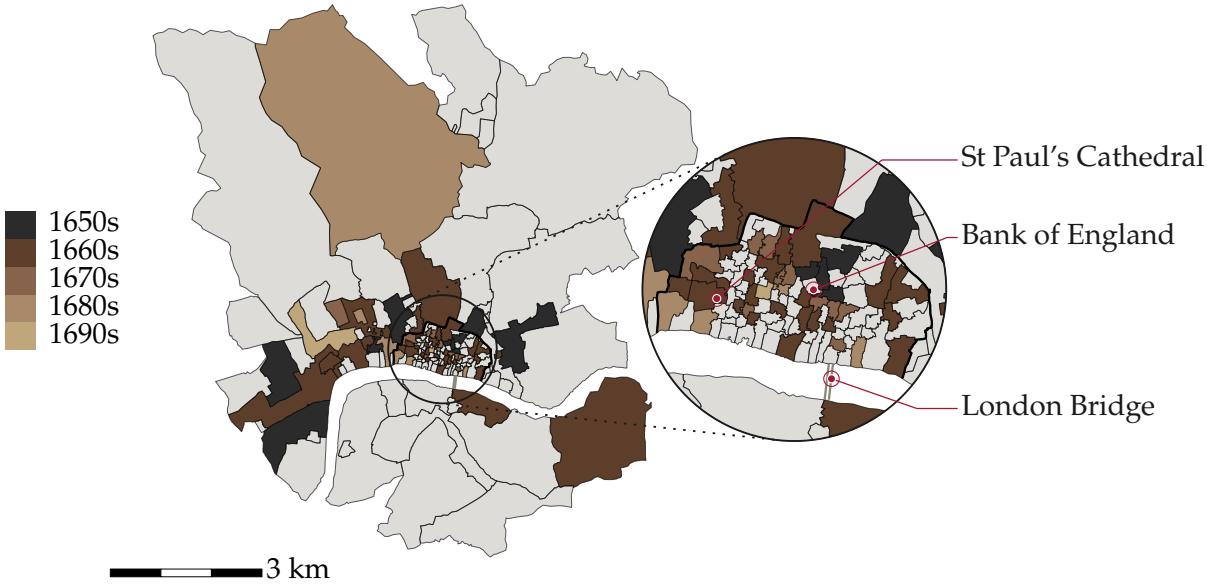


Figure 3. Mapping the first coffeehouses in London

Notes: Map of London showing the decade of first recorded coffeehouse by parish, with an inset of the area inside the wall. Gray parishes indicate no recorded coffeehouses in the seventeenth century. Red dots mark three present-day landmarks. [Return to page 15]

To our knowledge, Lillywhite (1972) remains the most comprehensive source on historical London coffeehouses, documenting far more than the prominent ones.[13] Its more widely cited predecessor, Lillywhite (1963), accounts for 2,034 of the 2,254 coffeehouses listed in Lillywhite (1972).[14] Ellis (2006) treats Lillywhite (1963) as *the* major reference work, Pincus (1995, p. 809) describes it as an "encyclopedic list of coffeehouses," and Cowan (2007, p. 1197) characterizes it as an "enormously valuable catalogue of references to London coffeehouses."[15]

In constructing the dataset, we address two sources of measurement error. First, we consolidate duplicate entries. When the same coffeehouse appears under multiple names, Lillywhite (1963, 1972) lists each separately and notes overlaps.[16] Second, we identify and remove a small number of non-coffeehouse public houses that Lillywhite (1963) includes for contextual completeness.[17] In the City wards that a 1663 survey (City of London Magistrates, 1663) and the returns of the 1690s (Cowan, 2005) cover,

[13] For instance, 34 of the 286 seventeenth-century coffeehouses in our panel are known only from a trade token (Appendix Table D6).

[14] Appendix Figures D2 and D3 show excerpts from both. In Lillywhite (1972, p. 1), entries 1 to 2,034 are from Lillywhite (1963).

[15] Lillywhite worked from London house signs, the addresses in use before the proclamations of 1762 and 1763 ordered overhanging signs removed, and came to coffeehouses as one class of sign-bearing house (Lillywhite, 1972, pp. xv–xvi). Some of his material was postal history, that is, letters addressed to those signs (Lillywhite, 1963, p. 10). He includes a coffeehouse when a document gives its sign, its address, and a year, and then adds whatever else his sources say. Hence, whether a coffeehouse is listed does not depend on its clientele, which only adds detail to an entry.

[16] For example, "The New Bagnio" (entry 1845) also appears as "Turk's Head Bagnio" (entry 1957). In general, coffeehouses were known by various names based on location (e.g., "St. Dunstan"), sign (e.g., "Turk's Head"), or proprietor (e.g., "Bowman"), and Lillywhite (1963) cross-references these variants.

[17] For example, "Pope's Head Tavern" (entry 1870) is "included here by reason of its site and close connexion with coffee-houses" (Lillywhite, 1963, p. 724).

the records hold three-fifths of the coffeehouses counted in the 1690s and about a third to a half of those surveyed in 1663, consistent with the broader loss of historical records in the Great Fire of 1666.[18]

In total, the panel contains 286 coffeehouses across 61 parishes in seventeenth-century London. Figure 3 maps the decade of first coffeehouse entry in each parish. Of the 61 treated parishes, 49 lie in the City of London. Openings in the 1650s cluster in the eastern part of the City, around its financial and intellectual centers (the Royal Exchange and Gresham College), with a second cluster to the west, in Westminster, the royal and political center. Thereafter, coffeehouses appear decade by decade across the walled city and surrounding suburbs, without persistent concentration in a small set of parishes.

Mathematical Practitioners. We measure applied scientists by counting their closest historical analogue: mathematical practitioners. These are individuals who applied mathematics in teaching, writing mathematical texts, instrument making, and related technical occupations. Our data come from Taylor (1954), a pioneering study of practical mathematics in early modern England that introduced the concept of the mathematical practitioner.[19] Taylor (1954) compiled a collective biography of 584 practitioners active in England between 1507 and 1714, drawing on contemporary works and diaries, bibliographical compilations, museum catalogs, and archival manuscripts. Since its publication, "[f]ew new practitioners have been added, and rarely has the category itself been seriously challenged" (Walton, 2017, p. 89).

Each biography reports first and last names, dates of flourishing (i.e., activity), workplaces, types of activity (e.g., instrument making, teaching, research), and connections to other practitioners.[20] We restrict the sample to the 244 practitioners with a precisely geocoded London workplace whose recorded flourishing overlaps 1600–1699. Of these, 223 began flourishing during the century, while 21 began earlier.[21] They worked in 69 of the 162 parishes. Each practitioner enters every decade spanned by their recorded flourishing, in every parish where they have a workplace in that decade, so the outcome is a stock of active practitioners.

Taylor (1954) records social and intellectual connections among practitioners, of many kinds and without dates, from "friends" and "master" to "corresponded with" to "employed" and "consulted." We extend this network with the same types of connections, inferred by machine learning from biographies in the *Oxford Dictionary of National Biography* available through the *Six Degrees of Francis Bacon* database of Warren et al. (2016), which covers 75 of the 244 practitioners (Appendix D.4). Two practitioners are ever connected if either source records a connection between them, and they are connected in decade t if they are ever connected and both are active in t. The resulting network contains 475 undirected ever-connections among 204 of the 244 practitioners,

[18] Appendix D.11 evaluates the completeness of the dataset against contemporaneous administrative records and independent archival searches.

[19] Appendix Figure D4 presents an excerpt from Taylor (1954), and Appendix Figure D20 shows examples of practitioners across cohorts.

[20] For the 65 practitioners for whom Taylor (1954) provides birth dates instead of dates of flourishing, we define flourishing as spanning from the year the individual turned 21 to the year of death or the last year of flourishing, following the implicit chronological order of biographies in Taylor (1954).

[21] Appendix Table D7 reports the complete set of harmonized occupational titles for the 244 practitioners. Titles may overlap: 69 practitioners are classified as mathematical practitioners proper, 54 as mathematical teachers, and 130 as scientific instrument makers.

with a mean of 4.7 and a median of 3 connections.[22] In a given decade of activity, a practitioner has 3.1 connections on average, with a median of 2. Of the 176 practitioners active between the founding of the leading scientific journal of the time, the *Philosophical Transactions*, in 1665 and 1699, we can confirm 32 by name in its pages.[23]

Scientific Instrument Shops. To capture scientific activity in physical as well as human capital, we compile data on scientific instrument shops, where instruments were manufactured, repaired, and sold. These data draw on Hay et al. (2025), on SIMON, the 1991 computerized database of scientific instrument makers compiled by Clifton (1991), and on its later published extract in Clifton (1995).[24] They identify makers from a wide set of objects, both material and documentary, commonly signatures on surviving instruments, guild records, and trade cards. Much of the underlying material was assembled at the National Maritime Museum and the Royal Observatory, Greenwich, in the 1980s and 1990s. The 2025 version extends this work through the digital humanities project *Tools of Knowledge: Modelling the Creative Communities of the Scientific Instrument Trade, 1500–1914*.

This dataset documents all known scientific instrument makers and shops with London addresses up to the 1690s, including the name, shop address, and active dates of each maker.[25] The panel contains 252 makers operating 345 shops across 68 parishes in the seventeenth century; all but one of these shops were first recorded during the century.[26] Shops enter every decade spanned by their recorded years of operation, so this outcome is a stock as well.

Geocoding London Addresses. We map each address by hand onto a present-day Google Map of Greater London, using digital historical maps and gazetteers, and spatially join the resulting coordinates with a shapefile from Cummins et al. (2016), which represents the parochial geography of London in 1660 (Appendix D.12).

[22] Appendix Figure D21 draws the network in four decades and the 14 connections of the clockmaker Thomas Tompion.

[23] We search the full text of all 1,325 seventeenth-century articles of the Royal Society Corpus (Fischer et al., 2020) for the surnames of all 176, in the spellings of the period, and count a practitioner as named only when first names or context confirm the identity, so 32 is a lower bound. Two language-model coders read the 1,199 occurrences independently and agreed on 1,195, and we count only occurrences that both coders and two further readers accept. Hooke, Newton, and Halley account for more than two-thirds of the mentions, and nine of the 32 were Fellows of the Royal Society, against nine of the 144 never named.

[24] We also consulted the published extract directly, mainly to fill in missing addresses. Appendix Figure D5 shows an excerpt from Clifton (1995).

[25] Appendix Figures D17 and D18 show that in a typical year about three-quarters of the scientific instrument makers recorded in the British Isles were active in London, above 80 percent from the 1660s, and that practical instruments such as dividers, sectors, and compasses dominated production until the 1660s, when experimental instruments including microscopes and air pumps began to expand rapidly.

[26] Of the 244 practitioners in our sample from Taylor (1954), 130 are scientific instrument makers, against 252 makers in Clifton (1995), the later work, which used Taylor as a source. The two also classify differently: Christopher Wren is an instrument maker in Taylor (1954) but not in Clifton (1995) (Appendix Figure D4). Since Taylor (1954) records dates of flourishing and Clifton (1995) dates of activity and shop operations, our analysis of scientific instrument shops draws only on Hay et al. (2025) and Clifton (1995).

European City-Level Data. For the extension to Europe in Section 6, we use data on 200 European cities from Bosker et al. (2013), those with at least 10,000 inhabitants in 1600, that paper's preferred definition of a city, and a recorded population in 1500 in the parts of Europe never under Ottoman rule. We add new data on their first coffeehouses, compiled through a systematic review of the historical scholarship (Appendix D.7).[27] In total, 37 cities record a coffeehouse in the seventeenth century (Appendix Table D2).

To our knowledge, no European source lists mathematical practitioners the way Taylor (1954) lists them for England, so we instead count applied mathematics titles printed in a city in the Universal Short Title Catalogue [USTC] (2026), classified by the fourteen subject headings that Kelly and Ó Gráda (2022, p. 849) use to measure English practical mathematics.[28] The substitution is natural, since Taylor (1954) typically relies on such titles to add to her set of mathematical practitioners. For scientific instrument makers, we count the makers recorded as active in a city in a decade in the *Webster Signature Database* (Webster and Webster, 2007), a catalog of makers who signed scientific instruments now held in collections worldwide.

Hooke's Diary, 1672–1683. To better understand the features of a coffeehouse, we manually transcribe the diary of Robert Hooke, curator of experiments at the Royal Society and the best-connected practitioner of the coffeehouse era (Appendix Figure D13). Hooke recorded where he went and whom he met from March 1672 to May 1683 (Henderson, 2007; Robinson and Adams, 1935), yielding diary entries for 3,464 days, with an average of 49 words per entry (Appendix Table D3). Coffeehouses appear on 2,244 days, other public houses on 337, and neither on 1,122, with 239 days having both. Furthermore, for each person an entry names, we record whether Hooke met them and identify them in the index of the printed editions, which yields 16,325 recorded meetings, counting each person once a day, with 1,426 distinct people. These are the meetings Hooke thought worth writing down, not everyone he saw. For further details and validation, see Appendix D.6.

Other. Additional variables enter the balance comparisons, robustness checks, and mechanism tests. Appendix D defines them, each with its source.

4. EFFECTS ON SCIENCE IN LONDON

This section estimates the local effect of coffeehouses on science in London. Using a staggered event study across parishes, we find that the opening of the first coffeehouse in a parish is preceded by flat pre-trends and followed by a persistent increase in scientific activity. Robustness checks on changing population density, commercial activity, the survival of records, and more support the identifying assumptions of parallel trends and no anticipation. We then show that earlier tavern openings produce no comparable increase, which speaks against the idea that the coffeehouse was just another meeting place. Finally, we find positive spillovers onto the immediate neighborhood of an

[27] A simple validation exercise supports the dates. Cities closer to one of the five ports through which coffee entered Europe opened coffeehouses earlier, by about 3.3 years per 100 kilometers (Appendix Figure D1).

[28] The headings are those of the *English Short Title Catalogue*, applied as keyword rules in seven languages; Appendix D.3 lists them with the number of titles under each.

opening, and that relocation of scientists already recorded in London accounts for at most two-fifths of the local effect.

4.1. Empirical Strategy

To estimate effects on science in London, we exploit the staggered introduction of coffeehouses across parishes beginning in 1652. Specifically, we employ an event study model that compares changes before and after the first recorded coffeehouse opens in a parish with changes over the same decades in parishes with no coffeehouse.[29] We focus on the first opening because it provides a clean transition from untreated to treated.[30] As a coffeehouse opening bundles the meeting place, coffee, newsprint, debate, and clientele, our estimates are of their joint effect.

The historical record suggests that entry followed commerce, not science (Appendix A.1). Proprietors were middle-class merchants and traders (Appendix Table A2) who sold coffee and chose sites for foot traffic and custom. Before the first coffeehouse opened, they were largely unconnected to mathematical practitioners, whose recorded commercial ties were rare (Appendix Table A4), and the coffeehouse clientele stayed broad throughout the century, reaching well beyond scientists to merchants, aristocrats, and politicians (Appendix Figure A1). Of the 145 coffeehouses whose seventeenth-century records mention a use, 11 mention science or learning, against 82 that mention commerce and 60 politics.

As descriptive evidence, Appendix Table C1 reports normalized differences between parishes with and without a coffeehouse. Treated parishes were poorer in 1582, but similar to controls by 1638 in the share of well-off households (rent of at least £20 a year), and before 1652 in scientific correspondence and in goldsmiths, a proxy for financial capital. They were less densely populated. The largest differences were in social capital and commerce: treated parishes had more tradesmen's tokens, commercial premises, taverns, and booksellers. They also lay closer to major centers such as the Royal Exchange, Gresham College, and Paternoster Row.

Nevertheless, entry need not be random, and treated and control parishes may differ in levels.[31] Instead, identification requires that parishes did not change behavior in anticipation of a first opening, and that without entry, scientific activity in treated parishes would have followed the path observed in never-treated parishes. Concretely, we estimate an unconditional staggered difference-in-differences model with multiple

[29] Our unit of analysis is a parish rather than an individual practitioner for three reasons. First, our margin of interest is how many people practiced science. Second, about half of the practitioners, 127 of 244, are observed only briefly, for a decade or two, which leaves little time before and after a coffeehouse opening. Third, coffeehouses may have changed who became a practitioner in the first place, so that being a practitioner is itself an outcome of the treatment.

[30] Parishes stay treated from their first coffeehouse on, so the estimates include whatever later openings added. Appendix B.10 groups treated parishes by the number of coffeehouses open in the decade of entry and estimates each group against the never-treated.

[31] Section 4.3 tests whether these differences matter, comparing changes rather than levels before 1652 and reweighting parishes by their estimated probability of receiving a coffeehouse.

time periods that is robust to heterogeneous treatment effects across groups and time:[32]

$$y_{pt} = \alpha + \sum_{g=1650}^{1690} \sum_{\substack{s=1600 \\ s \neq g-10}}^{1690} \beta_{gs} \mathbb{1}[s = t] \mathbb{1}[g = E_p] + \gamma_p + \delta_t + \epsilon_{pt}. \tag{1}$$

Here, y_{pt} denotes the number of mathematical practitioners or scientific instrument shops in parish p in decade t. γ_p and δ_t denote parish and decade fixed effects that control for local time-invariant differences and London-wide shocks and trends. $E_p \geq 1650$ denotes the decade in which the first coffeehouse is recorded in parish p.[33] For each cohort g, the omitted reference period is the decade before entry, $s = g - 10$. For $s \geq g$, β_{gs} is the average effect of coffeehouse entry for cohort g in decade s, relative to decade $g - 10$ and to the never-treated counterfactual, $E_p = \infty$. Earlier coefficients are pre-treatment contrasts, not effects. ϵ_{pt} is an error term. Standard errors are clustered by parish.

Dynamic treatment effects are our estimands of interest. Following Wooldridge (2023), we estimate equation (1) by OLS and predict outcomes using all estimated coefficients and fixed effects, yielding $\widehat{y}_{pt}$. We impute the untreated potential outcome, $y_{pt}(\infty)$, by predicting from equation (1) using only the estimated intercept and fixed effects, yielding $\widehat{y}_{pt}(\infty)$. The observation-specific treatment effect is therefore $\widehat{\tau}_{pt} \equiv \widehat{y}_{pt} - \widehat{y}_{pt}(\infty)$. We estimate the dynamic treatment effect by averaging $\widehat{\tau}_{pt}$ across parishes observed ℓ decades after the first coffeehouse opens:

$$\widehat{\tau}_\ell \equiv \frac{1}{|P_\ell|} \sum_{p \in P_\ell} \widehat{\tau}_{p, E_p + 10\ell}, \tag{2}$$

where P_ℓ denotes the set of parishes observed in period $E_p + 10\ell$.[34] We plot these effects, measured in levels relative to the decade immediately before treatment. Often, we summarize the pre-trends and post-treatment effects with the pre- and post-ATT, respectively, defined as $\frac{1}{4}\sum_{\ell=-5}^{-2} \widehat{\tau}_\ell$ and $\frac{1}{5}\sum_{\ell=0}^{4} \widehat{\tau}_\ell$.

The resulting dynamic treatment effect estimates and standard errors are numerically equivalent to those from the long-difference estimators of Callaway and Sant'Anna (2021). We adopt the approach of Wooldridge (2023) because, unlike long differences, its regression form extends to nonlinear models. Both outcomes are counts with many zeros, so as a robustness check we re-estimate the model by Poisson quasi-maximum likelihood with an exponential conditional mean:[35]

$$\mathbb{E}[y_{pt} \mid p, t] = \exp\left(\alpha + \sum_{g=1650}^{1690} \sum_{\substack{s=1600 \\ s \neq g-10}}^{1690} \beta_{gs} \mathbb{1}[s = t] \mathbb{1}[g = E_p] + \gamma_p + \delta_t\right). \tag{3}$$

[32] This addresses problems arising from treatment effect heterogeneity in staggered adoption designs. In contrast, conventional two-way fixed effects estimators can place non-convex or negative weights on group-time treatment effects, while dynamic two-way fixed effects event study estimators can suffer from contamination across relative periods (Borusyak et al., 2024; de Chaisemartin and D'Haultfoeuille, 2020; Goodman-Bacon, 2021; Sun and Abraham, 2021).

[33] Appendix Figure D15 shows the rollout of treatment across parishes. Appendix Figure D16 shows coffeehouse counts by event time relative to the first coffeehouse entry.

[34] Because the panel ends in the 1690s, fewer cohorts contribute at longer horizons: $\widehat{\tau}_4$ is identified from the 10 parishes treated in the 1650s (Appendix Figure D15).

[35] The exponential mean rules out negative predictions and avoids the need for transformations such as the inverse hyperbolic sine (Chen and Roth, 2024; Roth and Sant'Anna, 2023; Wooldridge, 2023).

Identification now requires that, absent a coffeehouse, mean outcomes in treated and control parishes would have grown by the same factor, not the same amount.

4.2. Mathematical Practitioners and Scientific Instrument Shops

Figure 4 reports the estimated dynamic effects of equation (2), obtained by estimating equation (1), for both outcomes along with the post-ATT.[36] Flat pre-trends support their validity.[37] Panel A shows a persistent increase in practitioners. The 61 treated parishes averaged 0.62 practitioners in the decade before entry, and the number rises by 0.68 on average over the decade of entry and the four decades after, roughly doubling.[38] Panel B shows a persistent increase in instrument shops, by 1.24 on a baseline of 0.33, a nearly fivefold rise.

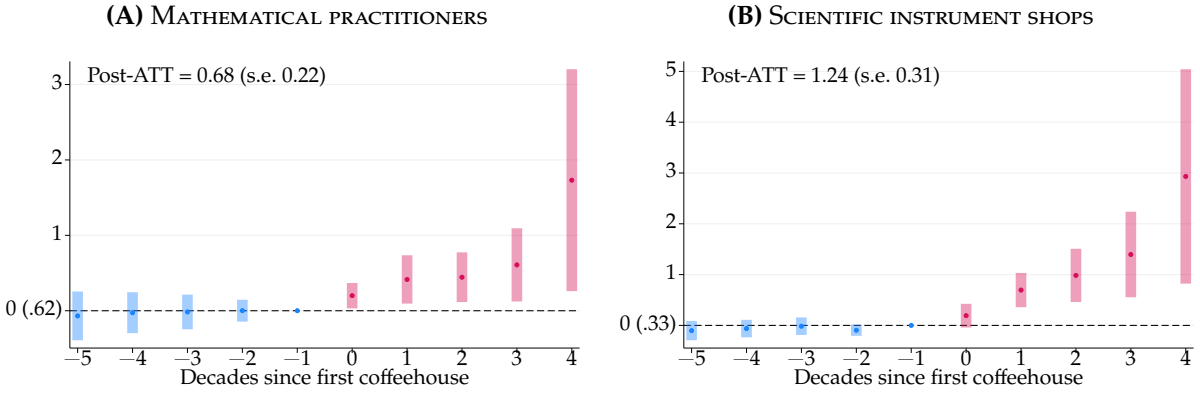


Figure 4. Effects on scientific activity

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on scientific activity. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to pages 20, 31, OA-7, OA-23, OA-106]

Despite data scarcity, the effects are precisely estimated and statistically significant. They are also large. Between the 1640s and the 1690s, London gained 68 mathematical practitioners and 136 instrument shops. Aggregated across treated parishes, the estimated effects in the 1690s account for 49 percent (s.e. 18) of the increase in practitioners and 63 percent (s.e. 16) of the increase in instrument shops. Relative to total activity rather than growth, coffeehouse entry accounts for 20 percent (s.e. 7) of all 502 practitioner-decades and 46 percent (s.e. 10) of all 412 instrument shop-decades recorded between

[36] Appendix Figure B1 plots the raw annual means in coffeehouse and control parishes. They follow similar trends before the first coffeehouse opened in London in 1652 and diverge afterward, as scientific activity rises in coffeehouse parishes while control parishes stay nearly flat.

[37] We fail to reject the null that the pre-treatment contrasts two to five decades before entry are jointly zero ($p = 0.99$ for practitioners and $p = 0.29$ for instrument shops).

[38] Because the outcome is a stock, the increase could in principle reflect longer recorded activity per practitioner rather than more practitioners. It does not: practitioners in parishes that ever received a coffeehouse flourish for 25.3 years per location spell against 22.8 in parishes that never did, an insignificant difference of 2.5 years (s.e. 2.4).

the 1650s and the 1690s.[39]

The treatment and the two outcomes come from three separate compilations, assembled by different scholars from different archives and for different purposes. The consistent effects are therefore not an artifact of the coverage of one compilation. This also informs us about observability bias, or the concern that those who frequented coffeehouses were more likely to enter the historical record. Though this concern seems relevant for practitioners, who are drawn from a collective biography of notable individuals, it has less force for instrument shops, which are identified from signatures on surviving instruments in museum collections and traced in guild records and trade cards, none of which plausibly depends on the presence of a coffeehouse.

4.3. Robustness

Coffeehouse openings could have coincided with unobserved local shocks to scientific activity. We address this concern in five ways. First, we test for effects on placebo outcomes that coffeehouses should not move, so that our main effects can be cleanly interpreted as due to coffeehouses. Second, we adjust for baseline characteristics that predict where coffeehouses opened, as one might believe parallel trends hold only conditional on them. Third, we compare the estimates against placebo assignments of treatment. Fourth, we check that the results do not depend on how the sources record coffeehouses and scientific activity. Fifth, we vary the remaining ingredients of the design one at a time. Appendix C develops each check in more depth.

We begin with outcomes that openings should not move. Population density is a key factor that increases the rate of interaction among people. Baptism and death densities, which proxy for population density where no direct data exist, do not move, and their pre-trends are flat. Luxury shops, catering to an affluent clientele, would have risen had entry coincided with gentrification, i.e., an inflow of the affluent and intellectually inclined who could themselves enter science. They do not move, consistent with what the design assumes, that coffeehouses raised the rate at which potential entrants turned to science rather than their number. Similarly, non-scientific letters would have risen had established elite correspondents within the Republic of Letters arrived with the coffeehouse, in which case the coffeehouse effect could reflect a connection to the Republic of Letters and its scientific exchange. They do not move. The tavern market, at 400 houses in the 1640s, was probably saturated, so one coffeehouse should neither add taverns nor close them; had it done so, the coffeehouse would have coincided with a general increase in meeting places. Taverns do not respond. Commercial premises are the clearest exception: commercial activity was already rising before entry, consistent with coffeehouses following commerce. This pre-trend in commercial activity does not translate into a pre-trend in scientific activity, so it does not threaten parallel trends (Appendix C.3).

Coffeehouses opened where commerce was dense (Section 4.1), and the parishes they entered also began with more practitioners and more instrument shops (Appendix Table C1). However, differences in levels threaten parallel trends only when they predict how scientific activity would have evolved without a coffeehouse (Baker et al., 2026). Two checks address this. First, descriptively, both scientific outcomes are balanced

[39]The shares are computed by summing the estimated dynamic effects across treated parishes and post-treatment decades and then dividing by observed activity.

in changes between the 1600s–1610s and the 1630s–1640s, at absolute normalized differences below 0.1, and only taverns and commercial premises exceed 0.25, two placebos already examined above that do not explain the result (Appendix Table C2). Second, reweighting control parishes by their estimated probability of ever having a coffeehouse, based on pre-1652 taverns, tradesmen's tokens, booksellers, and an indicator for the City, leaves both effects significant and stable (Appendix Figure C3).[40] Adjusting instead for the propensity score in each decade approximately halves the effects, with the effect on practitioners no longer significant. However, this test might be seen as too demanding, as the 13 parishes most likely to receive a coffeehouse have no comparable untreated parish (Appendix Figure C4 and Appendix Table C3).

We next compare the estimated main effects against a benchmark in which placebo first coffeehouses are randomly assigned across 61 parishes (the size of the treated group), from the 1650s to the 1690s. Across 1,000 such placebo samples, the post-treatment effects based on historical timing lie in the extreme upper tail of the placebo distributions for both outcomes, while the pre-treatment effects are centered near the medians (Appendix Figure C5). Because this benchmark places coffeehouses without regard to where they actually went, we repeat the exercise, drawing placebo locations to match the estimated probability of entry and preserving the observed entry decades. Again, the post-treatment estimates remain in the upper tail under this more demanding assignment (Appendix Figure C6).

Observability bias bears less on instrument shops than on practitioners, but for both, survival and registration may depend on local prosperity. On the outcome side, we therefore restrict the sample to the 175 of 252 instrument makers with a recorded guild, since guilds enrolled makers as apprentices and freemen whatever later became of their shops. We estimate with and without separate trends for parishes exposed to the Great Fire, which destroyed many guild records. On the treatment side, we re-estimate after excluding, in turn, each broad and each finer category of source through which a coffeehouse is first recorded, and the post-entry averages stay between 0.62 and 0.83 practitioners and between 1.26 and 1.50 shops (Appendix Figures C8 and C9). The estimates are broadly unchanged throughout (Appendix C.5). As a final exercise, matching the two rosters person by person links 93 of the 244 practitioners to one of the 252 makers, and estimating equation (1) separately on the two disjoint groups and on the overlap yields a positive and significant effect in each (Appendix C.6). This strengthens our statement that the main result is not an artifact of one source.

Our last checks vary the design itself. We allow parishes exposed to the Great Fire of 1666, and parishes inside the London Wall, to follow separate nonparametric trends (Appendix C.4). We change how treatment is defined and timed, moving from decades to two-, three-, and five-year intervals, allowing treatment to switch off, and estimating the effect of closures (de Chaisemartin and D'Haultfoeuille, 2026), which lower the number of mathematical practitioners (Appendix C.7). We change the unit and the standard errors, re-estimating on a hexagonal partition of the city and computing Conley (1999) standard errors (Appendix C.8). We change the control group and

[40] We choose these four as the most direct measures of the commerce and book trade that coffeehouses followed, and with them every control parish scores within the range of the treated parishes. Other choices give similar estimates. Covariates selected by a cross-validated lasso among the 28 pre-1652 measures give 0.59 (s.e. 0.24) and 1.00 (s.e. 0.38), and adding the remaining measures of social capital and commerce with normalized differences above 0.25 (apothecaries, commercial premises, and dissenting meetings) gives 0.53 (s.e. 0.26) and 0.90 (s.e. 0.41).

the estimator, adding not-yet-treated parishes (Callaway and Sant'Anna, 2021) and re-estimating under Poisson and inverse hyperbolic sine specifications (Appendix C.9). Finally, we remove differential trends and influential observations, detrending within treatment cohorts (Goodman-Bacon, 2021), dropping each of the 162 parishes in turn, and bounding how far parallel trends could fail before the effects lose significance (Rambachan and Roth, 2023; Appendix C.10). None changes the conclusion.

4.4. Taverns as a Placebo Treatment

Taverns, like inns and alehouses, had offered food, drink, lodging, and convivial exchange since the Middle Ages (Clark, 1983). Coffeehouses, by contrast, were a novel institution. They were comparably low-cost and sociable public venues, but relative to taverns they centered on news, debate, and business, consequently attracting civil, curious, and cosmopolitan customers, including virtuosi engaged in learned discourse (Cowan, 2005, p. 89). Scientific activity could and did occur in taverns (Stewart, 1992, p. 143), but historical scholarship more closely associates coffeehouses with the virtuosi and culture of experimental inquiry (Cowan, 2005; Ellis, 2004). As Cowan (2005, p. 260) argues, the coffeehouse was "not simply one among many backdrops" like the traditional taverns, but "the product of the cultural world forged by the virtuosi in Britain's age of scientific revolution."

Hooke's diary also separates the coffeehouse from the tavern. The words he wrote after naming a coffeehouse characterize it as a place of discourse: against phrases that name no public house, the most overrepresented word pairs are "discoursed about," "discoursd with," "told me," and "shewed his" (Figure 5, Panel A), while those after he named a tavern concern claret and payment (Panel B). On days he visited a coffeehouse, the diary also records mathematical practitioners and men in manual trades far more often than on days at a tavern (Appendix B.8).

(A) Coffeehouse



(B) Tavern



Figure 5. What Hooke wrote after naming a coffeehouse or a tavern

Notes: Figure shows the word pairs most overrepresented in what Robert Hooke wrote after naming a coffeehouse (Panel A) or a tavern or other public house (Panel B) in his diary, 10 March 1672 to 15 May 1683. Entries are runs of short phrases separated by semicolons and periods. Each passage runs from the phrase naming the house to the end of the entry. The 3,291 coffeehouse passages are compared with the 15,102 phrases outside them that name no public house, using the weighted log-odds ratio of Monroe et al. (2008); the 261 tavern passages are scored the same way, too few for Panel B to be more than an illustration. Spelling is Hooke's. Word size increases with the score. Names of people and of public houses are removed. [Return to page 23]

This distinction motivates a test using new tavern openings as a placebo treatment. If

meeting places alone raised scientific activity, tavern openings should raise it too. Now, as tavern and coffeehouse counts are correlated once coffeehouses appear (Appendix Table C4), we focus on the 1550s–1640s, before coffeehouses existed. Figure 6 reports the estimated effects of the first seventeenth-century tavern opening in this time period. Pre-trends are flat for scientific instrument shops but not for mathematical practitioners, whose numbers were already drifting upward where taverns opened, so a causal reading is not warranted there. If anything, as we read the practitioner estimates against the extrapolated pre-trend line, practitioners stop rising at the opening and fall further below the extended path with every decade. Yet instrument shops move the other way, with a positive but insignificant post-ATT of 0.11 (s.e. 0.07). Relative to the baseline mean of 0.11, that is an imprecise doubling that falls short of the precise and nearly fivefold increase over the same horizon after a first coffeehouse. Subtracting the estimated group-specific pre-trends rather than overlaying them gives the same conclusion (Appendix Figure B12). Full-period estimates, with strong pre-trends, are rather uninformative, but suggest no meaningful impact of taverns (Appendix Figure B11). Moreover, coffeehouses do not seem to matter for lack of other meeting places: before 1652, parishes that later received one already had 3.0 taverns on average, against 0.5 in other parishes (Appendix Table C1).

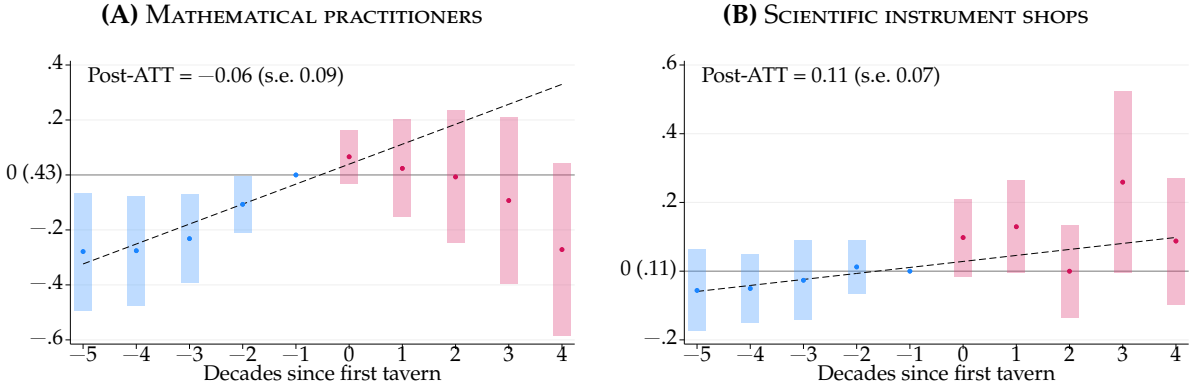


Figure 6. Tavern effects on scientific activity

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of the first seventeenth-century tavern opening on scientific activity, with treatment effect heterogeneity restricted to event time. The dashed line extends a least squares fit to the estimates from five decades to one decade before the first tavern. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1550s to the 1640s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before the first tavern opened. Post-ATT is the average of the estimates from the opening through four decades after. Standard errors clustered by parish. [Return to pages 24, OA-19]

4.5. Spillovers and Creation versus Relocation

Thus far we have estimated the local effect of a coffeehouse, which leaves two questions on the table. First, coffeehouses may have raised activity in neighboring control parishes, as people could reach a coffeehouse on foot, which would push our parish-level estimates downward (Butts, 2023). Second, some of the activity we count may not have been created in treated parishes but moved there from elsewhere.

To address the question of spillovers, we consider specifications on a partition of London into hexagons 200 meters wide, as parishes are too coarse to locate spillovers at

walking distance. At the level of these hexagons, we then compare the change from the 1640s to the 1690s in the hexagon that receives the coffeehouse, and in each 200-meter ring around it, with the change in hexagons more than 1,000 meters from any opening (Appendix Figure B2 and Appendix Table B1).[41] Mathematical practitioners more than double, rising by 0.39 in the opening hexagon and 0.17 in its immediate neighbors on means of 0.24 and 0.08 in the 1640s. Scientific instrument shops rise by 1.20 and 0.12 on means of 0.07 and 0.05. Beyond 200 meters, the estimates are small and jointly indistinguishable from zero. Both series are also flat for five decades before the opening and rise after it (Appendix Figure B4).[42] We find the same range in a second check, which uses neither rings nor distant controls. We rebuild the grid with hexagon cells from 50 to 1,200 meters wide and re-estimate the baseline specification at the level of these cells. The effect per coffeehouse in the cell grows with cell width up to about 400 meters and then stays flat, plausibly because, by that point, a cell already holds everyone the coffeehouse reaches (Appendix Figure B3).

Two implications follow. First, the parish-level estimates can understate the total effect of an opening: summed over the opening hexagon and its immediate neighbors, the effect by the 1690s is 0.77 mathematical practitioners and 1.47 scientific instrument shops, and about half of the practitioner response and a fifth of the shop response lie in the neighbors. Since most of those neighbors lie in parishes that the design counts as treated, most of their gain is already in the parish estimates.[43] Second, the aggregate shares in Section 4.2 sum only effects within parishes. Hence, they miss the spillovers onto control parishes but count as gains any activity that merely moved into treated parishes from elsewhere in London.

To address the question of creation versus relocation, we probe whether coffeehouses created scientific activity or relocated it. Three patterns favor creation. First, scientific activity grew both in London and elsewhere in England over the period, which weighs against London gaining only at the expense of the rest of the country (Appendix Figure D17). Second, if coffeehouses had only drawn activity from their immediate neighborhood, activity next to an opening would have fallen. The spillover estimates above show that it rose. Third, activity at a first recorded London location accounts for 84 percent of the post-ATT for practitioners and 62 percent for shops, and for shops, creation dates from the year a maker is first recorded, so it cannot come from moves between recorded London locations (Appendix Figure B5).[44] Moves from unrecorded locations, or from outside London, would still register as creation.

[41] Averaging the baseline over the 1600s to the 1640s, all before the first coffeehouse, gives nearly identical estimates.

[42] One shop coefficient beyond the first ring, at 400 to 600 meters, is significant at the 5 percent level on its own. The short range might seem surprising, but it fits the habits of Robert Hooke: 2,233 of the 2,915 located coffeehouse mentions in his diary lie within 400 meters of his lodgings (Appendix Figure B6).

[43] The sums add the effect on the first ring of hexagons, weighted by the number of such neighbors per opening hexagon (2.26, that is, 172 neighbors of 76 opening hexagons), with standard errors of 0.25 and 0.31. They are totals per opening hexagon, which holds 3.8 coffeehouses over the century on average. Of these neighbors, 72 percent lie in parishes coded as treated.

[44] That split does not count the losses in the parishes that people left. Counted at both ends, moves between recorded London locations account for 12 percent of the effect on practitioners and 15 percent of the effect on shops, since most ran between parishes that both had a coffeehouse (Appendix B.3).

5. MECHANISMS

Historical research points to several channels through which coffeehouses may have stimulated scientific contact and activity. First, the coffeehouses lowered the social costs of entering the public sphere of applied science, which widened access beyond established elites. Second, as open commercial settings, they brought natural philosophers who needed experimental instruments into geographic proximity with the craftsmen who made them. Third, this contact gave the craftsmen better knowledge of the demand for experimental instruments. In turn, these channels predict larger effects among applied scientists with weak family ties to Oxford and Cambridge, more connections that link craft skill to theory, and new shops that turn toward experimental instruments. We find evidence consistent with each of these predictions. Finally, we show that coffeehouses set practitioners into a wider ecology of applied science, raising their output, training, and institutional reach.

5.1. Lowering Barriers to Entry

Coffeehouses may have raised scientific activity by making knowledge that others already held cheaper to reach (Mokyr, 2005, p. 312). They are remembered as "penny universities" (Ellis, 1956); before their arrival, scientific interaction took place largely in private houses, from aristocratic great houses to the lodgings of individual gentlemen (Cowan, 2005, p. 102; Shapin, 1988, pp. 378–381). If coffeehouses relaxed these access constraints, effects should be stronger among practitioners with weaker family ties to elite institutions. Following Clark and Cummins (2014), we proxy such ties by the baseline relative representation of a practitioner's surname s in the matriculation rolls of the universities of Oxford and Cambridge (Oxbridge):

$$z(s) \equiv \frac{\text{share of } s \text{ among Oxbridge matriculants before 1650}}{\text{share of } s \text{ among English couples married 1538–1649}}. \tag{4}$$

The denominator proxies the surname share in the adult English population. Higher values of $z(s)$ indicate stronger ties. Surnames are observed for all 244 practitioners.[45]

Figure 7 shows the predicted pattern. Average post-treatment effects, measured relative to the mean in the decade before entry, are concentrated among practitioners below the median of $z(s)$ and smaller above it, by 0.99 times the pre-entry mean (s.e. 0.51; Panel A). Panel B estimates effects for the bottom x percent of practitioners ranked by $z(s)$, across values of x: the effect declines from approximately 5 for the 16 percent of practitioners whose surnames never appear in the Oxbridge matriculation rolls to about

[45]We observe paternal occupation, the more direct measure, for only 56 of the 244 practitioners, mostly from the biographies we link through Wikidata (Appendix D.4) and for a few from Taylor (1954). For 42 more, a linked biography exists but does not give the father's occupation, and the remaining 146 have no biography beyond Taylor's brief entry. Paternal background may be of more interest, and $z(s)$ captures it only in part: being built from surnames rather than from the household characteristics of each practitioner, it measures the elite intellectual background of a surname, and its values vary within paternal occupations. Appendix Figure D22 plots the individual values of $z(s)$ by paternal occupation, including those for whom it is unobserved. Fathers' occupations track $z(s)$: of the 20 practitioners whose fathers were gentry, clergymen, barristers, physicians, or magistrates, 17 lie above the median of $z(s)$, against 19 of the 36 whose fathers had other occupations. However, since biographies are more likely to record the father of a prominent practitioner, and 36 of the 56 lie above the median, this check only speaks to the direction of $z(s)$.

1.1 once the most represented are included.[46] In shares, the bottom half by $z(s)$ held 39 percent of the practitioners recorded in treated parishes in the decade before entry but accounts for 61 percent of the post-treatment effect (Appendix Figure B7).

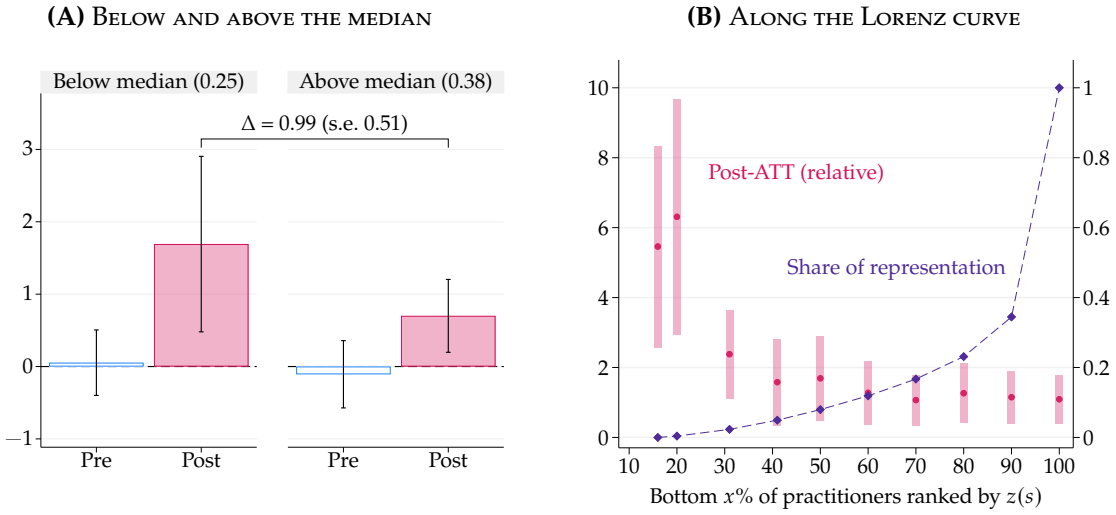


Figure 7. Effects on mathematical practitioners by Oxbridge representation

Notes: Figure shows ATTs and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on scientific activity. Outcomes are the decadal number of mathematical practitioners, conditional on the relative representation $z(s)$ of a practitioner's surname s at Oxbridge before 1650, as defined in equation (4). "Pre" and "Post" are the averages of the estimates two to five decades before entry and from entry through four decades after. Panel A splits practitioners by whether $z(s)$ falls above or below the median. The parenthetical beside each label reports the sample outcome mean one decade before treatment. Δ is the difference between the designated post-treatment averages, estimated on the difference of the two relative outcomes. Panel B restricts to practitioners in the bottom x percent of the empirical distribution of $z(s)$; diamonds on the dashed line, read against the right axis, trace the Lorenz curve of Oxbridge representation: the share of summed $z(s)$ that those practitioners hold. In both panels each outcome is divided by its mean in the decade before treatment. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to pages 26, 28, 31, OA-14, OA-15]

5.2. Connecting Theory and Practice

Coffeehouses may also have functioned as a decentralized institution that matched previously segmented knowledge communities: craftsmen trained in the guild system, who held prescriptive knowledge (knowledge how), and natural philosophers coming into science from Oxbridge, who held propositional knowledge (knowledge what).[47] This is the view of Ellis (2006, pp. x–xi), who portrays coffeehouses as spaces where virtuosi conducted business with instrument makers and where the experimental method was debated by the wider public.

The second prediction is that coffeehouses increased social connections among practitioners, above all between the makers who produced instruments and the theorists

[46] Pre-entry estimates are close to zero except for the bottom 16 and 20 percent, whose activity fell before entry. Net of group-specific trends, their effects are larger (Appendix Figure B8).

[47] The distinction between propositional and prescriptive knowledge was made popular by Mokyr (2002) and has more recently been studied in the history of science by Koschnick (2025a).

most likely to put them to use.[48] Figure 8 divides connections by the two practitioners they join and shows each effect as a multiple of its pre-entry mean. Connections as a whole rise by 1.21 (s.e. 0.62) times their pre-entry mean.[49] Connections between makers and theorists rise by 1.63 times theirs, and connections among makers by more, while connections among theorists rise little and imprecisely, with pre-treatment estimates close to zero for all three. The rise between makers and theorists exceeds the rise among theorists by 1.04 (s.e. 0.48), though not the rise among makers.[50] Read together with the heterogeneity in Figure 7, this pattern is consistent with the matching the second channel predicts, although it does not isolate that channel.

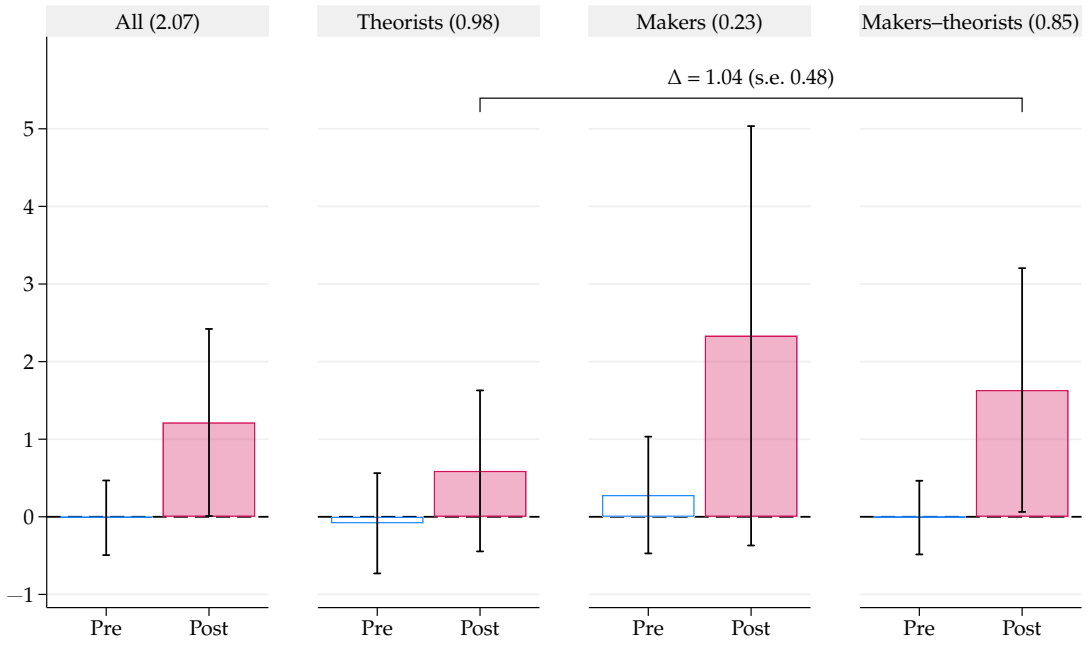


FIGURE 8. EFFECTS ON CONNECTIONS BY PRACTITIONER TYPE

Notes: Figure shows ATTs and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on all connections (All) and on connections between two theoretically oriented practitioners (Theorists), between two scientific instrument makers (Makers), and between a maker and a theorist (Makers–theorists). Each connection is counted once in every parish where one of its two practitioners works. "Pre" and "Post" are the averages of the estimates two to five decades before entry and from entry through four decades after. The parenthetical beside each label reports the sample outcome mean one decade before treatment. Each outcome is divided by this mean. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Δ is the difference between the post-treatment averages of Makers–theorists and Theorists, estimated on the difference of the two relative outcomes. Standard errors clustered by parish. [Return to pages 28, 31, OA-15]

Hooke's diary shows what a coffeehouse day added to the company one practitioner

[48]Theorists are the 114 practitioners who are not makers: 41 taught mathematics or navigation, 18 were surveyors, navigators, or hydrographers, and 10 held professorships. Taylor (1954) records study at Oxford or Cambridge for 23 of them, against 2 of the 130 makers (Appendix Table B2).

[49]Much of this rise comes with the rise in practitioners: per practitioner working in the parish, connections rise by 0.36 times their pre-entry mean (s.e. 0.40).

[50]More makers and theorists bring more connections even at an unchanged propensity to connect. Counting each connection at the end that works in the parish, the gap is 0.96 (s.e. 0.50). Net of the connections the extra makers and theorists would bring at the pre-entry rate per person, it is 0.79 (s.e. 0.41).

wrote down. On days he visited a coffeehouse, Hooke recorded meeting 5.69 people, against 2.92 on other days (Figure 9, Panel A). Comparing days in the same year and on the same weekday, Hooke recorded 2.23 more people on coffeehouse days (s.e. 0.12). Of these, 1.44 (s.e. 0.08), about two-thirds, were outside the Republic of Letters, a long-distance correspondence network of a learned elite (Panel B). On other days, 1.69 of the 2.92 people he recorded, 58 percent, were outside it. The mix changed little. The diary records only the people Hooke thought worth noting, and he wrote more on coffeehouse days.[51] Hooke might have met the extra people anyway, and the diary seldom says where he met them. Still, the company he recorded on coffeehouse days mixed social groups and knowledge communities.

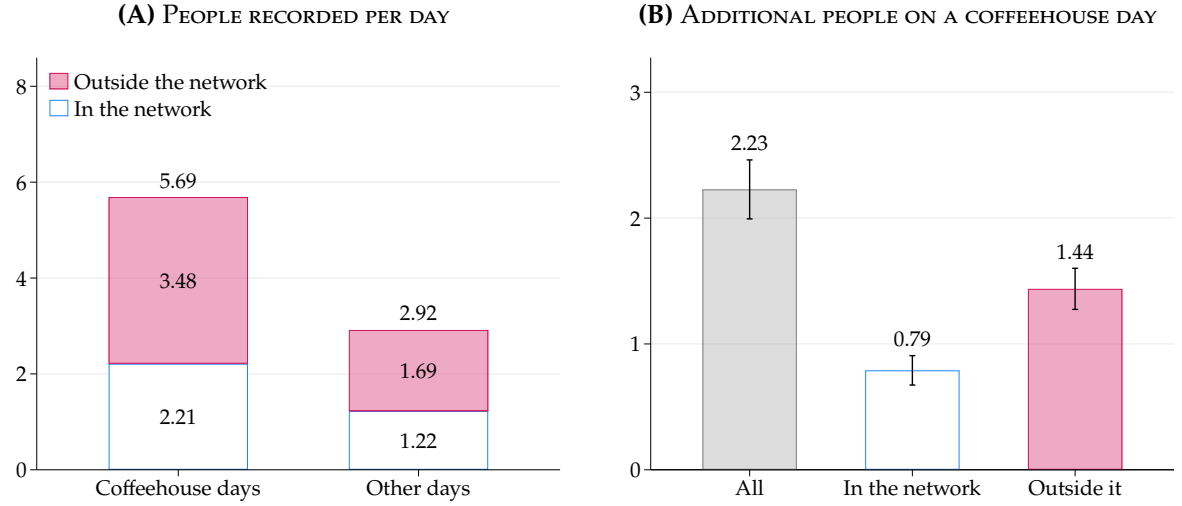


Figure 9. Robert Hooke's recorded company on coffeehouse days

Notes: Figure reports the number of people Robert Hooke records meeting on each day of his diary, 10 March 1672 to 15 May 1683: 3,464 days, 2,244 of them coffeehouse days. Panel A gives raw means on coffeehouse days and on other days, each split into people in the Republic of Letters, who sent at least one letter from London in the seventeenth century recorded in *Early Modern Letters Online* (Hotson and Lewis, 2024), and people outside it. Panel B reports the difference between coffeehouse days and other days from a regression with year-by-weekday fixed effects, for all people recorded and separately for those inside and outside the network, with 95 percent confidence intervals from heteroskedasticity-robust standard errors. The diary dates each meeting but seldom places it, so a coffeehouse day counts everyone Hooke records meeting that day, and only those he thought worth noting. [Return to pages 29, OA-16, OA-17]

5.3. Experimental Science

Publicly performed experiments stimulated interest in testing and demonstrating scientific theories using the new instruments of experimental inquiry (Shapin and Schaffer, 1985; Stewart, 1992). If coffeehouses brought theorists and makers into more frequent contact, makers could learn about theorists' needs and encounter a larger market for instruments that made new phenomena visible and measurable. This yields the third prediction: coffeehouse entry should increase the supply of experimental instruments, not only established practical tools.

Figure 10 compares average treatment effects on practical and experimental instrument shops. Both types of shops rise after entry, and by about the same number:

[51] Entries on coffeehouse days average 57 words, against 36 on other days. Per hundred words they still record more meetings, 11.6 against 8.5.

0.61 experimental and 0.54 practical shops per parish. Relative to its smaller base, the increase is larger for experimental instruments, 5.3 against 2.5 times the pre-entry mean, a difference of 2.76 (s.e. 1.18). The pattern is consistent with coffeehouses strengthening the link between experimental inquiry and the craftsmen who supplied its material tools.

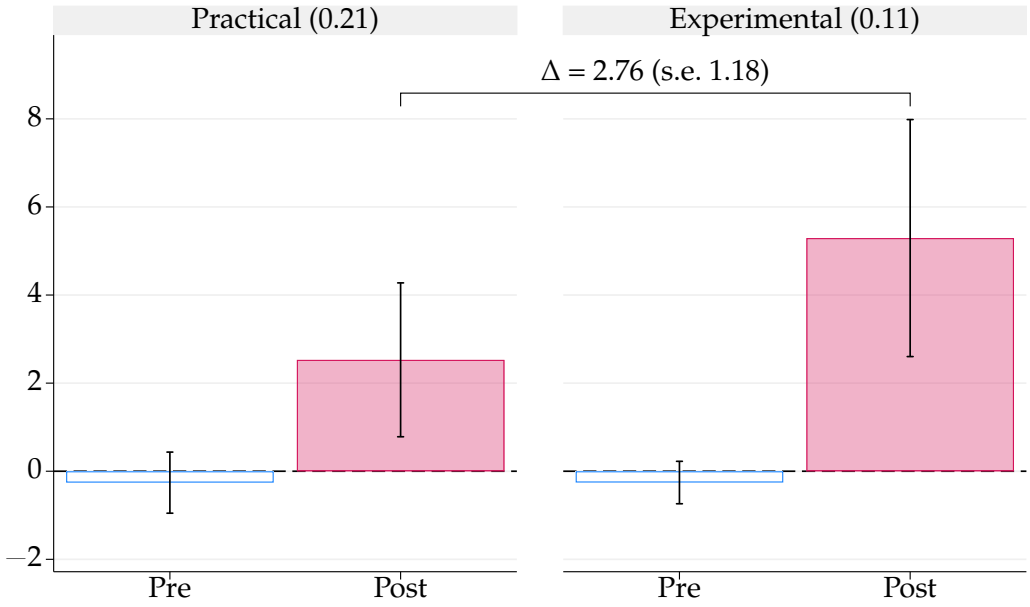


Figure 10. Effects on scientific instrument shops by type

Notes: Figure shows ATTs and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on practical (mathematical, navigational, and surveying) and experimental (optical and philosophical) instrument shops. Treatment effect heterogeneity is restricted to event time, since with separate effects for each decade of entry, as in equation (1), the standard errors for experimental shops cannot be computed. "Pre" and "Post" are the averages of the estimates two to five decades before entry and from entry through four decades after. The parenthetical beside each label reports the sample outcome mean one decade before treatment. Each outcome is divided by this mean. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Δ is the difference between the designated post-treatment averages, estimated on the difference of the two relative outcomes. Standard errors clustered by parish. [Return to pages 29, 31]

5.4. Putting Practitioners into Circulation

Historical scholarship portrays the coffeehouse as a meeting technology that turned proximity into knowledge exchange (Cowan, 2005; Stewart, 1999). The coffeehouse did not necessarily create the skills needed to become a "London mathematician," but raised the chance that a potential entrant transitioned into applied science by placing him in the circulation of knowledge around applied mathematics and the instrument trade. Coffeehouse sociability was open in principle, but implicit norms steered conversation toward rational, polite, and evidence-based discussion (Ellis, 2008). Within those norms, coffeehouses circulated codified knowledge, pamphlets and periodicals along with commercial intelligence, while demonstrations and learning from men who already had the relevant skills supplied tacit knowledge (Higgitt et al., 2024; Johns, 2006).

Figure 11 gathers the evidence that coffeehouses set practitioners into a wider ecology of applied science. For comparison, it repeats the main results of Section 4.2. First,

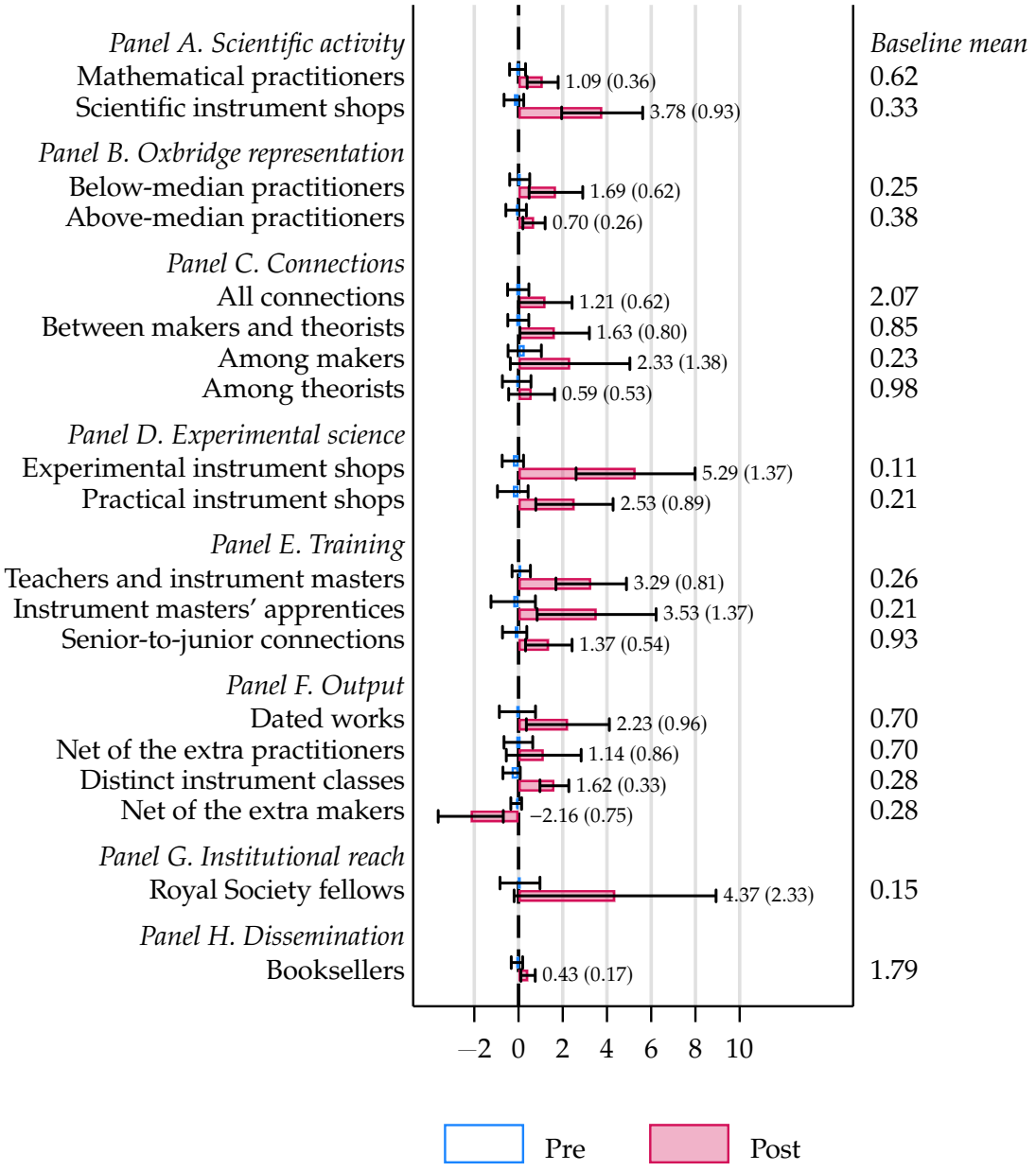


FIGURE 11. EFFECTS ON THE WIDER ECOLOGY OF APPLIED SCIENCE

Notes: Figure shows ATTs and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on each outcome. Panels A to D repeat Figures 4, 7, 8, and 10. Net rows subtract the pre-entry rate per practitioner or per shop, so zero means a response at the rate of those already there. For experimental shops and fellows, treatment effect heterogeneity is restricted to event time, since with separate effects for each decade of entry their standard errors cannot be computed; practical shops are estimated the same way for comparison. Each outcome is divided by its baseline mean, the sample mean one decade before treatment, and each net row by that of its gross row. "Pre" and "Post" are the averages of the estimates two to five decades before entry and from entry through four decades after. The number beside each Post interval is the Post-ATT and its standard error. Appendix D.3 defines each outcome. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to page 30]

practitioners and makers take on successors: teachers and instrument masters rise by 3.3 times their pre-entry mean, apprentices by 3.5 times, and links from senior to junior practitioners rise, suggesting that established practitioners drew younger ones in. Perhaps public experimental science at coffeehouses steered newcomers, bound as apprentices at about fourteen (Wallis, 2025), into instrument making. Second, the practitioners' dated works rise by 2.2 times their pre-entry mean. Per practitioner, dated works rise from 1.12 before entry to 2.29 for those gained after it, but the excess, plotted as the net row in Panel F, cannot be distinguished from zero.[52] In terms of other output, the range of instruments made in a parish grows, measured by the crafts recorded for its makers, because there are more shops rather than more versatile ones. Net of what the extra makers would bring at the pre-entry rate per shop, crafts fall short (−2.16, s.e. 0.75).[53] Third, the effect reaches beyond practical science. Booksellers rise,[54] and so does the number of Fellows of the Royal Society, which rises the most relative to its own mean, albeit imprecisely.[55]

6. EXTENSION TO EUROPE

Coffeehouses marked a shift toward open sociability with easier access in Europe more broadly (Albrecht, 1989; Habermas, 1991 [1962], pp. 30–33). In London, that access clustered applied scientists around the coffeehouse parishes (Section 4). We ask whether the relationship between coffeehouses and applied science found in London extends to European cities, without claiming to identify the causal effect of a coffeehouse. Instead, we take the first coffeehouse in a city as a marker of a critical juncture in social change, as the arrival of the first social institution "where it was possible to establish a bourgeois-oriented public forum" (Albrecht, 1989, p. 95). Such a forum may, as in London, have benefited practical science more broadly; in 1690s Hamburg one keeper styled his coffeehouse an "Academy" with "the special character of an assembly of Science" (Robilliard, 2024, p. 159).

To this end, we use new data on the first coffeehouses in 200 European cities in the seventeenth century, together with existing measures of applied science (Section 3). We focus on the parts of Europe never under Ottoman rule in the sixteenth or seventeenth centuries, where the coffeehouse was a private trade rather than an institution of the ruler.[56]

[52]Since both series are outcomes, the rate is an association rather than the output of one more practitioner holding everything else fixed.

[53]Counting the distinct instruments each maker is recorded as making (Hay et al., 2025) gives the same pattern, a rise of 2.6 times the pre-entry mean (s.e. 1.25) and none net of the extra makers (−1.18, s.e. 0.73), although only 112 of 252 makers have such a record.

[54]The rise comes late and from the ten parishes first treated in the 1650s: the estimates are 0.12, 0.11, and 0.15 in the decade of entry and the two after it, and none exceeds 0.17 once those parishes are dropped.

[55]Fellows are rare and only observed from the 1660s, when the Royal Society was founded, with 337 records over 1,620 parish-decades, 133 of which contain one. Moreover, the count places a fellow where he died or was buried, as the workplace or residence is rarely known. Hence, the count is noisy and a long-run outcome, since a fellow may have settled near a coffeehouse late in life.

[56]In the Ottoman lands the coffeehouse was in the hands of the ruler: building a grand coffeehouse was among the first things he did in a newly conquered city (Ellis, 2004, p. 13), and in 1633 Murad IV, fearing the sedition plotted in coffeehouses, had those of Istanbul torn down; they stayed closed for decades (Hattox, 2014, p. 102). The institution arrived in lands that were or soon became Ottoman a century earlier: Mecca (1511), Cairo (1532), and Constantinople (1554) against Western Europe in the

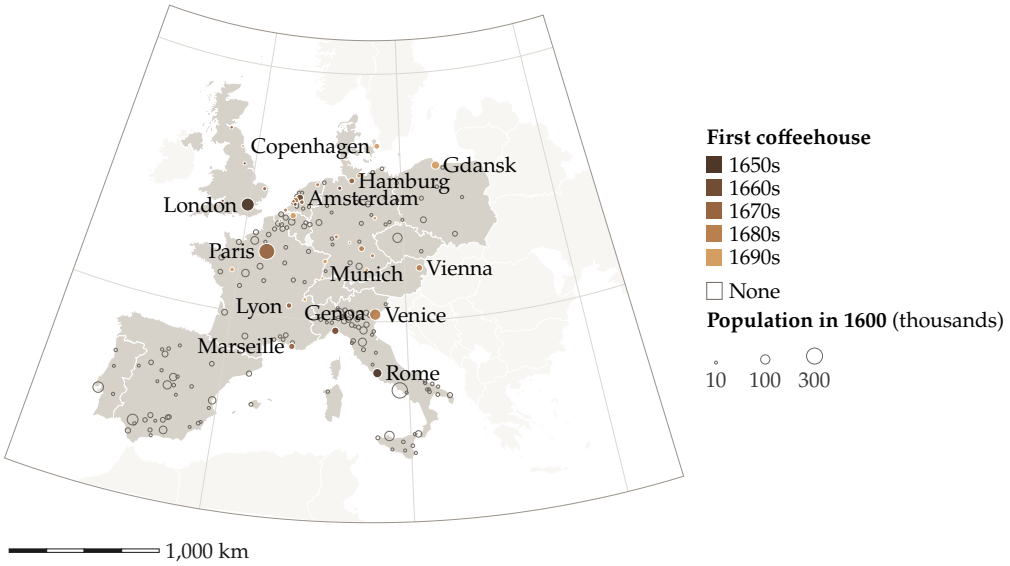


FIGURE 12. MAPPING THE FIRST COFFEEHOUSES IN EUROPE

Notes: Map of Europe showing our sample of 200 cities. These are populated areas with at least 10,000 inhabitants in 1600 and a recorded population in 1500 in Bosker et al. (2013). Circle area is population in 1600, and fill is the decade of the first recorded coffeehouse, gray for the 163 cities with no coffeehouse recorded in the seventeenth century. [Return to page 32]

Figure 12 maps the sample. Of the 200 cities, 37 record a coffeehouse in the seventeenth century, from London in the 1650s to Paris in the 1670s and Munich in the 1690s. To compare them with the rest in terms of applied science, we take the two London outcomes to the city level (Section 3). Instrument makers recorded in a city stand in directly for instrument shops. Mathematical practitioners have no European counterpart, so applied mathematics titles printed in a city take their place.

Figure 13 compares the 37 cities with a coffeehouse to the 163 without, by decade relative to the first coffeehouse, estimating equation (1) at the city level and controlling for the growth of the city from 1500 to 1600 and its log population in 1600, each with a separate coefficient in every decade. Flat pre-trends support the comparison conditional on size and growth.[57] Panel A shows a persistent rise in applied mathematics titles. The 37 coffeehouse cities averaged 5.95 titles in the decade before entry, and the number is 4.97 (s.e. 2.30) higher over the decade of entry and the three decades after, close to a doubling. Panel B shows a persistent rise in instrument makers, by 4.89 (s.e. 2.97) on a baseline of 3.73, more than a doubling.

We interpret these as conditional correlations, and Appendix C.11 shows that they are largely stable. The titles difference holds whether the cities whose sources admit more than one entry decade are dated as early or as late as the sources allow, or dropped, at between 4.59 and 5.45 against 4.97 in the main estimate (Appendix Table C6), and it holds within countries, at 4.25 (s.e. 2.38). Nor do the differences rest on London alone. Over the first two decades after entry, the other coffeehouse cities print 2.29 more titles (s.e. 1.29) and record 0.91 more makers (s.e. 0.53), about two-fifths of their pre-entry

1650s (Ellis, 2004, p. 259). The restriction removes cities in Bulgaria, Greece, Albania, Cyprus, Hungary, Romania, and the lands of the former Yugoslavia.

[57] We fail to reject the null that the differences two to five decades before entry are jointly zero ($p = 0.46$ for titles and $p = 0.33$ for makers).

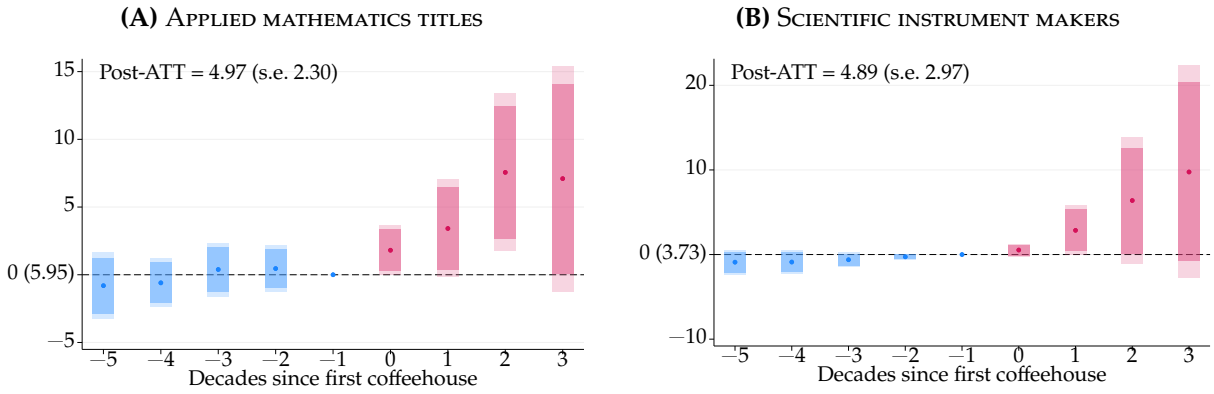


Figure 13. Coffeehouse cities relative to comparison cities of similar size and growth

Notes: Figure shows event study estimates and 90 (darker) and 95 (lighter) percent confidence intervals from equations (1) and (2) at the city level. Outcomes are the decadal number of applied mathematics titles printed and scientific instrument makers recorded in a city. Controls added to equation (1) are log population in 1600 and growth from 1500 to 1600, each interacted with decade fixed effects. The window stops at three decades because only London and Rome are observed at four. Sample includes all 200 cities from the 1600s to the 1690s. Unit of observation is city-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through three decades after. Standard errors clustered by city. [Return to pages 33, OA-21, OA-47]

means.[58]

If the association reflects coffeehouses drawing new entrants into science, and not just city size, it should be strongest where the new science already had readers. We locate them with the census by Gingerich (2002) of every known copy of Copernicus's *De revolutionibus* (1543), the heliocentric treatise conventionally taken to open the Scientific Revolution (Jacob, 1988, p. 256). Holding a copy in 1620 has little to do with size: 10 of the 19 coffeehouse cities at or above the median population in 1600 do, against 7 of the 18 below it. Among the large cities, the post-entry difference in titles is 18.20 (s.e. 7.40) where a copy was held and 1.26 (s.e. 1.63) where none was, and among the small neither group shows a rise (Appendix B.11 and Appendix Table B3). The association thus appears where a larger stock of potential entrants into science already existed.

We take these results as evidence that the London pattern is not peculiar to London. The same institution, in 37 cities across ten countries, comes with the same two outcomes moving with entry, with the same timing and magnitudes of the same order. They also bear on the worry that coffeehouses simply relocated scientists: activity shifting between London parishes is easy to imagine, but between London, Paris, and Munich it is harder.

7. AGGREGATE IMPLICATIONS FOR LONDON

The event studies of Sections 4 and 6 measure what a coffeehouse on average did to a London parish or a European city. The parish estimates do not account for moves within London, and the decade fixed effects absorb whatever coffeehouses did for London as a whole. The city estimate gives the average difference after the first coffeehouse in a city, abstracting from London's coffeehouse geography. To get at what this geography did to

[58] We use the first two decades here because the third rests on the eight cities that opened a coffeehouse by the 1660s, seven once London is left out. Appendix Table C5 reports both windows.

London's science as a whole, we move beyond these estimates with a standard modern quantitative urban model (Redding, 2025), calibrated to both sets of estimates and detailed in Appendix E. What we add is a meeting technology behind its agglomeration force, estimated from documented connections and shifted by the coffeehouse.

Our model consists of two blocks. The first says how often scientists meet and what a coffeehouse does to that rate. The second says who takes up science and where they work, given what meetings are worth.

Formally, the first block conceptualizes the coffeehouse as a meeting technology: each applied scientist in parish p meets each in parish q, d_{pq} kilometers away, at a Poisson rate proportional to $e^{\phi D_{pt}} e^{-\delta d_{pq}} e^{\phi D_{qt}}$, with $D_{pt} = 1$ if p has a coffeehouse in decade t (Assumption E.1). Each coffeehouse multiplies the rate by e^{ϕ} because it puts the scientists of its parish into circulation, drawing them socially and intellectually into a public sphere of knowledge exchange around the new experimental science (Section 5.4). Thus, a coffeehouse at the other end adds to the first rather than competing with it. If each meeting is documented independently of everything else, the number of connections T_{pqt} documented between parishes p and q follows the gravity equation (Theorem E.1)

$$\mathbb{E}[T_{pqt}] = \exp\big(\ln S_{pt} + \ln S_{qt} - \delta d_{pq} + \phi(D_{pt} + D_{qt}) + \mu_t\big), \tag{5}$$

with S_{pt} parish p's scientists, the combined de-duplicated roster of 403 drawn from the 244 mathematical practitioners and 252 scientific instrument makers of Section 3, and μ_t a decade fixed effect for how often meetings are documented. Estimating equation (5) by Poisson pseudo-maximum likelihood on the 244 practitioners' connections gives $\phi = 0.554$ and $\delta = 0.277$. Thus, a coffeehouse multiplies the rate at which its parish's scientists meet by 1.74, and the rate halves with every 2.5 kilometers of distance, which keeps most meetings local.

The second block assumes a choice model that governs entry into science and location choices of scientists. Scientists locate where the return to practicing is highest, and that return rises with the meetings a parish offers. Entry into science in the first place rises with the expected return the parishes offer together. The two elasticities estimated below, β_P for parish location and β_S for entry into science, measure these responses. Here, the return to practicing in parish p is $R_{pt} = \psi_{pt} K_{pt}^{\eta} S_{pt}^{-\gamma}$. It rises at elasticity η with the parish's access $K_{pt} = e^{\phi D_{pt}} \sum_q e^{-\delta d_{pq}} e^{\phi D_{qt}} S_{qt}$, proportional to the meetings each scientist there expects, and, conditional on access, falls at elasticity γ with those already there, who compete for its premises. The fundamental ψ_{pt} makes the parish attractive apart from access. Given these quantities, (i) whether a potential entrant ν practices and (ii) where, p_ν, are given by

$$\nu \text{ practices if } V_t\, \zeta_{1\nu} > \overline{u}\, \zeta_{0\nu}, \qquad p_\nu = \arg\max_p\, R_{pt}\, \xi_{p\nu} \text{ if it does,} \tag{6}$$

with $\overline{u}$ the outside trade's payoff and $\xi_{p\nu}$ and $(\zeta_{0\nu}, \zeta_{1\nu})$ Fréchet tastes of shapes ε_P and ε_S, respectively (Assumption E.2). Solving backward, the parish choice gives the value of practice $V_t = (\sum_k R_{kt}^{\varepsilon_P})^{1/\varepsilon_P}$. Parish p's share is $\sigma_{pt} \propto R_{pt}^{\varepsilon_P}$ (Theorem E.2).

These blocks lead to two equations, for where scientists work and for how many there are, used for estimation and counterfactuals. The first is given by substituting $S_{pt} = \sigma_{pt} S_t$ and $K_{pt} = \kappa_{pt} S_t$ into $\sigma_{pt} \propto R_{pt}^{\varepsilon_P}$: $\ln \sigma_{pt} = \beta_P \ln \kappa_{pt} + \ln \tilde{\psi}_{pt} + c_t$, with κ_{pt}

access in shares σ_{qt}, $\tilde{\psi}_{pt} = \psi_{pt}^{\varepsilon_P/(1+\gamma\varepsilon_P)}$, $\beta_P = \varepsilon_P\eta/(1+\gamma\varepsilon_P)$, and c_t common to all parishes (Theorem E.3). The event study's decade fixed effects absorb c_t, so it sees only shares moving with access at elasticity β_P. Indirect inference picks $\beta_P = 0.560$, at which the event study on the model's parish counts, built from London's observed totals and coffeehouses, with each $\tilde{\psi}_{pt}$ inverted from its 1600–1640 share and frozen, best matches the post-entry coefficients on the combined roster (Appendix Figure E1). The second is given by $V_t = \overline{K}_t^{\eta} S_t^{-\gamma}$, which the shares imply, and, with a large pool of potential entrants, $S_t \propto V_t^{\varepsilon_S}$: $\ln S_t = \beta_S \ln \overline{K}_t + \overline{c}_t$, with $\overline{K}_t = S_t(\sum_p \tilde{\psi}_{pt}\kappa_{pt}^{\beta_P})^{1/\beta_P}$ London's average access, $\beta_S = \varepsilon_S\eta/(1+\gamma\varepsilon_S)$, and $\overline{c}_t$ set by the pool and the outside payoff (Corollary E.1).

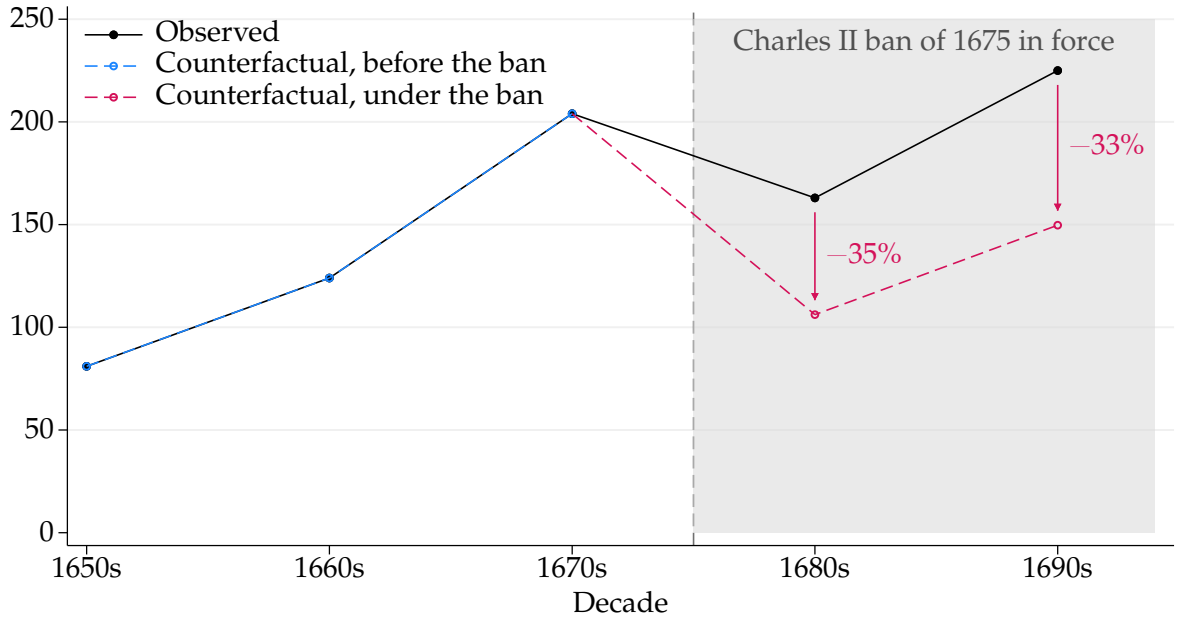


Figure 14. London's applied scientists with and without the ban of 1675

Notes: Figure plots London's observed applied scientists, the combined roster of mathematical practitioners and scientific instrument makers, by decade and the counterfactual number the model gives with every coffeehouse closed in the 1680s and 1690s, at $\beta_S = 0.39$, the average of the two city estimates (Procedure E.4). The counterfactual equals the observed count until the ban, and the labels give its shortfall under the ban in percent. [Return to page 37]

To quantify the aggregate implications, we consider a counterfactual, marked by primes, that changes each decade's coffeehouse geography but not its fundamentals. Taking a coffeehouse away lowers access in its parish and London's average access. The first moves scientists out of the parish at elasticity β_P, and the second lowers entry at elasticity β_S. In ratios to the observed decade, $\tilde{\psi}_{pt}$ and $\overline{c}_t$ cancel and the equations become

$$\sigma'_{pt}/\sigma_{pt} = \left(\kappa'_{pt}/(M_t\kappa_{pt})\right)^{\beta_P}, \qquad \ln(S'_t/S_t) = \tfrac{\beta_S}{1-\beta_S}\ln M_t, \tag{7}$$

with $M_t = (\sum_p \sigma_{pt}(\kappa'_{pt}/\kappa_{pt})^{\beta_P})^{1/\beta_P}$ the change in $\overline{K}_t/S_t$, average access in shares (Theorems E.8 and E.10). As κ'_{pt} depends on the new shares, the first equation is a fixed point, solved uniquely from the observed counts, ϕ, δ, and β_P (Theorem E.5), and the second the total from β_S. No comparison within London sees β_S, but the first coffeehouse in a city can, absent migration between cities. If it reaches the whole city, it multiplies every pair's rate by e^{ϕ} at each end and every κ_{pt} by $M_t = e^{2\phi}$, so

by (7) the city's log count rises by $2\phi\beta_S/(1-\beta_S)$. The treated cities of Section 6 rise from a pre-entry mean base to base + b, and calibrating the model to these moments, $2\phi\beta_S/(1-\beta_S) = \ln([b + \text{base}]/\text{base})$, gives $\beta_S = 0.35$ for applied mathematics titles and 0.43 for instrument makers.

At the average $\beta_S = 0.39$, removing every coffeehouse in the 1650s to 1690s would have cost London 243 of 797 scientists counted decade by decade, 31 percent (Appendix Table E1). Coffeehouse parishes would have lost 182, 23 percent to other parishes and 77 percent to the outside trade, and the others, losing access too, a net 61 (Theorem E.11). The implications are illustrated by Figure 14, which shows what would have happened if Charles II's proclamation of 29 December 1675, forbidding the retail sale of coffee from 10 January 1676, had not been suspended on 8 January (Cowan, 2005, pp. 196–198). London would have had 106 scientists in the 1680s and 150 in the 1690s, 35 and 33 percent fewer, respectively, if nothing had replaced the coffeehouses.

8. CONCLUSION

This paper examines the effects of coffeehouses on science in seventeenth-century London. Using newly digitized geocoded panel data and a staggered event study across parishes, we find that the first coffeehouse in a parish was followed by a persistent increase in the number of mathematical practitioners and scientific instrument shops. Pre-trends, local commercial booms, and the survival of records do not explain the increase. Earlier tavern openings rooted in traditional English sociability produce no comparable increase. Moreover, positive spillovers onto the immediate neighborhood of an opening weigh against simple displacement. Consistent with the London result, across European cities, applied mathematics titles and instrument makers rise after the first coffeehouse. To get at the aggregate implications, we calibrate a quantitative urban model to the reduced-form parish- and city-level estimates and find that coffeehouses account for 31 percent of London's applied scientists, counted decade by decade.

These results inform us about the importance of broadening access to intellectual exchange for the production and use of knowledge. First, effects are largest among practitioners whose surnames were least represented at Oxford and Cambridge, so science drew on a reserve of talent beyond the learned elite. Second, connections between instrument makers and theoretically oriented practitioners rise. Third, shops making experimental instruments rise proportionally faster than practical ones, from a smaller base. These patterns are consistent with coffeehouses drawing science out of purely scholarly circles and into the tacit skills of London's instrument trade.

These results also add to the economic history of England. Arriving in London in 1652, at the onset of modern growth, the coffeehouse raised scientific activity where it opened, and the applied scientists we count are among the skilled implementers that some accounts place at the center of Britain's later technological change (Meisenzahl and Mokyr, 2012; Mokyr, 2016). Though our data do not reach that change, they show how coffeehouses turned proximity into exchange across divided knowledge communities when experimental philosophy needed what craftsmen knew. Coffeehouses, then, fell on the fertile ground of the Scientific Revolution, and by making science more open and more connected, accelerated its applied side.

More than three centuries later, what lessons can we draw from these results? Key features of the historical context are still with us, as a reserve of talent lies outside formal

academic networks. For example, in the United States, children from below-median-income families become inventors at one-tenth the rate of those from top-1-percent families (Bell et al., 2019), and across the globe, olympiad mathematicians would publish 10 percent more if those from poorer countries matched equally scoring peers from rich ones (Agarwal and Gaule, 2020). That figure counts only talent already discovered, whereas, in our model, coffeehouses also added talent that would otherwise have been "lost Newtons." Furthermore, the exchange that coffeehouses fostered between those who understood the formal theories and those who could build the tools to test them now runs between universities and firms: most patents that cite science directly are held by firms, and most of the papers they cite come from universities (Ahmadpoor and Jones, 2017). Geographic proximity has mattered, and still matters, for such connections (e.g., Andrews, 2023; Jaffe et al., 1993; Kantor and Whalley, 2019). Social institutions that make it cheaper to learn from others can therefore widen who produces knowledge and increase the number of such fruitful connections.

We conclude with three potential extensions of this work and directions for future research. First, we are testing whether coffeehouses changed the content of knowledge. Only 87 of our 244 practitioners have a printed work, too few to compare parishes by what they wrote, so we compare cities. We are focusing on the content of the books printed in each, measured by their titles or full text. Second, the closed societies that arose in the eighteenth century, such as coffeehouses that became private clubs (Ellis, 2004) and Masonic lodges that met in taverns (Lane, 1895), could show whether shutting outsiders out reversed what the open coffeehouse did. Third, tracing apprentices, whom Hay et al. (2025) record into the nineteenth century, could show whether shops in coffeehouse parishes taught more of the skills of the instrument-making trade that would turn out to be beneficial to later industrialization (Kelly et al., 2023; Meisenzahl and Mokyr, 2012).

For modern times, the café remains the archetype of what Oldenburg (1989) calls a "third place," neither home nor work. Sociologists have long studied how such places form social ties (Small and Adler, 2019), and a smaller literature links them to innovation (Gagliardi and Roche, 2026; Roche, 2020). Yet, to the best of our knowledge, no study on contemporary data estimates whether the opening of such a venue changes who enters science. In seventeenth-century London, by our estimates, the coffeehouse drew outsiders into science for a penny.

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ONLINE APPENDIX

"Coffeehouses and the Rise of Science"

Monir Bounadi & Jens Oehlen

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A. HISTORICAL BACKGROUND

A.1. Why Coffeehouses Opened

The identifying assumption in Section 4 requires that the timing and location of first coffeehouse openings be unrelated to the trends local scientific activity would have followed absent coffeehouses, and that differential activity between coffeehouse and non-coffeehouse parishes did not respond before openings. One concern, then, is that keepers anticipated scholarly demand and opened where scientific activity was already poised to grow. The documentary record cannot rule out such selection, but it points instead to non-scientific demand. Indeed, as we explain below, every recorded motive is commercial. Moreover, Table A2 documents the middling, rather than virtuosic, economic status of coffeehouse keepers, while Table A4 shows that commercial ties among mathematical practitioners were rare before 1650.

The first coffeehouse in London illustrates this decision rule. Pasqua Rosée was a Greek servant whom the Smyrna merchant Daniel Edwards brought to London in 1651 to prepare coffee (Cowan, 2017; Ellis, 2004b). When visitors seeking coffee overran Edwards's household, Edwards sponsored Rosée in a shed in the churchyard of St. Michael Cornhill because membership in the Levant Company barred Edwards from retailing coffee himself. Rosée (1652) successfully advertised the drink with a handbill invoking Galenic health claims. Because of the increasing popularity of Rosée's coffeehouse, and because he was not a freeman, alehouse keepers competing for customers petitioned the Lord Mayor to stop Rosée from trading and selling coffee. Rosée and Edwards were able to overcome this obstacle in 1654 by taking in Christopher Bowman, a freeman of the Grocers' Company who brought no knowledge of coffee but did bring his status as a freeman of the City. In 1656, these partners leased premises for four pounds a year. In sum, the first coffeehouse entered London as a new public house with a supply chain, a licensing problem, a landlord, and competitors.

The other documented coffeehouse keepers in the *Oxford Dictionary of National Biography* differed only in the commercial niches they served: Thomas Garraway built his Exchange Alley coffeehouse around auctions, share dealing, and commercial news (Cowan, 2004a). Edward Lloyd made his coffeehouse the resort of shipbrokers and marine underwriters and began publishing shipping intelligence in 1692 (Palmer, 2007). The coffeehouse run by William Urwin attracted the literary wits (Cowan, 2004c), while Alexander Man opened a coffeehouse near Charing Cross in 1666 close to the Court (Lillywhite, 1963). Even the hard case in terms of association with science confirms the pattern that coffeehouses were established for reasons largely unrelated to science. The Grecian, the coffeehouse most closely associated with the Royal Society, was founded by George Constantine, a Greek immigrant and former mariner who was selling coffee in Threadneedle Street by 1665. Its initial appeal lay in the classical associations of his name and its location beside the Temple (Harris, 2000). A Royal Society clientele is documented only from 1709. The uses recorded for the 286 coffeehouses of the panel point the same way (Figure A1): 82 carry a record of commerce, 74 of news and literature, and 60 of politics or a club, against 11 with any indication of a clientele in science or learning, while 141 carry no indication of a specialized clientele.

At the scale of the whole of London, which our parish-level specification controls for as long as a shock hits all parishes equally, which is likely given their small size, timing

was shaped by non-scientific shocks common to the whole city: bulk imports by the East India Company from 1657 and its first sale in 1660 (Table A3), the Excise Act of 1660, the licensing requirement introduced by the excise reform of 1663, and the Fire of 1666 (Cowan, 2005; Ellis, 2004a). Unlike the rest, the Fire did not hit parishes alike, and Appendix C.4 allows separate trends for the burned area. Attempts by the Crown to suppress coffeehouses, in 1666 and with the proclamation of December 1675, accused them of sedition, never of natural philosophy (Cowan, 2004b, 2005).

The record cannot, however, entirely rule out the idea that coffeehouse keepers and scientists or potential entrants into science co-located. Coffeehouses concentrated in the wards around the Exchange, as did instrument makers and mathematical practitioners (Stewart, 1999). Nevertheless, what the historical evidence shows is that keepers did not seem to deliberately target anticipated scientific demand; it does not show whether coffeehouses and scientific activity shared the same commercial geography. Section 4 addresses the latter concern using pre-treatment dynamics, covariate adjustment, randomization inference, and, most importantly, placebo outcomes.

Selection into the historical record is also unlikely to explain the aforementioned evidence. The coffeehouses discussed above are famous partly because historians later connected them to science, which makes them the coffeehouses most likely to have been sited on the outcome, yet their documented origins still primarily lie in insurance, auctions, literary custom, and Court trade. The anonymous establishments comprising most of the sample are even less likely to have been founded in response to scholarly demand. This does not deny that the virtuosi shaped the reception of coffee or that coffeehouses later became consequential for science (Cowan, 2005; Pincus, 1995). Here our narrower claim is that the available evidence identifies non-scientific aspects, such as coffee supply, commercial geography, immigrant expertise, taxation and licensing, and non-scientific clientele, as the main determinants of where and when coffeehouses opened.

A.2. Coffee, Coffeehouses, and Science

Table A1 traces coffee, coffeehouses, and science in England from the 1620s to the end of the seventeenth century. English natural philosophers wrote about coffee decades before the first London coffeehouse opened. The previous subsection shows that the main determinants of why coffeehouses opened were commercial. This subsection shows that once the coffeehouses existed and became integrated with social life, what passed through them was not only natural philosophy but mathematical practice and instrument making: designs handed from theorists to clockmakers, calculating devices shown across a table, and printers and makers carried into the Royal Society.

A.3. Figures

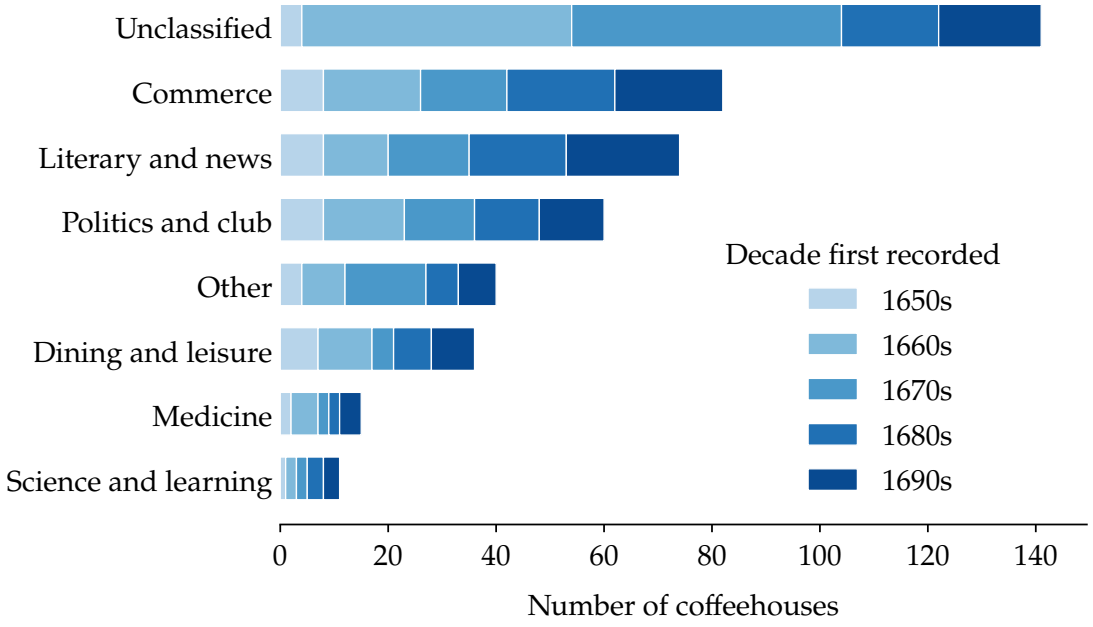


Figure A1. Recorded uses of coffeehouses by decade of first record

Notes: Figure counts the 286 seventeenth-century coffeehouses of the panel by the uses their records mention, with each bar split by the decade in which the coffeehouse is first recorded. Uses are coded from keyword searches of the entries in Lillywhite (1963) dated before 1700 and from the activity tags of Mackie (2013) for years before 1700, and grouped into seven categories; science and learning covers records of virtuosi, the Royal Society, experiments, mathematics, and instrument makers. A coffeehouse can carry several uses, so the seven classified bars count 318 uses of 145 coffeehouses. The 141 coffeehouses with no recorded use are unclassified. [Return to pages 18, OA-1]



1639	Baptized in Northill, Bedfordshire, the son of a blacksmith.
1671	Joins the Clockmakers' Company in London.
27 June 1674	"Told him at Childs coffee house of new Dividing compasses screw upon a Rule."
8 March 1675	"At Garaways [coffee house]. Tompion. I shewd my way of fixing Double Springs to the inside of the Ballance wheel."
7 April 1675	"With the King and shewd him my new spring watch, Sir J. More and Tompion there [. . .] commended it far beyond Zulichems."
1676	Makes two year-going clocks, commissioned by Sir Jonas Moore, for the new Royal Observatory at Greenwich.

Figure A2. Coffeehouse meetings joined craft skill to experimental science

Notes: Figure sets a 1697 portrait of the clockmaker Thomas Tompion (1639–1713) beside dates from his life (Evans, 2008) and three entries that name him in the diary of Robert Hooke (1635–1703) (Robinson and Adams, 1935, pp. 109, 151, 157). [Return to page 12]

A.4. Tables

Table A1—Chronology of coffee, coffeehouses, and science

Coffee becomes an object of scientific inquiry	
1623	Francis Bacon, the philosopher of the experimental method, discusses coffee in *Historia Vitae et Mortis*.
1627	Bacon returns to coffee in *Sylva Sylvarum*, classing it with tobacco and opium among intoxicants that "condense and relieve the spirits" and sharpen the mind.
1640	John Parkinson, one of the first of the great English botanists and apothecary to King James I, introduces coffee to English botanical literature in *Theatrum Botanicum*, describing it as the "Turkes berry drinke."
1650s	William Harvey, who established the circulation of the blood, drinks coffee privately with his merchant brother Eliab "before Coffee-houses were in fashion in London"; the family's Levant and East India trade was the likely channel.
Coffeehouses become sites of scientific contact and activity	
1652	Pasqua Rosée, a Greek servant of the Smyrna merchant Daniel Edwards, opens the first coffeehouse in London near the Old Exchange.
1655	The natural philosopher Robert Boyle's circle, including Christopher Wren and John Wilkins, meets in the coffee-room of the Oxford apothecary Arthur Tillyard, constituting the earliest documented gathering of natural philosophers in an English coffee-room.
1659	The Rota Club, a debating society founded by the political theorist James Harrington, meets at Miles's Coffee House at the Turk's Head. Eleven of its twenty-seven identifiable members later became Fellows of the Royal Society (Hunter, 1989).
1660	The Royal Society is founded; the East India Company holds its first official coffee sale; the Excise Act taxes coffee at the keeper.
1663	Samuel Pepys, the naval administrator and diarist, records "good discourse about physique and chymistry" at a coffeehouse, including news of a projector's design for "an instrument to sink ships."
1672–1683	Robert Hooke's diary records visits to 57 London coffeehouses, on nearly two of every three days, where he exchanged information, displayed instruments, and debated scientific questions.

Continued on next page

Continued

1674	Hooke meets the clockmaker Thomas Tompion at Child's Coffee House and, in October, mathematical practitioners Henry Oldenburg, John Collins, Moses Pitt, and Joseph Moxon, who shows a calculating device made from Napier's bones.
1678	Joseph Moxon, a printer who moved into globes, instruments, and mathematical authorship through Hooke's coffeehouse circle, is elected to the Royal Society, an exceptional election for a tradesman.
1684	Hooke, Wren, and Edmond Halley debate planetary motion at a London coffeehouse, prompting Halley's visit to Newton and the manuscript *De motu corporum in gyrum*, the basis of the *Principia*.
1689	Naturalists begin to club together at the Temple Coffee House, among them Hans Sloane and the apothecary James Petiver, meeting on Friday evenings to exchange specimens and botanical intelligence until about 1706.
1698	John Harris begins lectures on mathematics and natural philosophy at the Marine Coffee House in Birchin Lane.
1699	John Houghton, an apothecary, coffee merchant, and Fellow of the Royal Society, publishes *A Discourse of Coffee* in the *Philosophical Transactions*, giving a history of the coffee trade and a natural history of the plant, and concluding that the "coffee-house makes all sorts of people sociable, they improve arts, and merchandize, and all other knowledge."
1701	Houghton returns to the theme in his *Collection for the Improvement of Husbandry and Trade*: an inquisitive man "may find out such coffee-houses, where men frequent, who are studious in such matters as his enquiry tends to," and there "gain the pith and marrow of the others reading and studies," getting "more in an evening than he shall by books in a month."

Notes: Table summarizes key dates linking coffee, coffeehouses, natural philosophy, mathematical practice, and instrument making in England and London to the end of the seventeenth century based on Clark (2000); Cowan (2005); Ellis (2006a); Lillywhite (1963); Mount (2021); Riley (2006); Shapin and Schaffer (1985), on the diaries of Hooke (Robinson and Adams, 1935) and Pepys (1660–1669), and on Houghton (1699, 1701). [Return to pages 12, OA-2]

Table A2—Relative wealth in the London victualling trades, 1692–93

Trade	Individuals	Householders	Mean Rent, £	Mean Stock, £
Victuallers	773	768	21	26
Coffeemen and Women	137	135	30	20
Vintners	131	123	80	149
Innholders or Keepers	91	91	80	74
Tapsters	23	3	–	–
Alehouse-keepers	10	10	21	25
Strongwater-men	10	10	16	42
Total	1,175	1,140		

Notes: Data from Cowan (2005, table 7). [Return to pages 18, OA-1]

Table A3—Coffee trade of the East India Company, 1650s–80s

Period	Activity	Pounds avoirdupois
1657	1st coffee order	22,400
1659	2nd coffee order	44,800
1660	1st official coffee sale	–
1660s	Coffee imports	45,000–56,000 per year
1680s	Coffee imports	280,000 per year

Notes: Data from Smith (2001, pp. 264–265). [Return to page OA-2]

Table A4—Commercial Connections of Mathematical Practitioners before 1650

Practitioner network size	Practitioners	With commercial tie	Commercial ties / all ties
1–9 ties	7	0	$0/36 \approx 0.0\%$
10–19 ties	15	3	$6/197 \approx 3.0\%$
≥ 20 ties	9	6	$12/348 \approx 3.4\%$
Total	31	9	$18/562 \approx 3.2\%$

Notes: The sample is the mathematical practitioners whose recorded flourishing ends before 1650. Network size is the number of SDFB relationships touching each practitioner; relationships are treated as undirected. Commercial contacts comprise merchants, traders, mercers, drapers, grocers, haberdashers, clothiers, shopkeepers, innkeepers, tavern keepers, victuallers, vintners, brewers, and publicans. Booksellers, printers, stationers, publishers, bankers, and financiers are excluded. The third column counts practitioners with at least one such contact. Relationships between practitioners in different rows count in both rows, so the denominators sum to 581 rather than the total of 562.

B. ADDITIONAL RESULTS

B.1. Raw Means

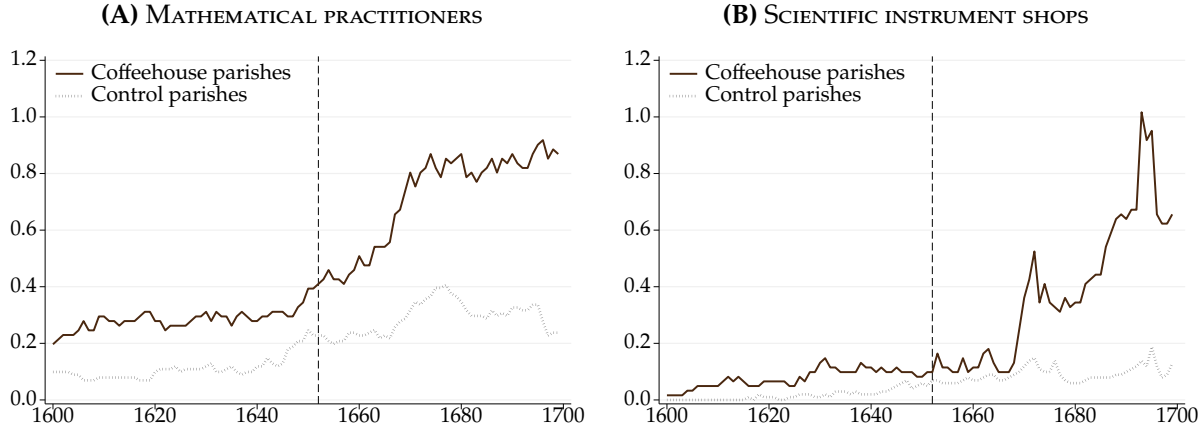


Figure B1. Scientific activity in coffeehouse and control parishes

Notes: Figure plots the mean number of mathematical practitioners (Panel A) and scientific instrument shops (Panel B) per parish in each year, for the 61 parishes whose first coffeehouse opened before 1700 and the 101 parishes without one. The dashed line marks 1652, when the first coffeehouse in London opened. Outcomes are annual versions of those in the event study of Figure 4, with each shop counted in the years its address is dated and a maker who moves counted once in the year of the move. Figure 1 dates the same shops by the working dates recorded for their makers, which include years without a dated address, so its levels are higher. [Return to page 20]

B.2. Spillover Estimation

Section 4 measures spillovers on a partition of London into 2,830 hexagons 200 meters across (Appendix Figure B2). Let y_{ht} be the number of mathematical practitioners or scientific instrument shops in hexagon h in decade t, and r_h its ring: $r_h = 0$ if a coffeehouse opens in the hexagon itself, and otherwise the 200-meter band $r_h \in \{200, 400, 600, 800, 1000\}$ holding the distance to its nearest opening hexagon. E_h is the decade in which h is first exposed, by its own first coffeehouse if $r_h = 0$ and by the earliest opening within 200 meters if $r_h = 200$. Hexagons beyond 1,000 meters have no ring, $r_h = E_h = \infty$, and serve as controls.

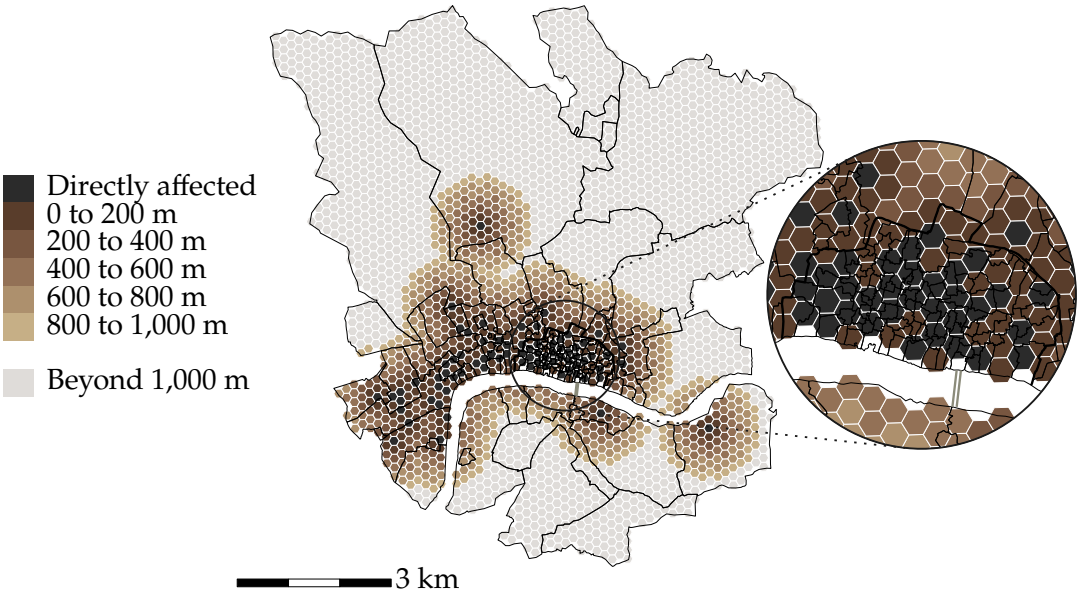


FIGURE B2. SPILLOVER RINGS AROUND FIRST COFFEEHOUSE OPENINGS

Notes: Map of London divided into 2,830 hexagons of 25,981 m^2 each, 200 meters corner to corner, with black lines for the 162 parish boundaries and an inset of the area inside the wall. Hexagons with a first coffeehouse in the seventeenth century are directly affected. Every other hexagon is assigned to a 200-meter distance ring around its nearest opening hexagon; the 1,906 gray hexagons more than 1,000 meters from any opening serve as controls in Appendix Table B1. [Return to pages 25, OA-7, OA-9, OA-11]

Table B1 reports the two-period regression of Butts (2023), in which the outcome is the change in each hexagon between the 1640s and the 1690s,

$$\mathbb{E}[y_{h,1690} - y_{h,1640} \mid r_h] = \Delta\mu + \sum_{r \in \mathcal{R}} \tau_r \mathbb{1}[r_h = r], \qquad \mathcal{R} = \{0, 200, 400, 600, 800, 1000\}, \tag{B.1}$$

where $\Delta\mu$ is the change common to all hexagons, τ_0 the effect on the hexagon receiving the coffeehouse, and τ_r the effect at distance r, both by the 1690s. Identification requires that spillovers are local, so hexagons beyond a kilometer are unaffected, and that absent an opening within a kilometer, hexagons in each ring would have changed as hexagons beyond it did (Butts, 2023).

Table B1—Direct and spillover effects of coffeehouse openings

		Mathematical practitioners			Scientific instrument shops		
	Hexagons	Mean	(1)	(2)	Mean	(3)	(4)
Opening hexagon	76	0.237	0.381**	0.392**	0.066	1.182***	1.196***
			(0.157)	(0.159)		(0.249)	(0.250)
0 to 200 m	172	0.081		0.166***	0.052		0.121**
				(0.054)			(0.051)
200 to 400 m	121	0.074		−0.019	0.017		0.048
				(0.048)			(0.037)
400 to 600 m	172	0.012		0.009	0.000		0.027**
				(0.013)			(0.013)
600 to 800 m	225	0.013		0.011	0.004		0.007
				(0.014)			(0.011)
800 to 1000 m	158	0.013		0.010	0.000		0.036
				(0.012)			(0.027)
Beyond 1,000 m	1906	0.001			0.001		
Hexagons in control group			2754	1906		2754	1906
R^2			0.038	0.054		0.169	0.173
Hexagons			2830	2830		2830	2830

Notes: Table reports estimates from equation (B.1) of the effect of first coffeehouse opening on scientific activity, on the hexagonal partition shown in Appendix Figure B2. Outcomes are the change in the number of mathematical practitioners and scientific instrument shops in a hexagon from the 1640s to the 1690s. Each hexagon is assigned to a 200-meter distance ring around its nearest opening hexagon, following Butts (2023). Columns (1) and (3) omit the ring indicators, so exposed hexagons remain in the control group; columns (2) and (4) estimate the effect on the directly affected hexagon jointly with the effect on each ring. Mean reports the outcome mean in the 1640s. Sample includes all 2,830 hexagons. Unit of observation is hexagon. Standard errors follow Conley (1999) with a Bartlett kernel and a 1-kilometer cutoff; significance at the 10, 5, and 1 percent levels is denoted by*,**, and***. [Return to pages 25, OA-8, OA-9]

Appendix Figure B4 estimates the same two effects dynamically. The first stage estimates the fixed effects on the observations not yet exposed, directly or as an immediate neighbor,

$$\mathbb{E}[y_{ht} \mid h, t] = \alpha_h + \mu_t \quad \text{for } (h,t) \text{ with } r_h > 200 \text{ or } t < E_h, \tag{B.2}$$

and imputes the untreated potential outcome $\widehat{y}_{ht}(\infty) = \widehat{\alpha}_h + \widehat{\mu}_t$, as in equation (1). The second stage regresses the imputed deviation on event time,

$$\mathbb{E}\big[y_{ht} - \widehat{y}_{ht}(\infty) \mid h, t\big] = \sum_{r \in \{0,200\}} \sum_{\ell=-5}^{4} \tau_{r,\ell} \mathbb{1}[r_h = r] \mathbb{1}[t - E_h = 10\ell], \tag{B.3}$$

where $\tau_{0,\ell}$ and $\tau_{200,\ell}$ are τ_0 and τ_{200} indexed by event time. Standard errors are clustered by hexagon in equation (B.3), accounting for first-stage estimation of the fixed effects. Figure B4 treats hexagons more than 200 meters from an opening as unexposed, the distance beyond which Table B1 finds no effect. Treating every hexagon within a kilometer of an opening as exposed instead, as the table does, changes the post-opening estimates by at most 0.02 and leaves the pre-opening estimates jointly indistinguishable from zero.

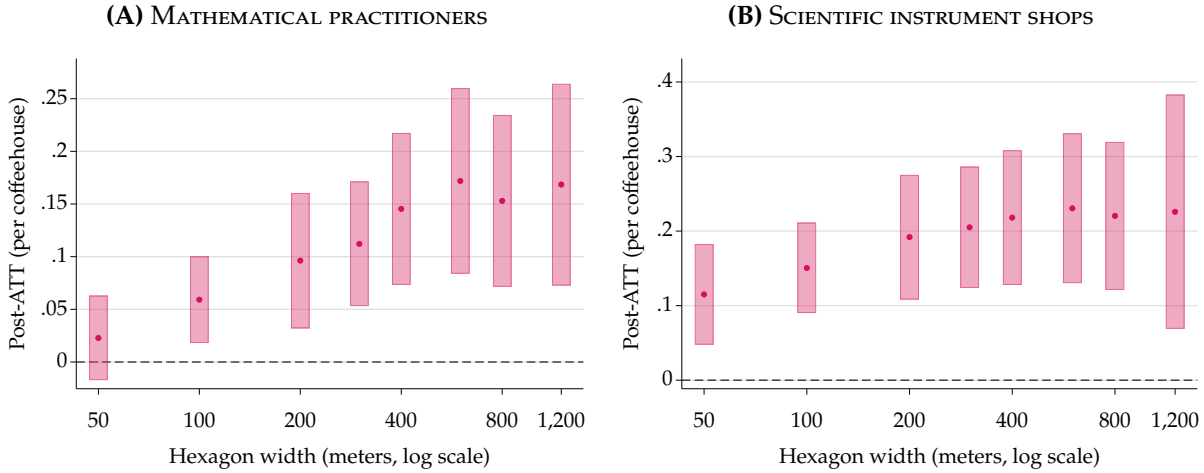


Figure B3. Effects on scientific activity: size of grid cell

Notes: Figure shows average post-treatment effects and 95 percent confidence intervals of first coffeehouse opening on scientific activity, divided by the number of coffeehouses in the treated hexagon, across hexagonal partitions of increasing cell width. Each partition is built anew, and every coffeehouse, practitioner, and instrument shop is reassigned to it. The eight estimates therefore come from eight separate panels. Estimation follows equation (1), with never-treated hexagons as controls. Coffeehouses per treated hexagon rise from 2.8 at 50 meters to 19.5 at 1,200 meters. Without the normalization, the effects would confound spillovers absorbed within the cell with treatment intensity. Unit of observation is hexagon-decade. Standard errors clustered by hexagon. [Return to page 25]

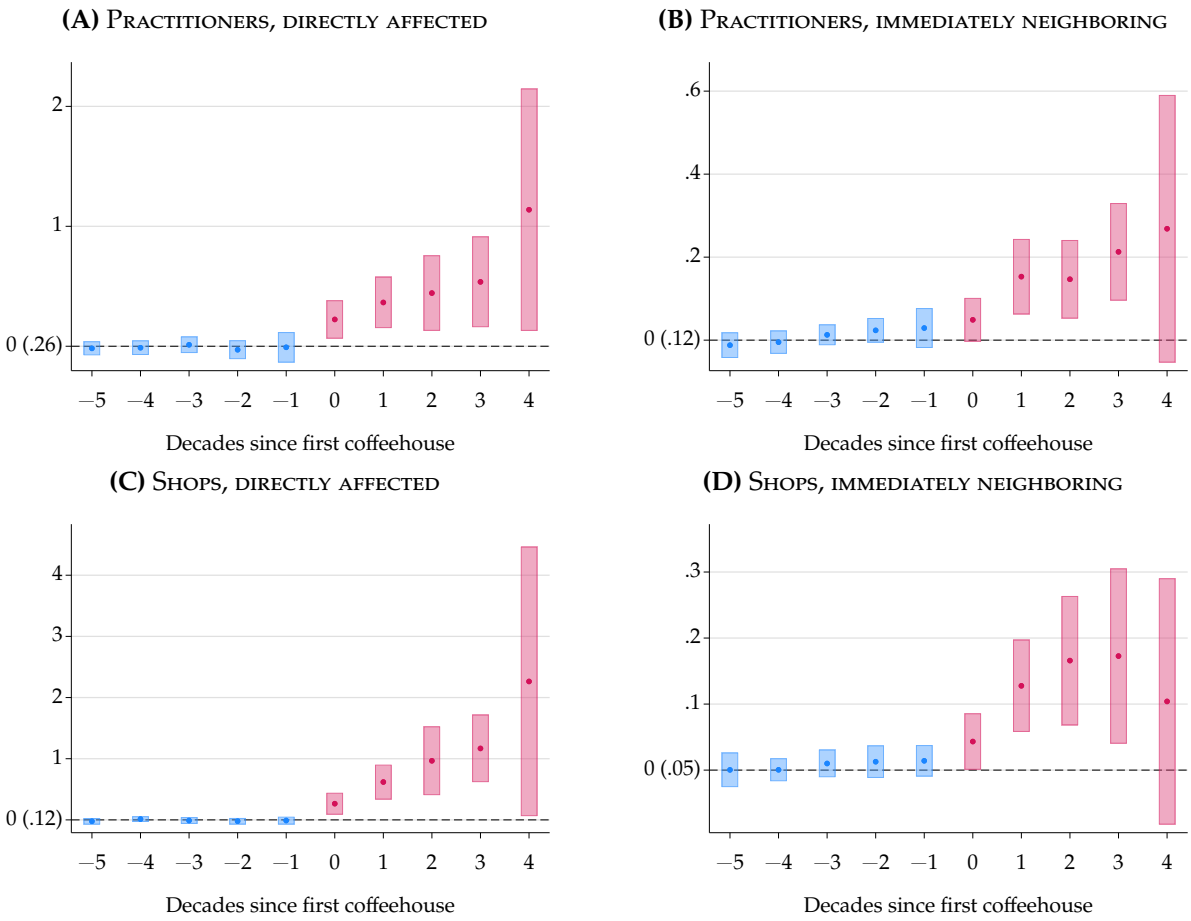


Figure B4. Effects on scientific activity: direct and spillover effects

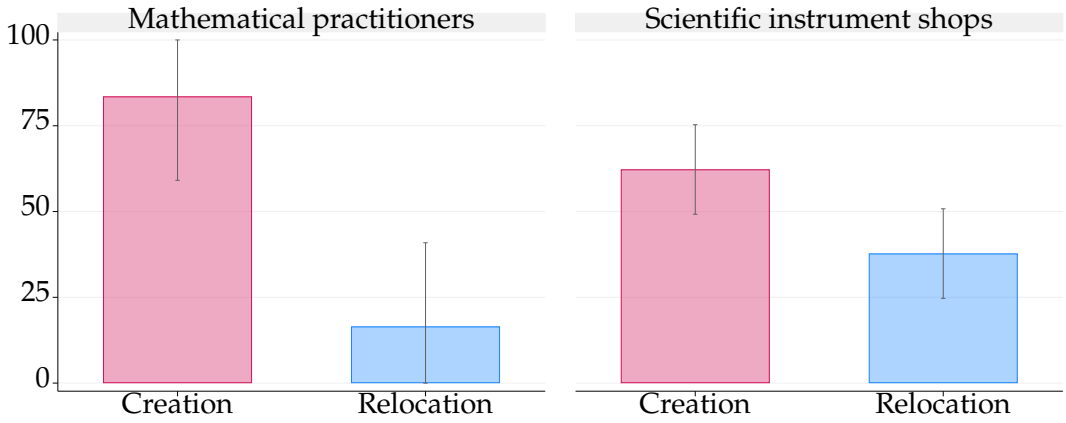
Notes: Figure shows event study estimates and 95 percent confidence intervals of the effect of first coffeehouse opening on scientific activity, from equations (B.2) and (B.3), following Butts (2023), on the hexagonal partition shown in Appendix Figure B2. Hexagon and decade effects are estimated on observations neither directly affected nor within 200 meters of an opening. Exposure begins with the earliest opening within 200 meters. No period is omitted. Pre-treatment decades also enter the first stage, so pre-treatment estimates average close to zero by construction; their slope, not their level, bears on parallel trends. Vertical scales differ across panels. Sample includes 76 directly affected, 172 immediately neighboring, and 2,582 remaining hexagons from the 1600s to the 1690s. Unit of observation is hexagon-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean in the relevant group one decade before treatment. Standard errors clustered by hexagon. [Return to pages 25, OA-9]

B.3. Creation and Relocation

Appendix Figure B5 splits the post-ATTs by where activity arrives. Creation counts practitioners at their first recorded London location and shops opening in the year a maker is first recorded, and relocation counts later locations and later shops. Activity at a first recorded London location accounts for 84 percent of the post-ATT for practitioners and 62 percent for shops. However, note that moves can also lower activity in the parishes that people leave, and so this simple split does not count those losses. For this reason, as an alternative exercise, we assign each practitioner to the first London parish on record and each shop to the parish of the first shop of its maker, and re-estimate. The post-ATTs fall by 0.08 practitioners and 0.18 shops, 12 and 15 percent of the effects. Most moves ran between parishes that both had a coffeehouse. In or after the decade of

a first opening, 5 of the 11 moves into a coffeehouse parish, and 10 of the 51 later shops opened there, came from parishes that never had one. Of these 51 shops, 37 opened while the first shop of the maker was still recorded, so holding them at the first parish overstates relocation. Nor did openings empty their neighborhoods. Within 400 meters of a first opening, there were on average 5.4 practitioners and 3.7 instrument shops in the decade before, and 7.7 and 6.5 in the decade of the opening, against 4.5 to 5.7 practitioners and 3.1 to 4.7 shops around the centers of the 101 parishes that never had a coffeehouse.

(A) Share of the post-ATT, percent



(B) Relative post-ATT

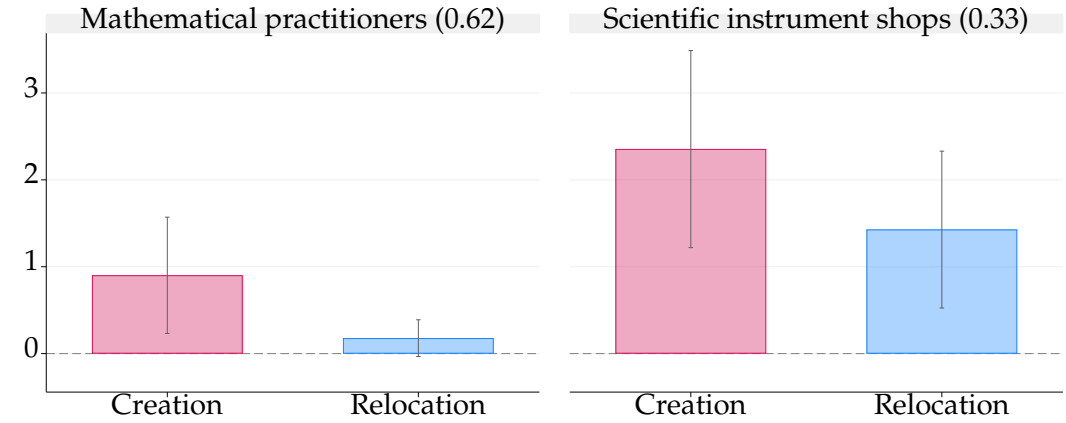


Figure B5. Effects on scientific activity: creation and relocation

Notes: Figure splits post-ATTs from equations (1) and (2) of first coffeehouse opening into creation and relocation. Creation counts practitioners at their first recorded London location and shops opening in the year a maker is first recorded; relocation counts later locations and later shops. Since later shops include second shops as well as moves, relocation overstates moves within London. Post-ATTs average the decade of treatment and the four decades thereafter. Panel A gives each component as a share of the post-ATT, with 95 percent confidence intervals bootstrapped by parish. Panel B divides each component by the outcome mean in the decade before treatment, given in parentheses, with 95 percent confidence intervals. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to pages 25, OA-11]

B.4. Hooke's Coffeehouse Visits Were Local

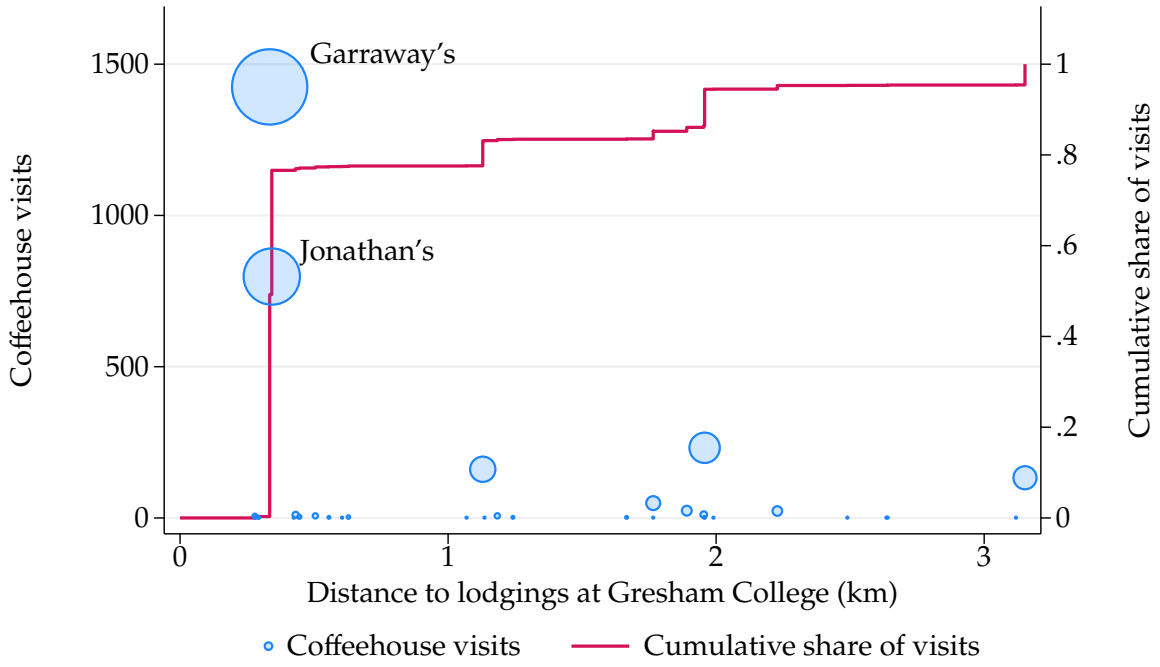


Figure B6. Robert Hooke's coffeehouse visits, 1672–1683

Notes: Figure shows the number of visits Robert Hooke made to different coffeehouses between 10 March 1672 and 15 May 1683, by their distance from his lodgings at Gresham College in Bishopsgate. Visits are days on which his diary names the coffeehouse. Circle size is proportional to the share of the 2,915 visits to the 32 coffeehouses that Brown et al. (2021) locate, and the step function read against the right axis gives the cumulative share of those visits made within a given distance. Of the 2,915 visits, 2,233 were within 400 meters of his lodgings. The diary names 25 further coffeehouses, 182 times, that cannot be located. Locations from Brown et al. (2021); visits from the diary as described in Appendix D.6. [Return to pages 25, OA-58]

B.5. Oxbridge Representation in Shares

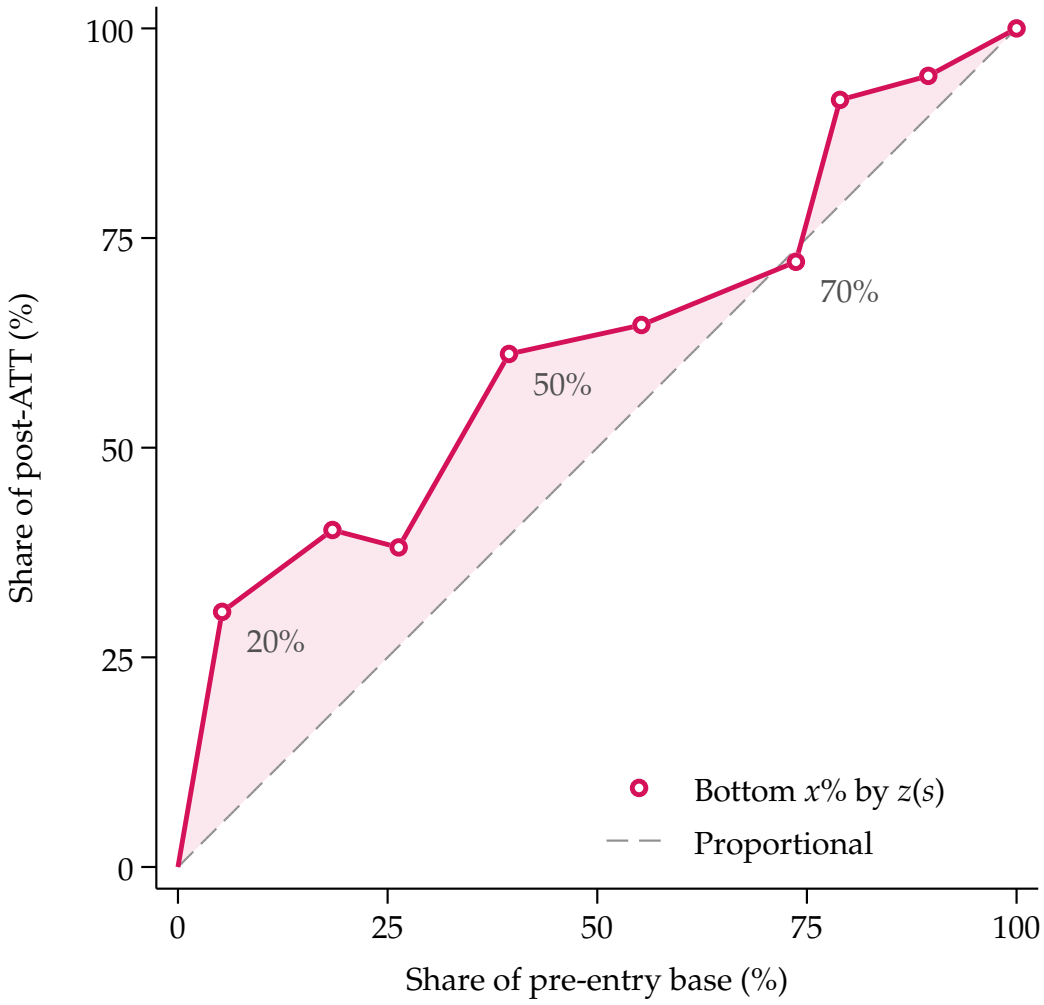


Figure B7. Shares of the effect and of the base by Oxbridge representation

Notes: Figure plots, for groups of mathematical practitioners from the bottom 20 percent of the distribution of $z(s)$ upward, the share of the average post-treatment effect on all practitioners (0.68) that each group accounts for against its share of the 38 practitioner-decades recorded in treated parishes in the decade before entry. The dashed line marks equal shares, and the shaded area the excess of the first over the second. Effects are estimated from equation (1) as in Figure 7, without dividing by the pre-entry mean. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. [Return to page 27]

B.6. Oxbridge Representation before Entry

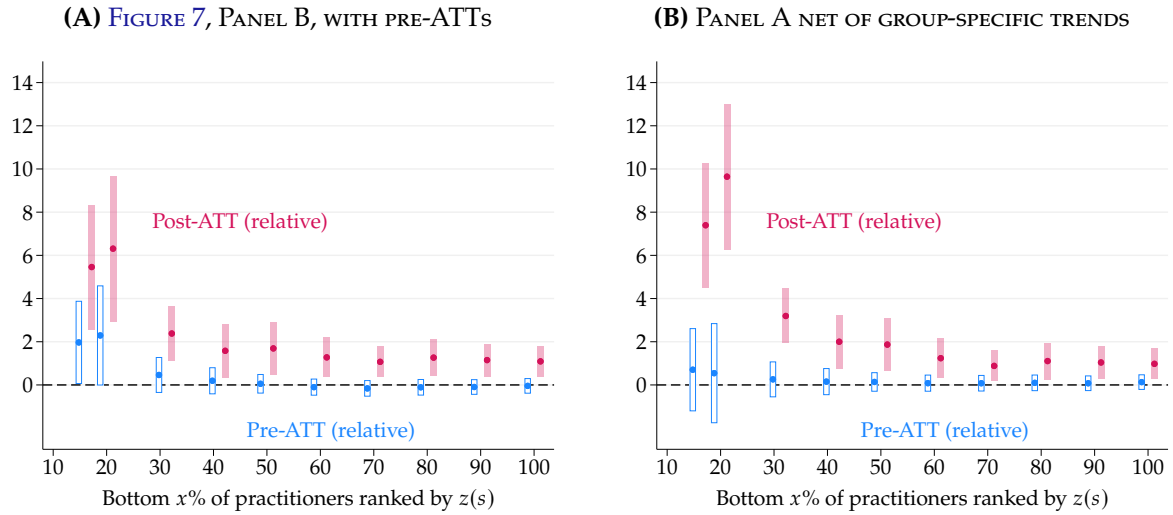


Figure B8. Pre- and post-entry effects by Oxbridge representation

Notes: Figure adds pre-ATTs, the averages of the estimates five to two decades before entry, to Panel B of Figure 7. Panel B estimates the same equations on outcomes net of linear trends estimated by treatment cohort on pre-treatment observations (Goodman-Bacon, 2021), as in Appendix Figure C22. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to page 27]

B.7. Makers and Theorists

Appendix Table B2 compares the makers and theorists whose connections Figure 8 divides. Of the 114 theorists, 41 taught mathematics or navigation, 18 were surveyors, navigators, or hydrographers, 10 held professorships, 25 are recorded only as mathematical practitioners, and 20 had other occupations. Taylor (1954) records study at Oxford or Cambridge for 23 of them, against 2 of the 130 makers. Theorists are also the more visible group in the record, with more entries in the *Oxford Dictionary of National Biography*, more printed works, and more connections. Yet their surnames are about as represented at Oxford and Cambridge as those of makers. Where the occupation of the father is known, theorists more often had fathers among the gentry or in a learned profession, but only 56 fathers are known.

Table B2—Makers and theorists among the mathematical practitioners

	Makers	Theorists	Difference
Practitioners	130	114	
Panel A. Career			
Flourishing from, mean year	1660	1646	−14 (4)
Years of flourishing, mean	26	28	3 (3)
Active from 1665	78	65	−14 (6)
Panel B. Output and recognition			
At least one printed work	17	57	40 (6)
Entry in the ODNB	16	47	31 (6)
Fellow of the Royal Society	5	13	9 (4)
Named in the *Philosophical Transactions*	11	28	18 (6)
Named in the Royal Society minutes	2	11	9 (4)
Panel C. Connections			
Connections, mean	3.2	4.7	1.6 (0.7)
Connections to makers	58	37	−21 (5)
Panel D. Background			
Studied at Oxford or Cambridge	2	20	19 (4)
Percentile of $z(s)$ among the 244, mean	49	51	2 (4)
Father's occupation known	18	29	11 (5)
Father gentry or of a learned profession	17	48	31 (12)

Notes: Table compares the 130 makers among the 244 mathematical practitioners, those whose recorded occupations place them in the instrument trade, including chart makers, engravers, and lens grinders, with the 114 theorists, all others. Rows are percentages unless marked as means. Difference is theorists minus makers, with standard errors allowing unequal variances in parentheses. Being named requires the first name or the context to confirm the identity in the *Philosophical Transactions* (Fischer et al., 2020), with every reader accepting the occurrence as in Section 3, among the 176 practitioners active from 1665, and the first name or an honorific in the minutes (The Royal Society, 2024), among the 182 active from 1660. Connections are those recorded by Taylor (1954) and Warren et al. (2016), and the share to makers is among the 204 practitioners with any. Study at Oxford or Cambridge is as Taylor (1954) records it. $z(s)$ enters as its percentile among all 244, 50 on average. The father's occupation is known for 56, mostly from linked biographies. Gentry or learned professions are gentlemen, baronets, clergymen, barristers, physicians, and magistrates. [Return to pages 28, OA-15]

B.8. Hooke's Company on Coffeehouse and Tavern Days

Figure B9 splits the additional company of a coffeehouse day in Figure 9 by occupation.

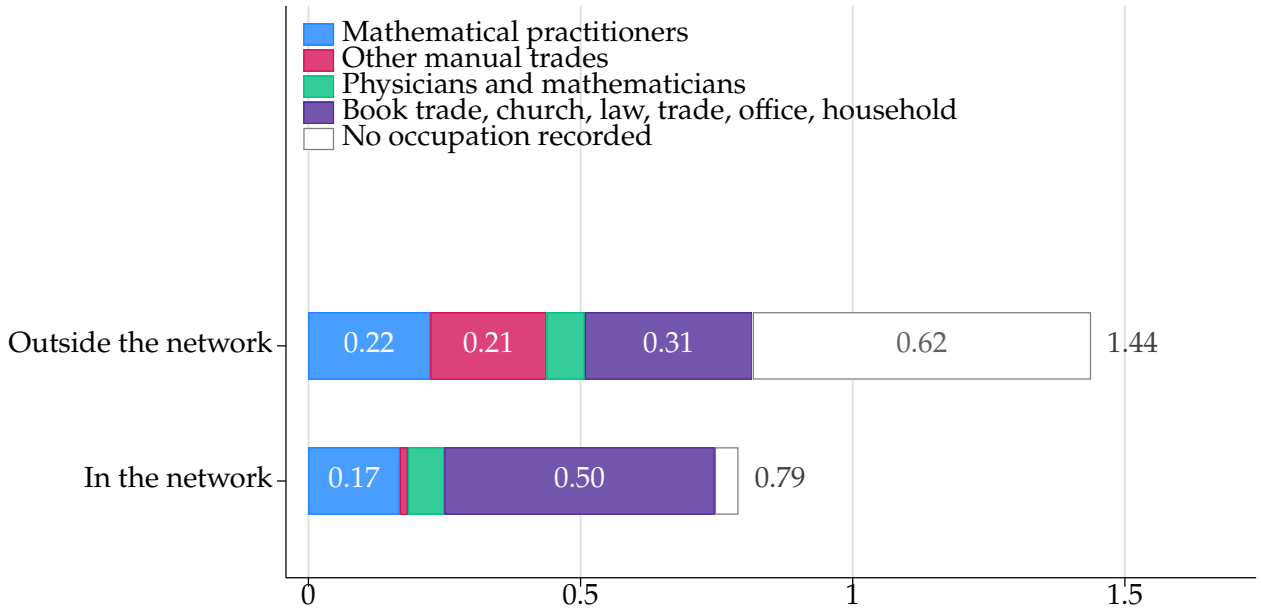


FIGURE B9. HOOKE'S ADDITIONAL COMPANY ON COFFEEHOUSE DAYS BY OCCUPATION

Notes: Figure splits the difference in people recorded between coffeehouse days and other days in Figure 9, Panel B, by occupation, for people outside the Republic of Letters and in it. Each segment is the coefficient on a coffeehouse day from a regression of the number of people in that occupation recorded per day on that indicator and year-by-weekday fixed effects, over the 3,464 days of the diary. Mathematical practitioners are the people matched by name to Taylor (1954) or to SIMON; the match is partly circular, since Taylor cites the diary in 58 entries. Other occupations are read from the notes in the index of the printed editions. Appendix D.6 describes the data. [Return to pages OA-16, OA-18]

Coffeehouse days and tavern days brought different company (Figure B10). In one regression per occupation, a coffeehouse day raises the number of mathematical practitioners Hooke records meeting by 79 percent of its rate on days with neither, against 8 percent for a day at a tavern or other drinking house, and the number of men in other manual trades by 109 percent, against 25 percent. For the church, law, trade, and office, the two kinds of day do not differ.[59]

[59]The p-values of the three differences are < 0.001, 0.002, and 0.28.

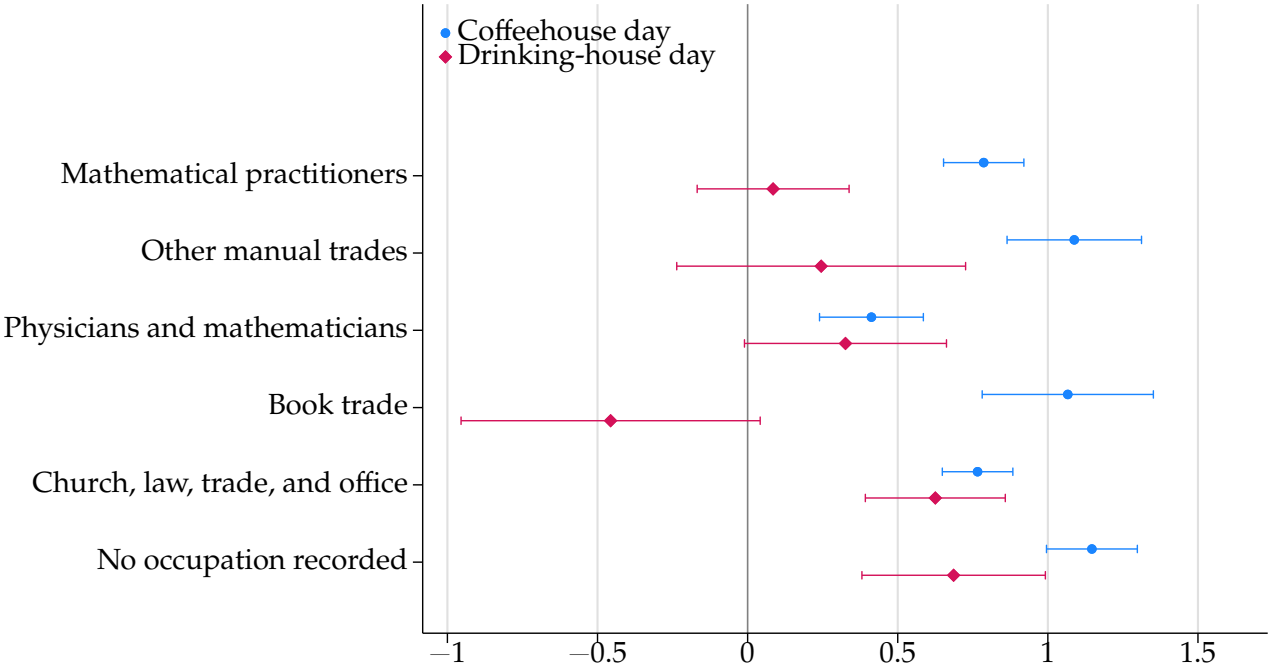


Figure B10. Hooke's company on coffeehouse and tavern days by occupation

Notes: Figure reports, for each occupation, the additional number of people Hooke records meeting on a coffeehouse day and on a day at a tavern or other drinking house, each as a multiple of the number recorded on days with neither, with 95 percent confidence intervals. Both come from one regression per occupation with indicators for the two kinds of day and year-by-weekday fixed effects over the 3,464 days of the diary, with heteroskedasticity-robust standard errors. A day can be both. Occupations are defined as in Figure B9; Hooke's household is left out. [Return to page OA-17]

The diary seldom says where a meeting took place. Reading each coffeehouse-day entry, a language model places 2,896 of the 16,325 meetings at the coffeehouse itself (Appendix D.6). These meetings are more often with correspondents than the meetings placed elsewhere, 44 against 39 percent.

B.9. Tavern Openings over the Full Period

Over the full 1550s–1690s sample, strong pre-trends in mathematical practitioners indicate that the placebo design is invalid there (Figure B11). Controlling for group-specific linear trends removes these pre-trends and yields negative effects on practitioners (Figure B12); estimated effects on instrument shops are positive over the full sample but small and insignificant before the 1650s. Over the full sample, instrument shops are 0.21 higher (s.e. 0.05) on average over the decade of entry and the four decades after a first tavern, on a pre-entry mean of 0.09, against 1.24 after a first coffeehouse on a mean of 0.33: rises of 2.2 and 3.8 times the pre-entry means.

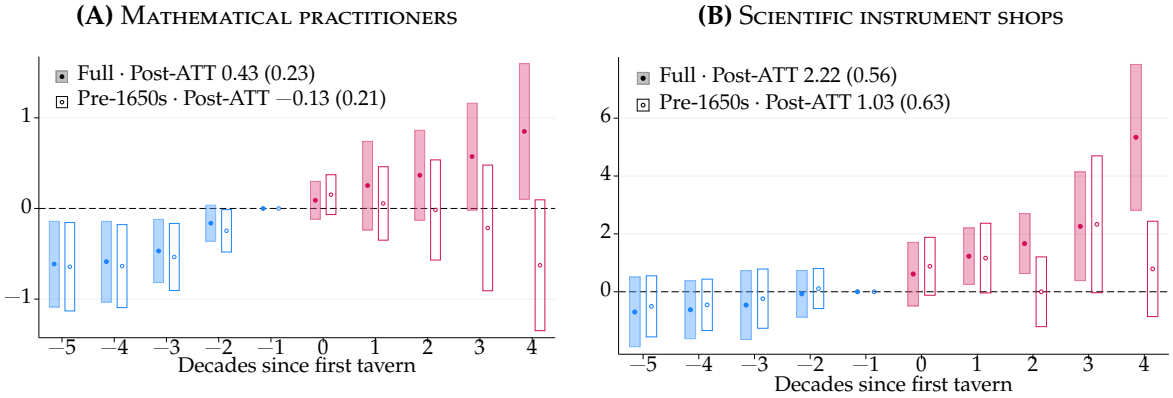


Figure B11. Tavern effects on scientific activity over the full period

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of the first seventeenth-century tavern opening on scientific activity, over the full period, filled markers and shaded intervals, and before the 1650s, hollow markers and outlined intervals. Treatment effect heterogeneity is restricted to event time, as in Figure 6. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Each outcome is divided by its reference mean, i.e., the sample mean of the outcome one decade before the first tavern opened. Sample includes all 162 parishes from the 1550s to the 1690s (full) or the 1550s to the 1640s (before the 1650s). Unit of observation is parish-decade. Post-ATT is the average of the estimates from the opening through four decades after. Standard errors clustered by parish. [Return to pages 24, OA-18]

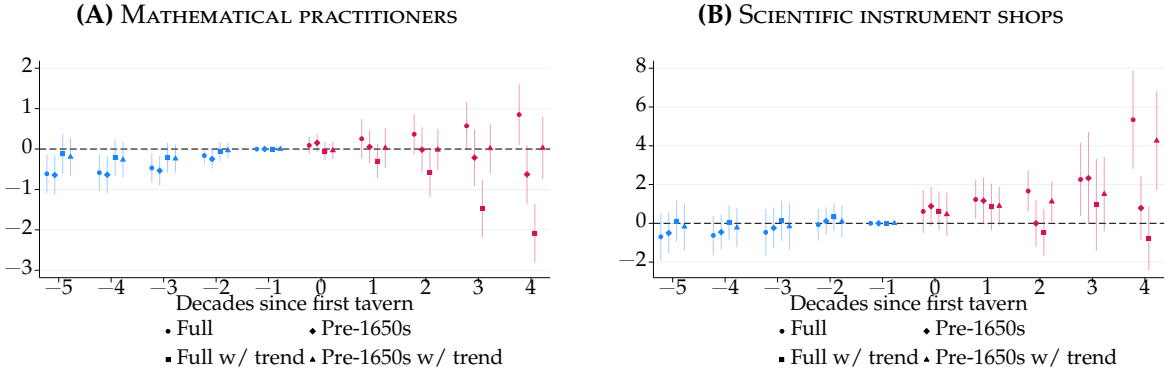


Figure B12. Tavern effects on scientific activity: group-specific trends

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of the first seventeenth-century tavern opening on scientific activity. Treatment effect heterogeneity is restricted to event time, as in Figure 6. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Each outcome is divided by its reference mean, i.e., the sample mean of the outcome one decade before the first tavern opened. Sample includes all 162 parishes from the 1550s to the 1690s (full) or the 1550s to the 1640s (before the 1650s). Results "w/ trend" first adjust for group-specific linear trends, following a suggestion in Goodman-Bacon (2021): we estimate a linear outcome trend by treatment cohort using only pre-treatment observations and then subtract the estimated trend from the outcome. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to pages 24, OA-18]

B.10. Treatment Intensity

Treated parishes differ in how many coffeehouses arrive. When we group them by the number open in the decade of entry and compare each group with the never-treated, both groups roughly double their practitioners, while instrument shops rise by 3.2 times their pre-entry mean in the 40 parishes that begin with one coffeehouse and 4.7 times in

the 21 that begin with two or more, from the same pre-entry mean of 0.33 (Figure B13). These are group-specific average effects rather than a dose-response curve. Identifying the response to an additional coffeehouse would require the stronger parallel trends condition that rules out selection on gains into intensity (Callaway et al., 2026), and with 40 parishes at one coffeehouse and five above two, the intensity observed at entry has too little variation to estimate it.

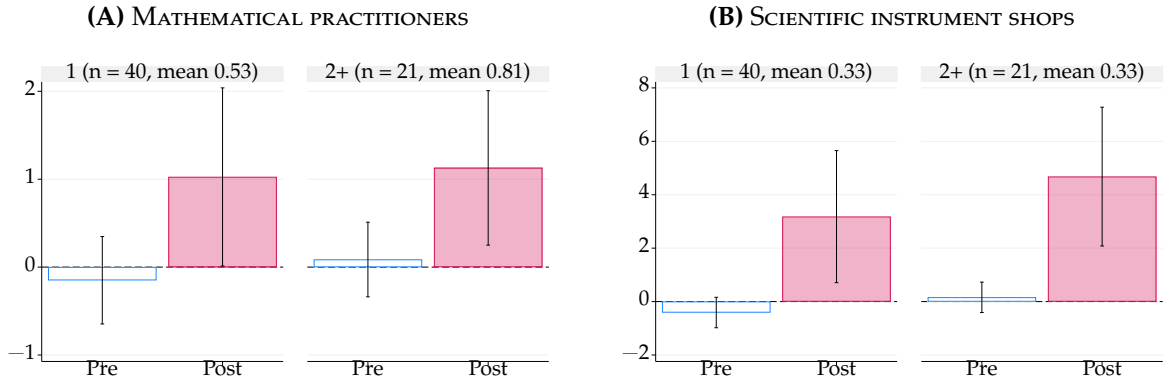


Figure B13. Effects on scientific activity: coffeehouses at entry

Notes: Figure shows average effects before and after first coffeehouse opening, with 95 percent confidence intervals, from equations (1) and (2). Treated parishes are grouped by the number of coffeehouses open in the parish in the decade of first entry, and each group is estimated separately against all 101 never-treated parishes. Pre-entry effects average event study estimates from five to two decades before opening; post-entry effects average them from opening through four decades after. Both are divided by the mean of the outcome in that group one decade before entry, which the panel heading reports beside the number of treated parishes in the group, n, so 1 denotes a doubling; standard errors are divided by the same constant, so the intervals carry no sampling error in the group mean. Intensity is measured in the decade of entry rather than as the peak over the panel, which is realized after treatment. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to page OA-20]

B.11. Where the European Association Concentrates

Gingerich (2002) traces the provenance of every known copy of Copernicus's *De revolutionibus* (1543), so a copy held in a city in 1620 marks early engagement with the new science at large, not with astronomy alone. Read for dated, city-specific provenance, the 593 census entries place a copy in 17 of the 37 coffeehouse cities. In large cities holding a copy, the post-entry difference in applied mathematics titles is 18.20 (s.e. 7.40) on a pre-entry mean of 10.30; in large cities without one it is 1.26 (s.e. 1.63) on a mean of 7.33, and among small cities neither group shows a rise (Table B3). Instrument makers run the same way, 16.68 (s.e. 11.39) against 0.99 (s.e. 0.62), without the precision to carry the point alone. The rise appears where there was already a sizable pool of potential entrants into science, which is what the London mechanism predicts and equally what one expects if coffeehouses and science went to the same cities.

Table B3—The post-entry difference by city size and Copernican stock

	Copy recorded	No copy	Copy minus no copy
Panel A. Applied mathematics titles			
Large cities	18.20	1.26	16.94
	(7.40)	(1.63)	(7.44)
	[10.30]	[7.33]	
Small cities	−2.36	0.33	−2.69
	(1.60)	(1.45)	(0.97)
	[5.00]	[1.45]	
Large minus small	20.56	0.93	19.63
	(7.55)	(0.38)	(7.51)
Panel B. Scientific instrument makers			
Large cities	16.68	0.99	15.69
	(11.39)	(0.62)	(11.40)
	[10.70]	[1.33]	
Small cities	0.32	0.77	−0.45
	(0.58)	(0.53)	(0.41)
	[0.71]	[1.27]	
Large minus small	16.36	0.23	16.14
	(11.40)	(0.15)	(11.40)

Notes: Table reports post-entry differences from equation (1) with the covariates of Figure 13, averaged over entry through three decades, the horizons every cell is observed at. Coffeehouse cities are split at their median population in 1600 and by whether any entry in the census of Gingerich (2002) places a copy of *De revolutionibus* in the city in 1620 on dated, city-specific provenance: 10 large and 7 small coffeehouse cities hold a copy, and 9 large and 11 small do not. The last column subtracts the no-copy cell from the copy cell, the last row subtracts the small cities from the large, and the corner, the triple difference, is the copy contrast among large cities minus that among small cities. Brackets give the mean of the outcome in the decade before entry. Within a panel all entries share one variance matrix. Sample includes all 200 cities from the 1600s to the 1690s. Unit of observation is city-decade. Standard errors clustered by city in parentheses. [Return to pages 34, OA-20]

C. ROBUSTNESS CHECKS

C.1. Covariate Balance and Adjustment

Coffeehouses did not open at random. Table C1 and Figure C1 compare parishes that ever received a coffeehouse with parishes that never did. Fourteen of twenty-eight pre-1652 measures show normalized differences above the 0.25 threshold of Imbens and Rubin (2015, p. 277). The largest gaps are in taverns, commercial premises, tradesmen's tokens issued between 1648 and 1651, and booksellers.

We start with balance in changes. Table C2 reports normalized differences in the change between the 1600s–1610s and the 1630s–1640s, before the first London coffeehouse in 1652, so treatment cannot explain any of these changes. The two outcomes are balanced in changes, at −0.05 and 0.08, although they differ by 0.32 in levels. For booksellers, the normalized difference goes from 0.57 in levels to −0.02 in changes. Only taverns and commercial premises are above 0.25 in changes, and we examine both directly as placebo outcomes below (Figure C7, Panels A and D).

Next, we adjust for the observed differences directly. We estimate the propensity score of ever being treated with a probit on pre-1652 taverns, tradesmen's tokens, booksellers, and an indicator for the City of London. We then weight control parishes by the odds of this score, so that the estimates refer to the treated parishes. This cuts the mean absolute normalized difference from 0.30 to 0.22 (Figure C2). Under this weighting, the effects are 0.56 practitioners (s.e. 0.25) and 0.99 shops (s.e. 0.37) (Figure C3). Interacting the score with decade fixed effects, with slopes estimated on all parishes and decades, including treated parishes after entry, instead lowers them to 0.31 (s.e. 0.24) and 0.64 (s.e. 0.30) (Figure C4). When a bootstrap re-estimates the probit in each draw, the standard errors are 0.23 and 0.30. Much of the fall reflects the 13 treated parishes whose score exceeds that of every control parish. Without them, the effects are 0.46 and 0.85 unadjusted and 0.33 and 0.59 with the score by decade (Table C3). In every specification, the pre-treatment estimates are jointly indistinguishable from zero.

C.2. Randomization Inference

We first compare the estimates against a benchmark in which parish labels and opening decades carry no information. We construct 1,000 placebo samples by randomly assigning treatment to 61 of the 162 parishes and drawing the decade of first entry for each placebo parish from the 1650s to the 1690s, coding the remainder as never treated. Figure C5 plots the resulting placebo distributions by event time. For both outcomes, post-treatment effects based on historical timing lie in the extreme upper tail of the placebo distributions, while pre-treatment effects are centered near the medians.

However, this benchmark places coffeehouses without regard to where and when they actually opened. Entry was more likely in commercial parishes. It was also bunched in time, since 31 of the 61 treated parishes received their first coffeehouse in the 1660s. We therefore repeat the exercise with a more demanding assignment. Using the propensity score estimated above, we group parishes into quintiles and draw the observed number of treated parishes within each quintile. That is, placebo entry is as likely as observed characteristics imply. Treatment rates across the quintiles range from 0.09 to 0.78. We then assign the observed entry decades at random among the drawn parishes, so the number of parishes contributing at each event time is the same

as in the data. Since placebo entry now concentrates where actual entry was most likely, and those parishes gained scientific activity over the century, the placebo distributions center above zero. Even so, across 1,000 draws, the post-treatment averages lie in the upper tail, while the pre-treatment averages sit closer to zero than the typical placebo draw (Figure C6).[60] Note that this assignment reproduces where coffeehouses went and how many arrived each decade, but not the association between the two.

C.3. Placebo Outcomes

Coffeehouse entry should leave a set of observable outcomes unmoved, and each placebo outcome targets a distinct alternative to the causal reading. Figure C7 reports each placebo under the linear specification of equation (1).

We start with population. If coffeehouses drew residents into a parish, the rise in scientific activity could simply reflect more people. The only measures of population we have by parish and decade are the densities of baptisms and deaths. Neither responds to entry (Figure C7, Panels E and F).

Next, we look at taverns, to see whether entry changed the market for public houses and might correlate with simple growth in public meeting places. The number of taverns does not move (Figure C7, Panel A).

Luxury shops capture a taste channel. These are the shops selling imported and fashionable goods, like coffee itself (grocers, confectioners, tobacconists, silk traders, and similar trades). Suppose that mathematics flourished wherever people took a growing interest in the wider world, which practitioners served through navigation and trade. Then a coffeehouse would only mark this interest and not cause the rise in science, and luxury shops should increase along with our outcomes. They do not (Figure C7, Panel B).

Non-scientific letters test whether elites moved in. We count the letters sent from or received at addresses in each parish. Correspondence within the Republic of Letters ran through networks that took years to build. Hence, even if coffeehouses had a real effect, general correspondence should stay flat over the decades we observe. If letter counts rose shortly after entry, this would instead suggest that established correspondents moved into treated parishes together with the coffeehouse. We see no such rise (Figure C7, Panel C).

Commercial premises test whether entry rode, or produced, a quickening of commerce at large. This is the one placebo that rises after a coffeehouse opening (Figure C7, Panel D). The linear estimates fall below zero before entry, so commercial activity was rising, consistent with coffeehouses following commerce; the scientific outcomes show no corresponding pre-trends (Figure 4), so the commercial drift does not threaten parallel trends. After entry, the linear estimates continue the climb. Read generously, the estimated coffeehouse effect may bundle some general commercial activity.

[60] Randomization p-values, the share of placebo draws at least as large as the observed estimate, counting the observed assignment in the reference set, are 0.011 for mathematical practitioners and 0.002 for scientific instrument shops.

C.4. Local Confounders: The Great Fire and the London Wall

Two features of London's geography could jointly determine coffeehouse locations and scientific activity. The Great Fire of 1666 reshaped the city's economic geography, displacing poorer residents, concentrating wealth in rebuilt areas, and shifting commerce westward toward Westminster (Ager et al., 2025), and the loss of records in the fire may bias observed treatment timing. The London Wall marks a second divide: the guilds controlled nearly all trade within the walls, no guild existed for scientific instrument making (Cormack, 2017, p. 79), and residential rents were higher inside (Baer, 2010). We additively allow for separate nonparametric time trends in parishes exposed and not exposed to the fire (Figure C10) and for locations inside and outside the wall (Figure C11). The main results are robust to both controls.

C.5. Selection into the Historical Record

Our outcome and treatment measures both depend on survival into the historical record, and coffeehouse activity could affect that survival. On the outcome side, prominent sources such as the diaries of Samuel Pepys and Robert Hooke often mention coffeehouses in connection with leading scientists, reflecting idiosyncratic reporting. Data on mathematical practitioners, which rely largely on diaries and published materials, are more exposed to this concern; data on scientific instrument shops come largely from museum catalogs of signed instruments, guild records, and trade cards. The difference is one of degree, not of kind: survival and registration are not independent of local prosperity either. To address the remaining exposure, we restrict the sample to the 175 of 252 instrument makers for whom a London guild is recorded (Figure C15, Panel A), and, because many guild records were destroyed in the Great Fire of 1666, we additionally allow separate trends for parishes exposed to the fire (Figure C15, Panel B). Record loss in the fire could also bias the estimates directly, in two ways. It thins the outcome records before 1666 where they burned, and it dates entry too late where the record of an early coffeehouse burned. The post-treatment effects stay positive when the sample keeps only the parishes outside the burnt area, 0.50 practitioners (s.e. 0.32) and 1.15 shops (0.32), the first imprecise on 21 treated parishes; when the panel ends in the 1660s, so that every record faced the same loss, 0.44 (0.20) and 0.41 (0.20); and when treated parishes are limited to those with a coffeehouse recorded after the fire, 0.77 (0.24) and 1.34 (0.32) (Figure C16). On the treatment side, the decade in which a coffeehouse is first recorded could depend on the type of source that records it. We therefore re-estimate the baseline after excluding, in turn, coffeehouses first recorded in published or private sources, administrative or official sources, material or visual sources, and sources of unknown type, and again after excluding each detailed source category (Figures C8 and C9). The estimates are broadly unchanged throughout.

C.6. Overlap between the Outcome Rosters

Practitioners and instrument shops are compiled independently, four decades apart, from different archives, but from overlapping populations, since makers prominent enough for Taylor (1954) are also makers whose signed instruments survive. Section 4.2 argues that the consistent effects across outcomes cannot come from one compilation's coverage; partitioning the two rosters tests that argument directly.

We match the 244 practitioners flourishing in London in the seventeenth century

against the 252 instrument makers active in the same century. To find candidate pairs, we use two tools, a zero-shot record linker (Dasanaike, 2026) and the language model Claude Opus 5, and then check each proposed pair by hand against the printed entries. We only keep links that pass three tests (the forenames agree, the surnames agree on a spelling that one of the sources prints, and the periods of activity are compatible). Note that the two rosters often date the same person differently, in 80 of the 93 links. We then take the widest window, from the earlier of the two first years of flourishing to the later of the two last years. Similarly, we place each matched person at every address that either roster records. That is, Taylor adds 40 parish assignments not found in SIMON, and SIMON adds 54 not found in Taylor.

The match links 93 people. Hence, 151 practitioners have no maker record and 159 makers have no practitioner record (Figure C17). The 93 links are a lower bound, since two of the Taylor entries name a father and son together and cannot be linked one to one. All three series count people, not shops, so that they are built alike. Relative to the pre-entry mean, the effect averages 0.99 (s.e. 0.36) among practitioners with no maker record, 1.62 (0.53) on the overlap, and 5.77 (1.45) among makers with no practitioner record. Pre-treatment estimates are close to zero in all three groups (Figure C18). If we read the name evidence as strictly as possible, and only accept identical forenames and surnames with intersecting windows, 73 links survive. The three effects then average 0.96, 2.00, and 4.18 times the pre-entry mean of each group. Neither compilation thus carries the result alone.

C.7. Treatment Definition and Timing

Event timing is based on the first recorded mention of a coffeehouse, which may differ from its actual opening year. The decade-level design absorbs this error, at the cost of coarser aggregation. Re-estimating equation (1) at two-, three-, and five-year intervals shows no evidence of pre-trends and a similar rise after entry (Figure C12).[61] Treatment need not be absorbing: applying the method of de Chaisemartin and D'Haultfoeuille (2026) to coffeehouse presence rather than first entry, using the variation shown in Panel B of Figure D15, yields results that closely match the baseline (Figure C20). The same method estimates the effect of losing the last coffeehouse in a parish. If the entry effects reflected differential trends rather than coffeehouses, closures should not reverse them. Twenty-two parishes lose their last coffeehouse inside the panel, ten of them in the 1690s, so few remain exposed at long horizons. Mathematical practitioners decline by 0.17 two decades after closure, against a pre-closure mean of 0.59, while instrument shop estimates are too imprecise to sign; pre-closure contrasts are jointly indistinguishable from zero for both outcomes (Figure C21). We note that closures are estimated on those 22 parishes, while entry is estimated on the 61 that gain a coffeehouse. The closure estimate is therefore not simply the entry effect in reverse. But the decline is small compared with the increase at entry. This is consistent with scientific activity staying in the parish after its coffeehouse closed.

[61] Annual specifications are infeasible due to limited outcome variation after controlling for parish and year fixed effects.

C.8. Spatial Aggregation and Inference

The parish is the natural unit of analysis because many historical addresses identify locations only by their nearest parish church, but many records are finer. Re-estimating equation (1) on a partition of London into 15,351 hexagons of 5,000 m^2 (Figure C13) leaves the findings qualitatively unchanged (Figure C14). The cell area is small enough that parishes contain several cells: 132 parishes hold more than one hexagon and the median parish holds four. The parish-by-decade specification is therefore identified from contrasts within parishes, and 56 of the 59 parishes containing a hexagon that receives a coffeehouse also contain hexagons that never do. Adding parish-by-decade fixed effects preserves the patterns for instrument shops while reducing the magnitude and significance of the effect on practitioners, plausibly because church-level addresses absorb much of the relevant variation. Because observations are densely clustered in space, we also compute Conley (1999) standard errors at cutoffs of 0.25, 0.5, 1, and 2 kilometers. Post-treatment effects are significant at every cutoff from one decade after opening on (Figure C27). The two widest cutoffs link 42 and 69 percent of all pairs of parishes. Note that the spillover analysis in Appendix B.2 uses larger hexagons, 200 meters across. Each cell there is about five times the size of a cell here, so the levels of the two analyses cannot be compared.

C.9. Control Groups and Estimators

Equation (1) uses never-treated parishes as controls. The event study design of Callaway and Sant'Anna (2021), which also draws on not-yet-treated parishes, leaves the main results unchanged (Figure C19). The results are likewise robust to an inverse hyperbolic sine transformation of the outcome (Figure C26). The Poisson specification in equation (3) reproduces the shape of the response for both outcomes, with wider confidence intervals (Figure C25). Effects on mathematical practitioners are significant at the 10 percent level throughout the post-treatment window. For instrument shops, they are significant at the 5 percent level two and three decades after entry. Estimation drops observations more than five decades before first opening, since cohort-decade cells containing no shops otherwise separate the likelihood.

C.10. Trends and Influence

Following Goodman-Bacon (2021), we detrend outcomes linearly within treatment cohorts using only pre-treatment observations; the results remain similar in magnitude and significance, with wider confidence intervals (Figure C22). We also re-estimate equation (1) 162 times, excluding one parish at a time. No single parish drives the findings, though the four-decade effect loses significance under some exclusions (Figure C23). Finally, following Rambachan and Roth (2023), we ask how far parallel trends could fail after entry before the average post-treatment effect loses significance. It remains significant at the 5 percent level as long as the decade-to-decade change in the violation after entry is at most 0.8 times the largest such change before entry for practitioners and 1.7 times for shops (Figure C24).

C.11. European Cities

Section 6 reports conditional correlations. Table C5 adds country-by-decade fixed effects, removes London, Paris, and every capital, and restricts the panel to France, Germany, the Netherlands, and the UK, which hold 27 of the 37 coffeehouse cities; Table C6 recodes the cities whose sources admit more than one entry decade to the earliest and the latest of them, and drops them. The titles difference holds within countries, at 4.25 (s.e. 2.38), and under every recoding of the dates; the makers difference is smaller and imprecise within countries, at 3.15 (s.e. 3.21), and 1.55 (s.e. 0.69) once London is left out.

The association does not rest on London alone. Without London, the post-entry difference is 1.67 titles (s.e. 1.29) and 0.98 makers (s.e. 0.49), roughly a third of the pre-entry mean for titles and two-fifths for makers (Table C5). Over the first two decades after entry, the differences are 2.29 titles (s.e. 1.29) and 0.91 makers (s.e. 0.53). London carries much of the magnitude. Without any of the ten capitals, the differences are smaller, 1.26 titles (s.e. 0.93) and 0.23 makers (s.e. 0.33). But these 27 coffeehouse cities also had fewer titles and makers to begin with, 3.56 titles and 1.56 makers per decade before entry, against 5.95 and 3.73 in the full panel. For titles, the difference is still about a third of the pre-entry level. We conclude that the correlation is substantive and that it keeps its sign in every comparison.

C.12. Figures

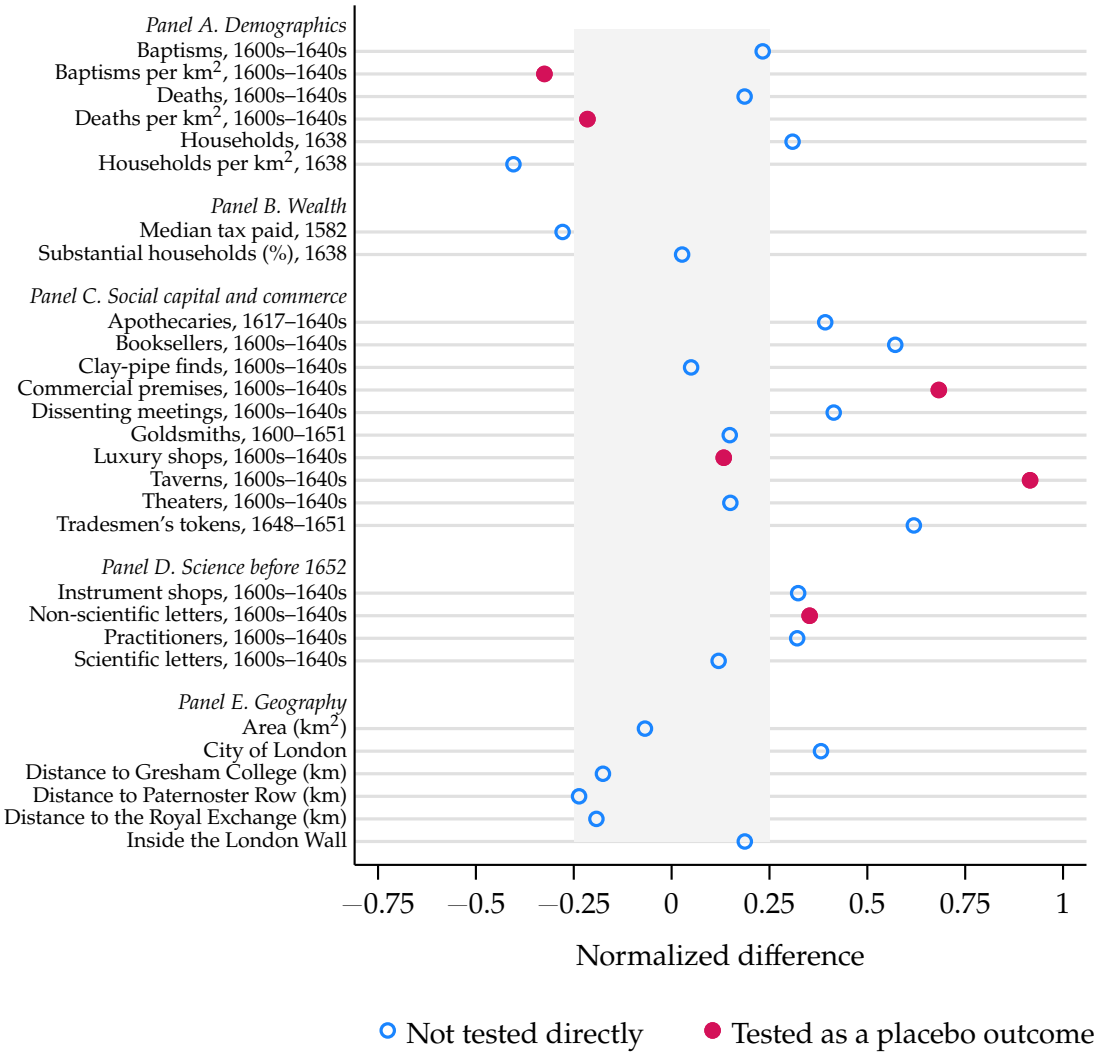


Figure C1. Normalized differences in baseline characteristics

Notes: Figure plots the normalized differences in pre-treatment characteristics between ever-treated and never-treated parishes. The shaded region marks absolute differences below 0.25, the threshold suggested by Imbens and Rubin (2015, p. 277). Filled markers indicate covariates that also appear as placebo outcomes in Figure C7. Rows and their measurement follow Table C1. [Return to pages OA-22, OA-29]



FIGURE C2. NORMALIZED DIFFERENCES BEFORE AND AFTER WEIGHTING

Notes: Figure plots the normalized differences of Figure C1 without weights and with the inverse-probability weights (IPWs) of Figure C3. The shaded region marks absolute differences below 0.25. Rows and their measurement follow Table C1. [Return to page OA-22]

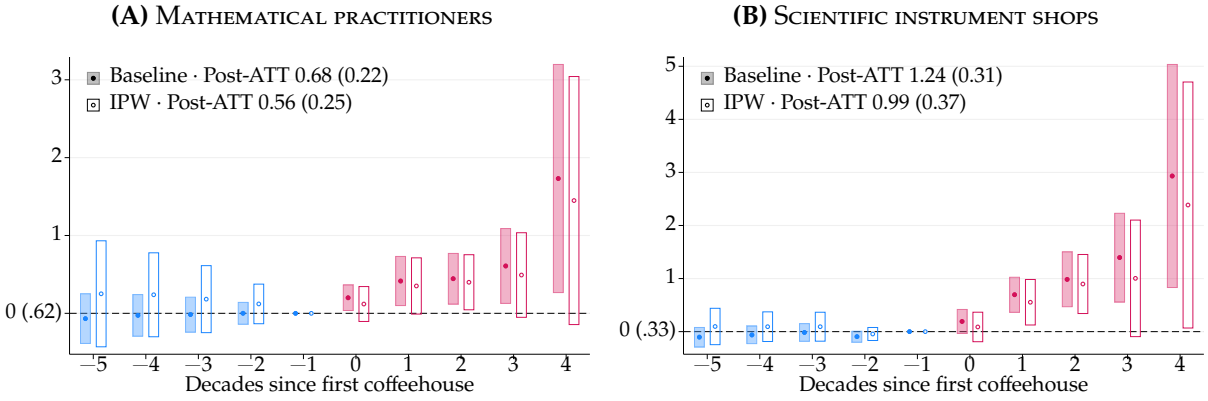


Figure C3. Effects on scientific activity: IPW adjustment

Notes: Figure shows event study estimates and 95 percent confidence intervals of the effect of first coffeehouse opening on scientific activity, from the baseline specification in equations (1) and (2), filled markers and shaded intervals, and the same equation weighted with inverse-probability weights (IPWs), hollow markers and outlined intervals. The IPWs are based on a probit-estimated propensity score for ever being treated, using pre-1652 taverns, tradesmen's tokens (1648–1651), and booksellers, together with an indicator for the City of London. Control parishes are weighted by the odds of the score, so that the estimates refer to the treated parishes; weights are not trimmed. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to pages 22, OA-22, OA-29, OA-30]

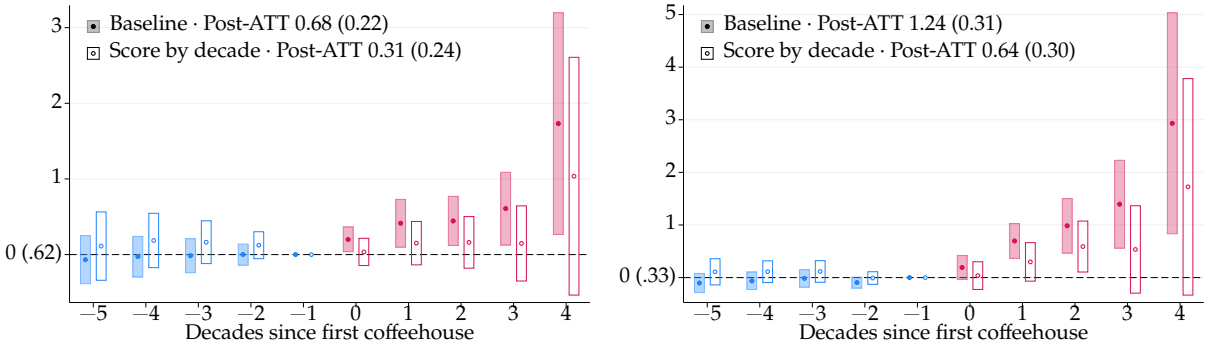


Figure C4. Effects on scientific activity: propensity score by decade

Notes: Figure shows event study estimates and 95 percent confidence intervals of the effect of first coffeehouse opening on scientific activity, from the baseline specification in equations (1) and (2), filled markers and shaded intervals, and the same equation with the propensity score of Figure C3 interacted with decade fixed effects, hollow markers and outlined intervals. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to pages 22, OA-22]

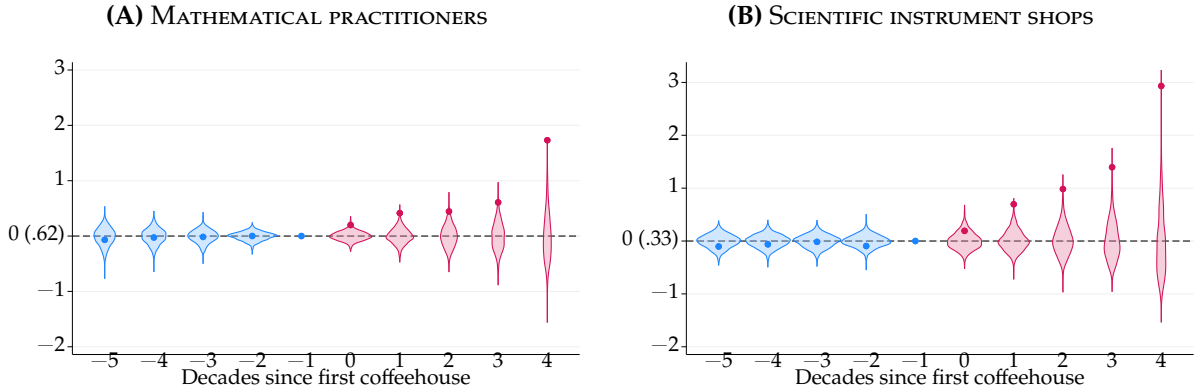


Figure C5. Effects on scientific activity: randomization inference

Notes: Figure shows violin plots of 1,000 placebo estimates of equations (1) and (2) of the effect of first coffeehouse opening on scientific activity. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. In each placebo dataset, we randomly assign the timing of the first coffeehouse opening to one of the decades from the 1650s to the 1690s for 61 of the 162 parishes. Violin plots show the distribution of placebo treatment effects by event time, with dots indicating the actual event study estimates. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. [Return to pages 22, OA-22]

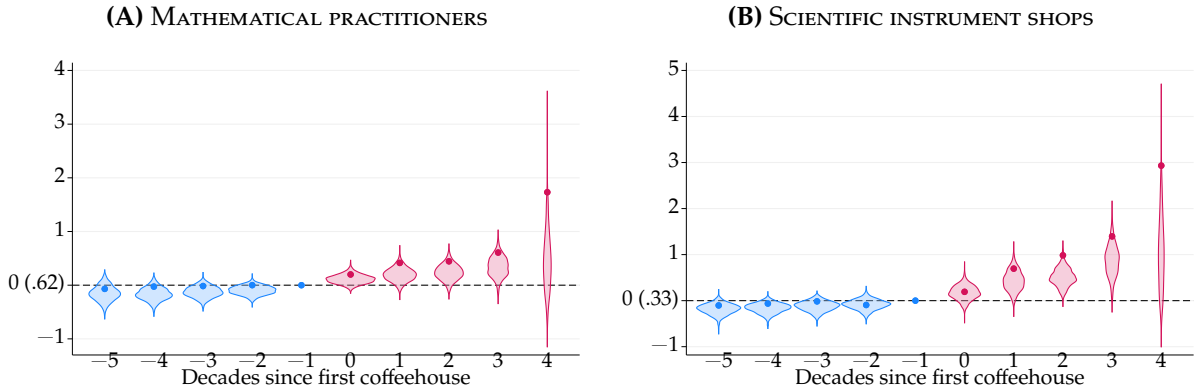


Figure C6. Effects on scientific activity: conditional randomization inference

Notes: Figure shows violin plots of 1,000 placebo estimates of equations (1) and (2) of the effect of first coffeehouse opening on scientific activity. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. In each placebo dataset, treated parishes are drawn without replacement within quintiles of the propensity score of ever receiving a coffeehouse, estimated by probit on pre-1652 taverns, tradesmen's tokens, and booksellers, together with an indicator for the City of London, preserving the number treated in each quintile, and the observed decades of first entry are then assigned at random among the drawn parishes. Violin plots show the distribution of placebo treatment effects by event time, with dots indicating the actual event study estimates. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. [Return to pages 22, OA-23]

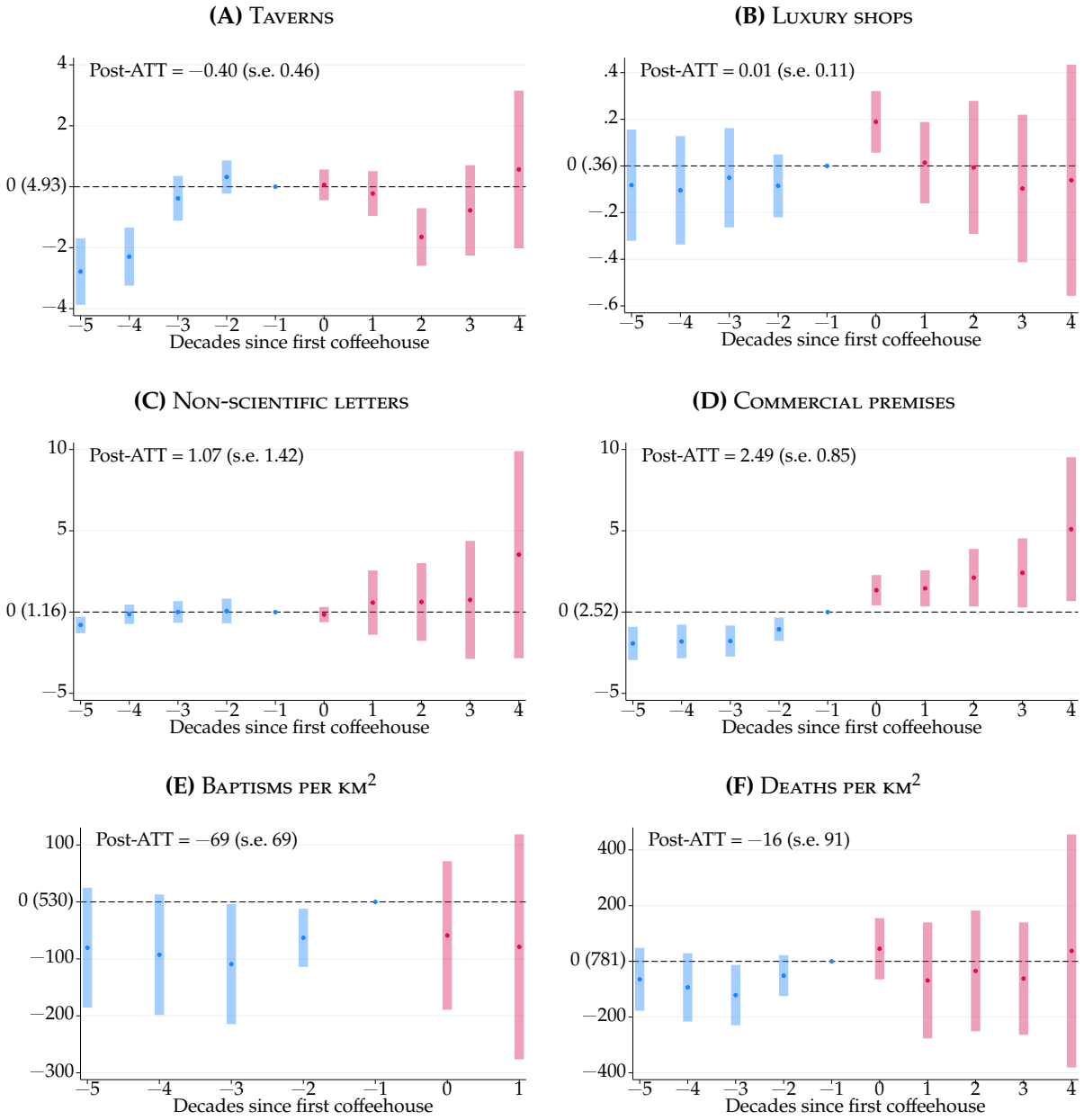


Figure C7. Effects on placebo outcomes

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on outcomes it should leave unmoved. Outcomes are the decadal number in a parish of taverns (Panel A), luxury shops (Panel B), non-scientific letters (Panel C), and commercial premises (Panel D, signed premises other than drinking houses), and the decadal number of baptisms and deaths per square kilometer (Panels E and F). Sample includes all 162 parishes from the 1600s to the 1690s, except for baptisms, 130 of 162 parishes from the 1600s to the 1660s, and deaths, 116 of 162 parishes from the 1600s to the 1690s; deaths are recorded in 119 parishes, but three of them are observed in a single decade and drop out of a design with parish and decade effects. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after (for baptisms, the two decades observed). Standard errors clustered by parish. [Return to pages OA-22, OA-23, OA-28]

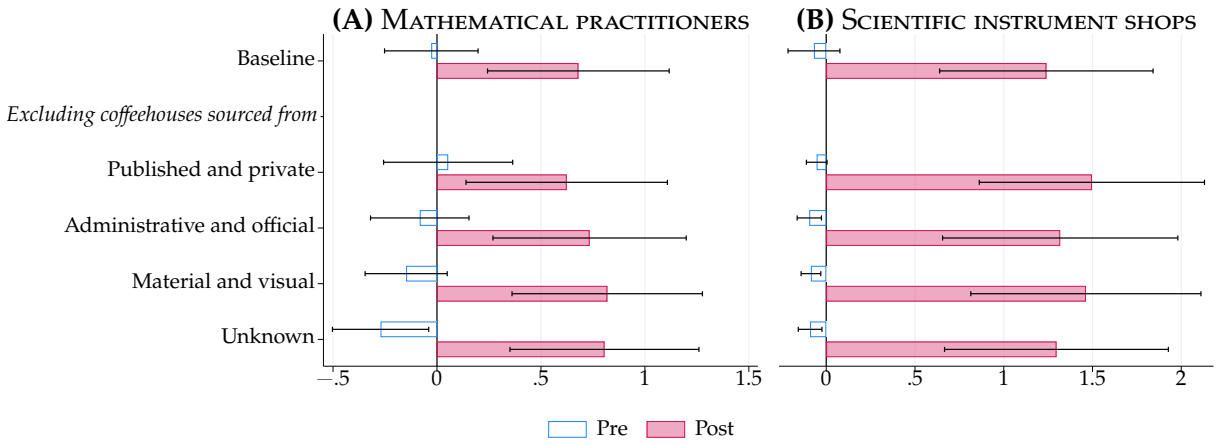


Figure C8. Effects on scientific activity: dropping coffeehouse source categories

Notes: Figure reports average pre-treatment and post-treatment effects, with 95 percent confidence intervals, from equations (1) and (2), on mathematical practitioners (Panel A) and scientific instrument shops (Panel B). In each alternative specification, we exclude coffeehouses first recorded in the indicated source category. Pre-treatment effects are averages of event study estimates from five to two decades before opening; post-treatment effects are averages from opening through four decades after. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to pages 22, OA-24]

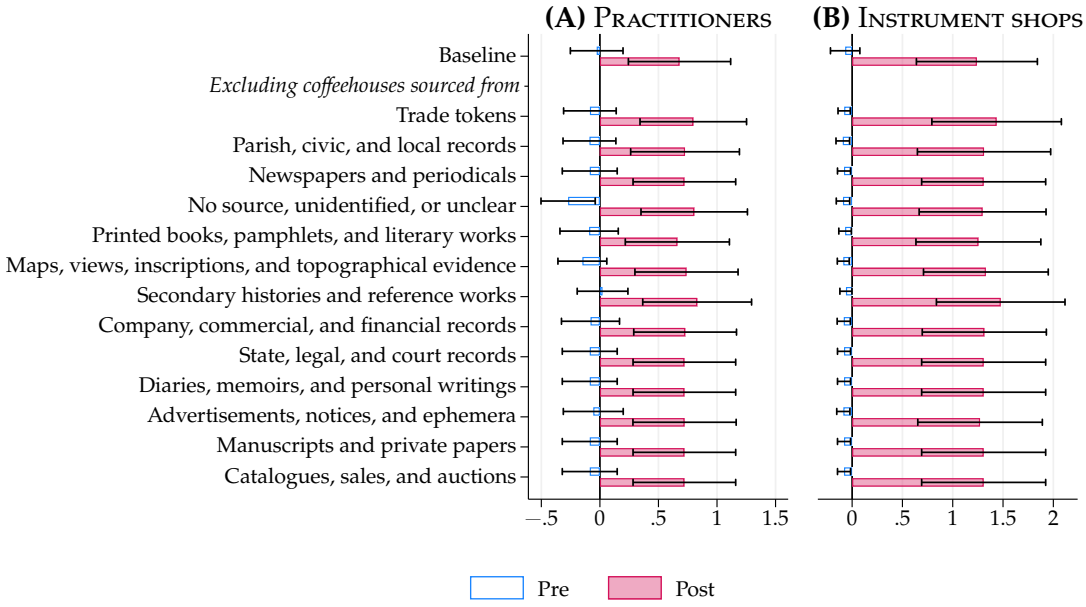


Figure C9. Effects on scientific activity: dropping detailed coffeehouse source categories

Notes: Figure reports average pre-treatment and post-treatment effects, with 95 percent confidence intervals, from equations (1) and (2), on mathematical practitioners (Panel A) and scientific instrument shops (Panel B). In each alternative specification, we exclude coffeehouses first recorded in the indicated detailed source category. Pre-treatment effects are averages of event study estimates from five to two decades before opening; post-treatment effects are averages from opening through four decades after. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to pages 22, OA-24]

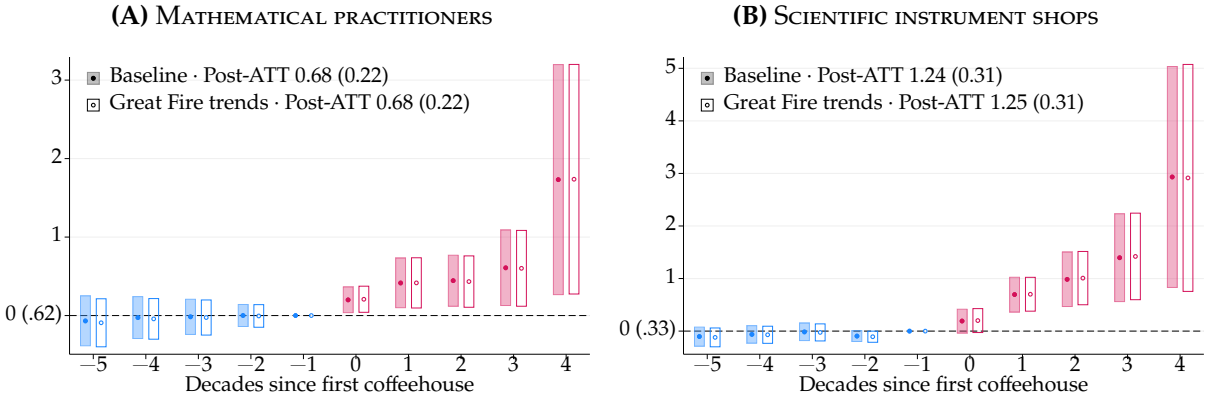


Figure C10. Effects on scientific activity: control for exposure to the Great Fire

Notes: Figure shows event study estimates and 95 percent confidence intervals of the effect of first coffeehouse opening on scientific activity, from the baseline specification in equations (1) and (2), filled markers and shaded intervals, and the same equation including fixed effects for the interaction between an indicator for exposure to the Great Fire and each decade, hollow markers and outlined intervals. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to page OA-24]

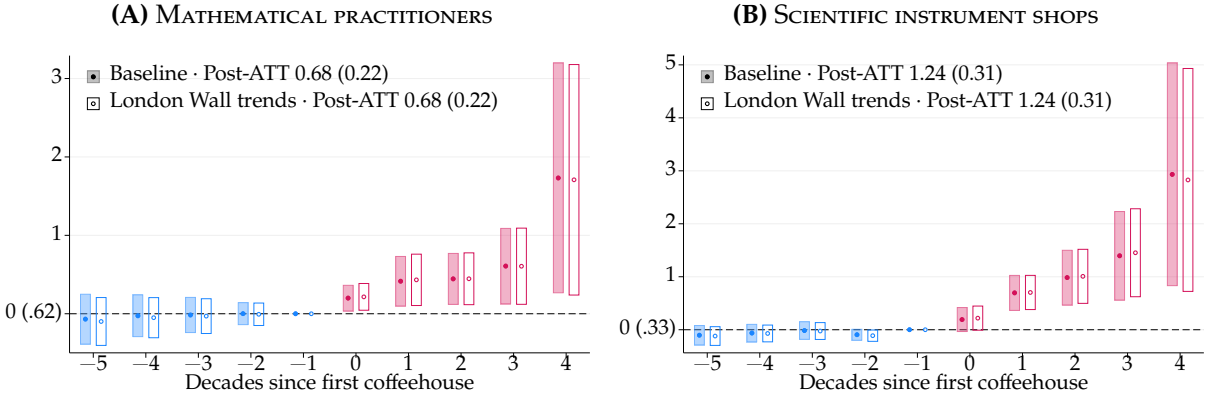


Figure C11. Effects on scientific activity: control for location within the London Wall

Notes: Figure shows event study estimates and 95 percent confidence intervals of the effect of first coffeehouse opening on scientific activity, from the baseline specification in equations (1) and (2), filled markers and shaded intervals, and the same equation including fixed effects for the interaction between an indicator for whether a parish lies within the London Wall and each decade, hollow markers and outlined intervals. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to page OA-24]

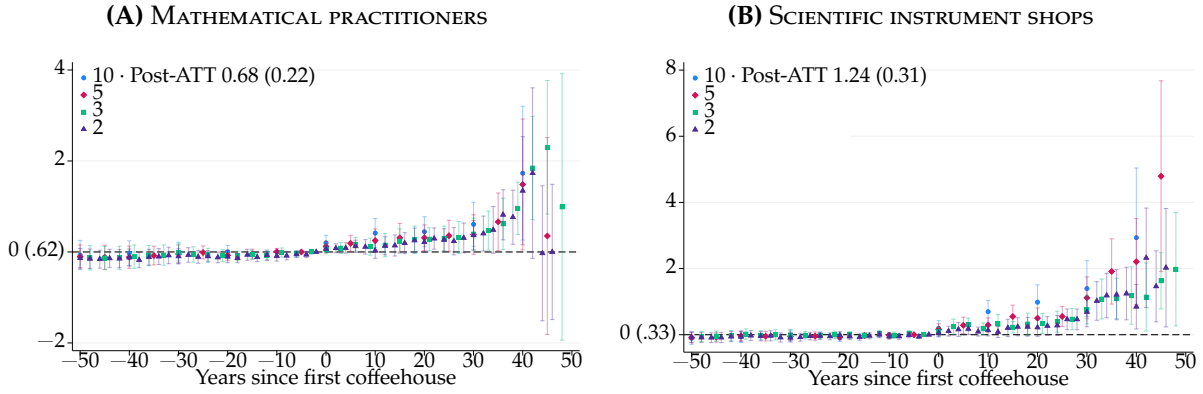


Figure C12. Effects on scientific activity by time-frame length

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on scientific activity. Outcomes are the number of mathematical practitioners and scientific instrument shops in a parish. For instrument shops at three and two years, effects vary by event time but not by cohort, since equation (1) leaves their standard errors uncomputable. Sample includes all 162 parishes from 1600 to 1699. Unit of observation is parish-period, with periods of ten, five, three, or two years. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT, shown for ten-year periods only, is the average of the estimates from entry through four decades after. Averages over shorter periods are not comparable with it, since counts per period fall with period length and their window ends 40 years after entry, whereas the last decadal estimate runs to 49 years after the start of the decade of entry. Standard errors clustered by parish. [Return to page OA-25]

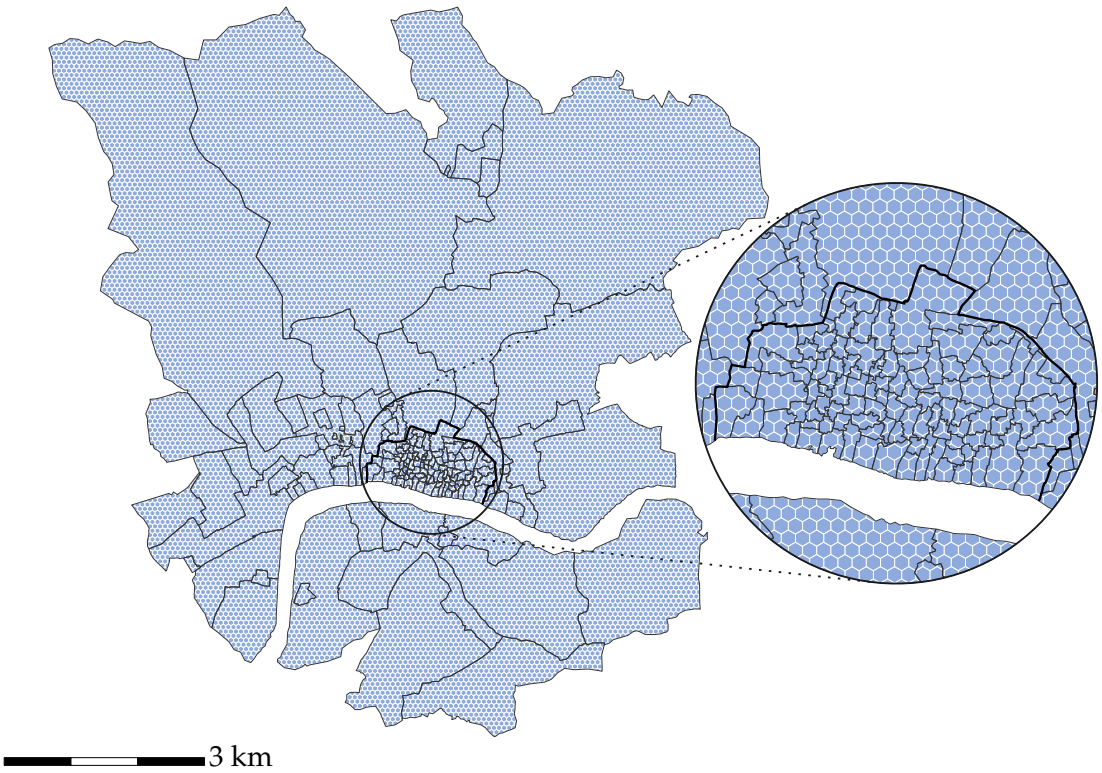


Figure C13. Hexagonal partition of London

Notes: Map of London divided into 15,351 hexagons of 5,000 m^2 each, with white lines for hexagon boundaries and black lines for the 162 parish boundaries. [Return to pages OA-26, OA-36]

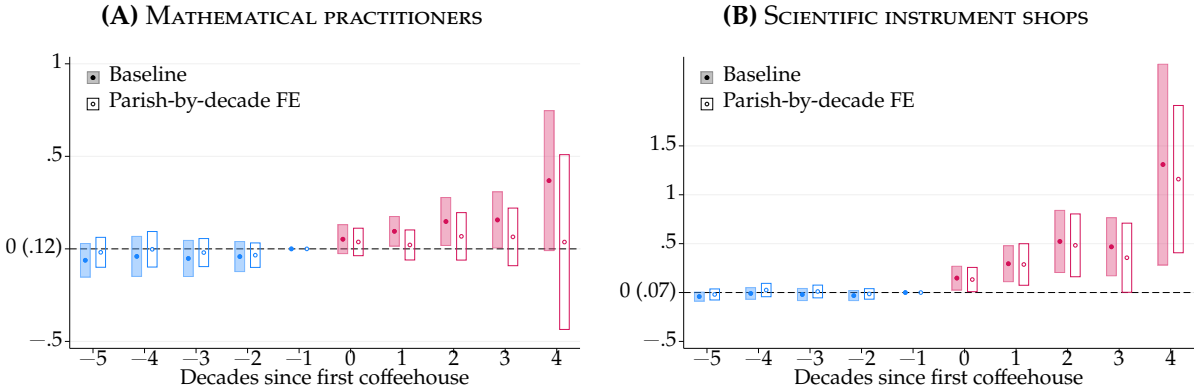


Figure C14. Effects on scientific activity: grid cell level

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on scientific activity, without and with parish-by-decade fixed effects. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a 5,000 m^2 hexagon. Sample includes all 15,351 hexagons (see Figure C13) from the 1600s to the 1690s. Unit of observation is hexagon-decade. The parish-by-decade specification drops the 593 hexagons whose centroid falls outside every parish, none of them treated; 155 of the 162 parishes contain at least one hexagon. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Standard errors clustered by parish. [Return to page OA-26]

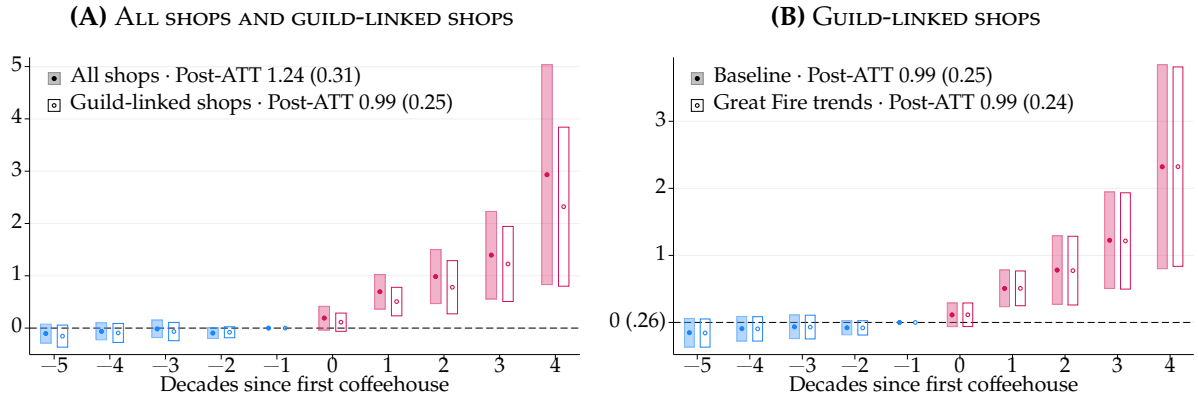


Figure C15. Effects on guild-linked scientific instrument shops

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on scientific instrument shops. Panel A counts all shops, filled markers and shaded intervals, and only those operated by instrument makers for whom a guild is recorded, hollow markers and outlined intervals; the sample mean one decade before treatment is 0.33 for all shops and 0.26 for guild-linked shops. Panel B counts guild-linked shops, without controls, filled markers and shaded intervals, and including fixed effects for the interaction between an indicator for exposure to the Great Fire and each decade, hollow markers and outlined intervals; the parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to page OA-24]

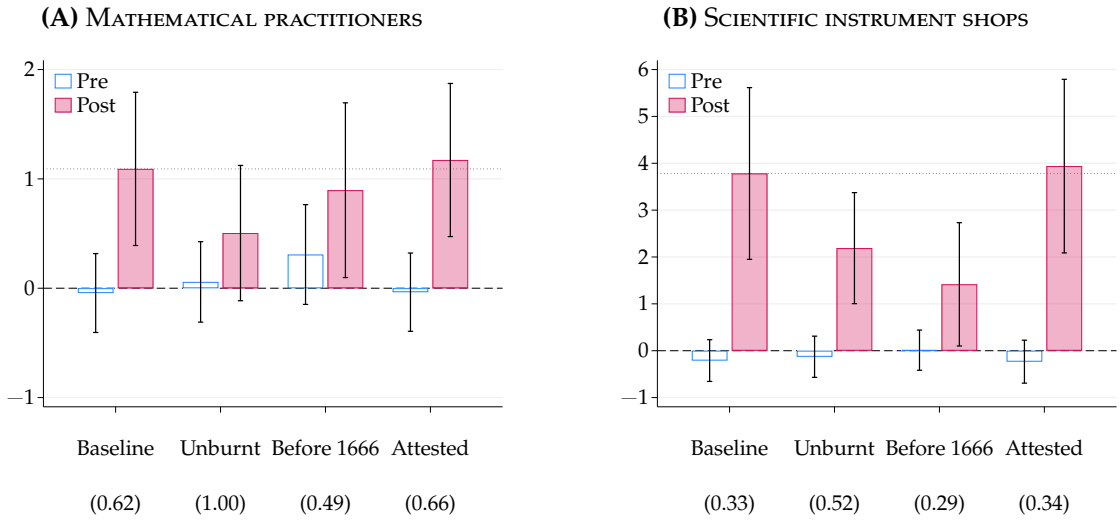


Figure C16. Effects on scientific activity: records lost in the Great Fire

Notes: Figure reports average pre-treatment and post-treatment effects of first coffeehouse opening, with 95 percent confidence intervals, from equations (1) and (2), each divided by the mean of the outcome among treated parishes one decade before treatment in its own sample, which the parenthetical under each label reports. Baseline uses all 162 parishes from the 1600s to the 1690s. Unburnt keeps the 67 parishes outside the area burnt in the Great Fire of 1666. Before 1666 ends the panel in the 1660s; parishes first treated from the 1670s serve as controls there. Attested drops the five treated parishes with no coffeehouse recorded after 1666 and keeps the other 56 at their baseline entry dates. Pre-treatment effects are averages of event study estimates from five to two decades before opening; post-treatment effects are averages from opening through four decades after. The dotted line marks the baseline post-treatment effect. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to page OA-24]

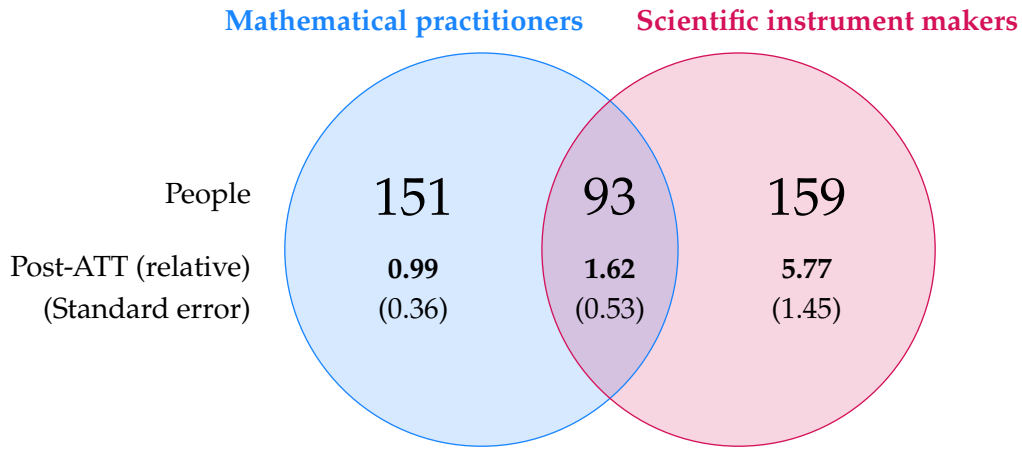


Figure C17. Overlap between the outcome rosters

Notes: Figure shows a Venn diagram of the two outcome rosters: the 244 mathematical practitioners of Taylor (1954) in the London sample described in Section 3 (left), the 252 scientific instrument makers recorded in SIMON and active in the same century (right), and the 93 people matched across the two (intersection), as described in Appendix C.6. Beneath each count is the post-ATT from equation (1), averaging the decade of treatment and the four decades thereafter, estimated on that region alone and divided by its mean one decade before treatment. Regions count people rather than shops. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors, in parentheses, clustered by parish. [Return to pages OA-25, OA-38]

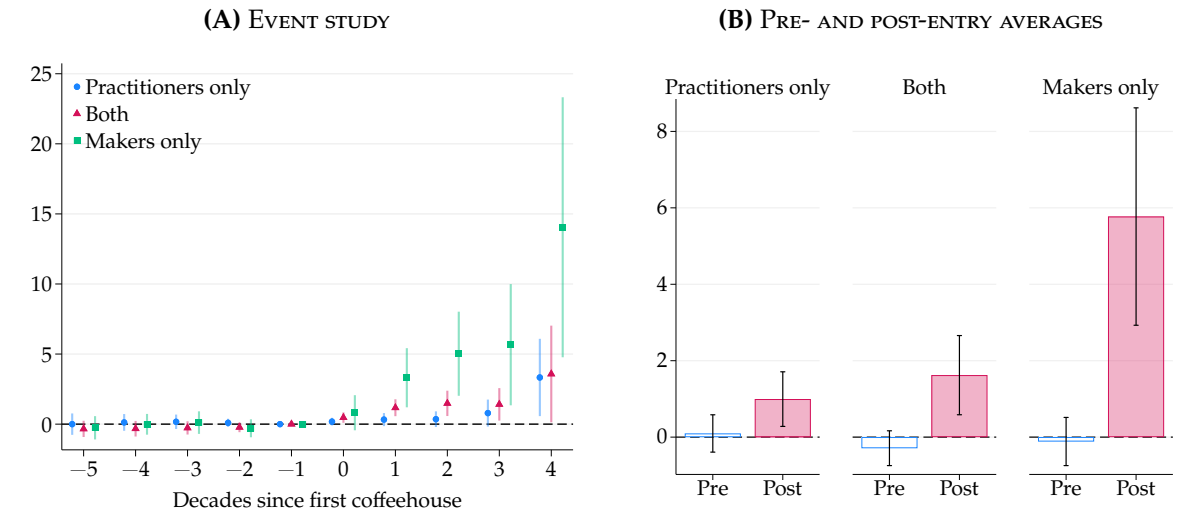


Figure C18. Effects by cell of the roster partition

Notes: Figure shows the effect of first coffeehouse opening from equation (1) estimated separately on each region of the partition in Figure C17: practitioners recorded only by Taylor (1954) (Practitioners only), people recorded in both rosters (Both), and instrument makers recorded only by SIMON (Makers only). The three regions start from pre-entry means of 0.36, 0.36, and 0.11, so both panels are expressed relative to the pre-entry mean of the region they belong to. Panel A divides each event study estimate and interval by that mean. Panel B divides the outcome itself by that mean before estimation, and then averages the coefficients over the pre-entry and post-entry windows. Whiskers and shaded intervals are 95 percent intervals. Every region counts people, not shops. Hence, a person enters once per parish-decade, and the maker series differs from the shop count used in the main text. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to page OA-25]

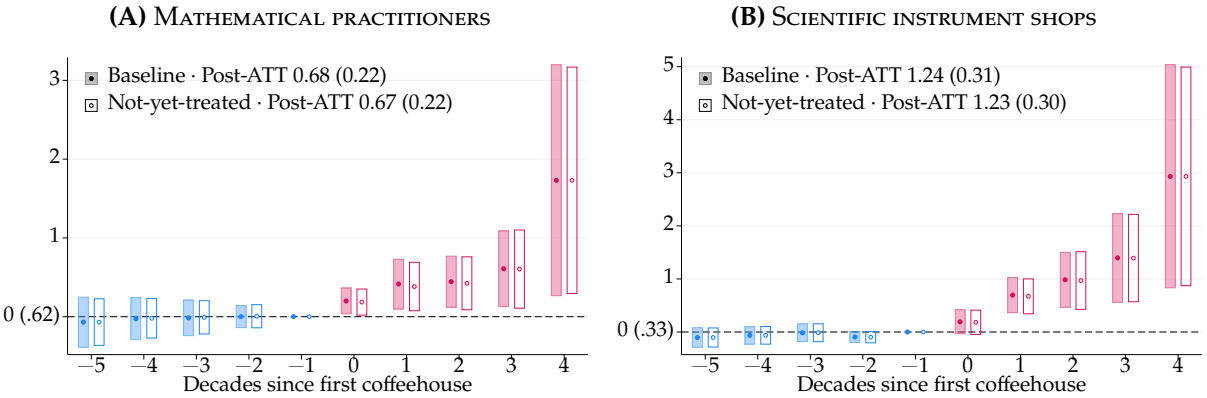


Figure C19. Effects on scientific activity: never- and not-yet-treated controls

Notes: Figure shows event study estimates and 95 percent confidence intervals from the baseline specification in equations (1) and (2), filled markers and shaded intervals, and the estimator of Callaway and Sant'Anna (2021), hollow markers and outlined intervals, where the control group consists of both never- and not-yet-treated parishes. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to page OA-26]

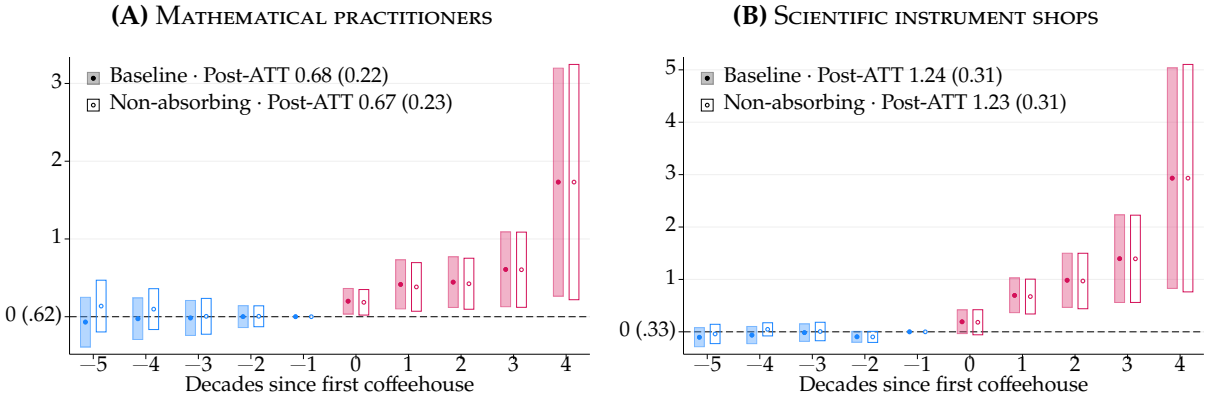


Figure C20. Effects on scientific activity: non-absorbing treatment

Notes: Figure shows event study estimates and 95 percent confidence intervals from the baseline specification in equations (1) and (2), filled markers and shaded intervals, and the estimator of de Chaisemartin and D'Haultfoeuille (2026) for the effect of coffeehouse presence on scientific activity, hollow markers and outlined intervals. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to page OA-25]

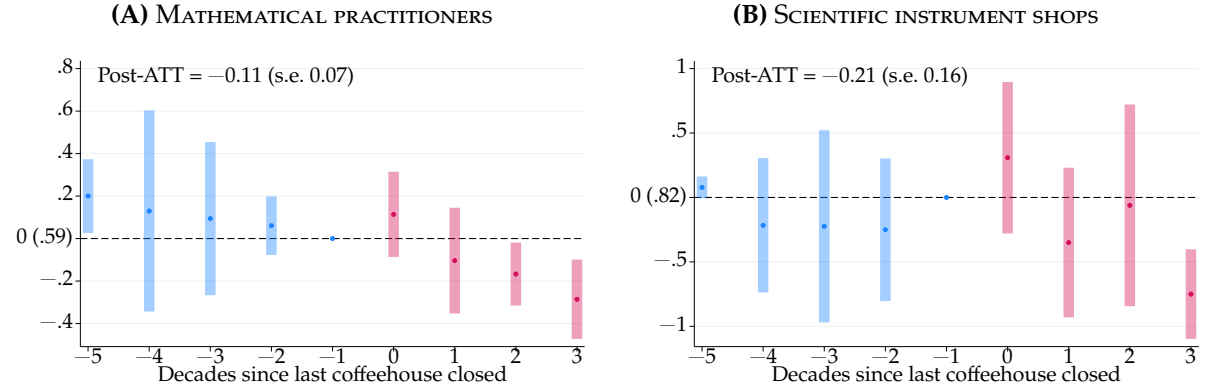


Figure C21. Effects on scientific activity: closing down the last coffeehouse

Notes: Figure shows event study estimates and 95 percent confidence intervals based on de Chaisemartin and D'Haultfoeuille (2026) for the effect of closing the last coffeehouse on scientific activity. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before closure. The label in the upper left of each panel reports the average of the four dynamic effects, with its standard error. Standard errors clustered by parish. [Return to page OA-25]

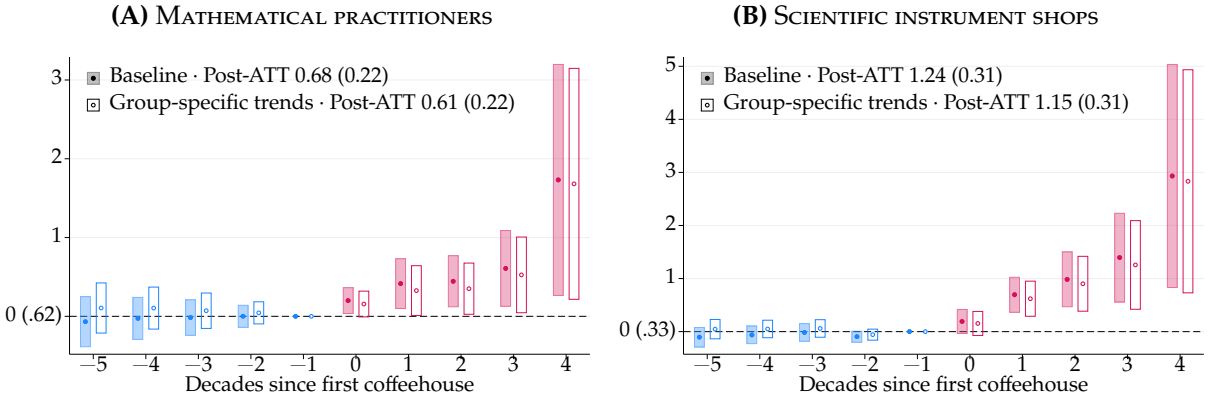


Figure C22. Effects on scientific activity: group-specific trends

Notes: Figure shows event study estimates and 95 percent confidence intervals of the effect of first coffeehouse opening on scientific activity, from the baseline specification in equations (1) and (2), filled markers and shaded intervals, and the same equation on outcomes net of linear trends estimated by treatment cohort on pre-treatment observations (Goodman-Bacon, 2021), hollow markers and outlined intervals. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample mean of the unadjusted outcome one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to pages OA-15, OA-26]

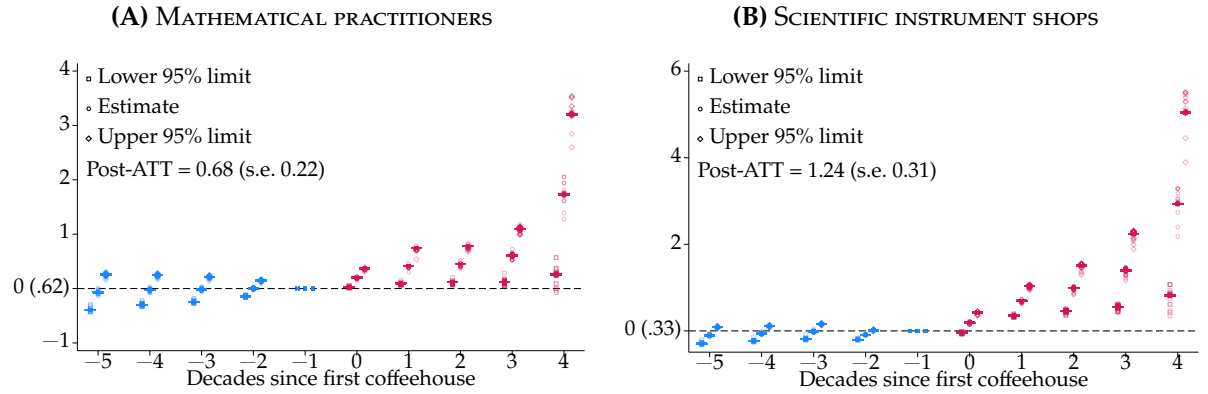


Figure C23. Effects on scientific activity: leave-one-out sensitivity check

Notes: Figure shows boxplots, including outliers, of event study estimates and their 95 percent confidence limits from equations (1) and (2) for the effect of first coffeehouse opening on scientific activity. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. The boxplots use 162 samples from the 1600s to the 1690s, with each parish omitted once. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the full-sample average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to page OA-26]

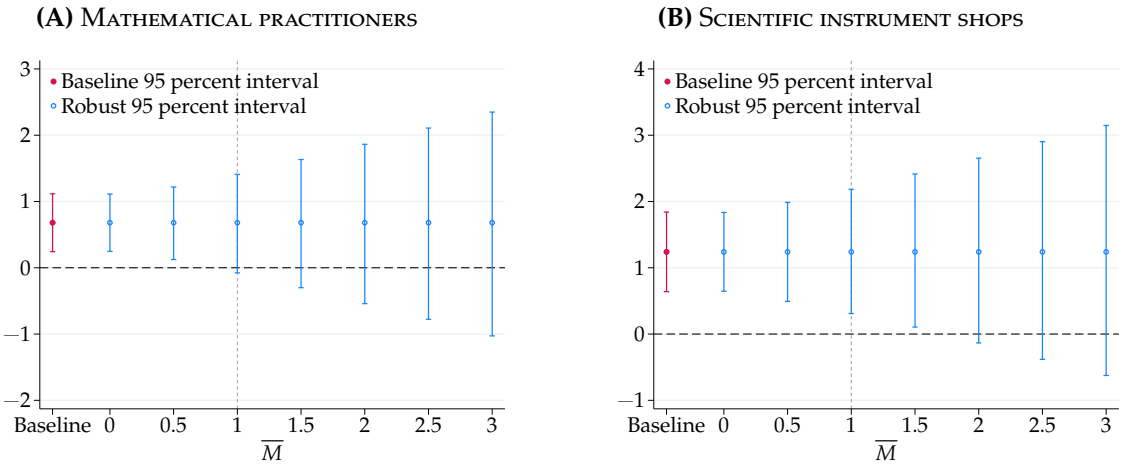


Figure C24. Effects on scientific activity: violations of parallel trends

Notes: Figure shows 95 percent confidence intervals for the average post-treatment effect of first coffeehouse opening from equations (1) and (2) that allow parallel trends to fail, following Rambachan and Roth (2023). Under their relative-magnitudes restriction, the change in the violation of parallel trends from one decade to the next after entry is at most $\overline{M}$ times the largest such change before entry; the intervals use their conditional least-favorable hybrid. The interval labeled "Baseline" is the conventional one, with its point estimate, and the vertical line marks $\overline{M} = 1$. Post-treatment effects are averages of event study estimates from opening through four decades after. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. Standard errors clustered by parish. [Return to page OA-26]

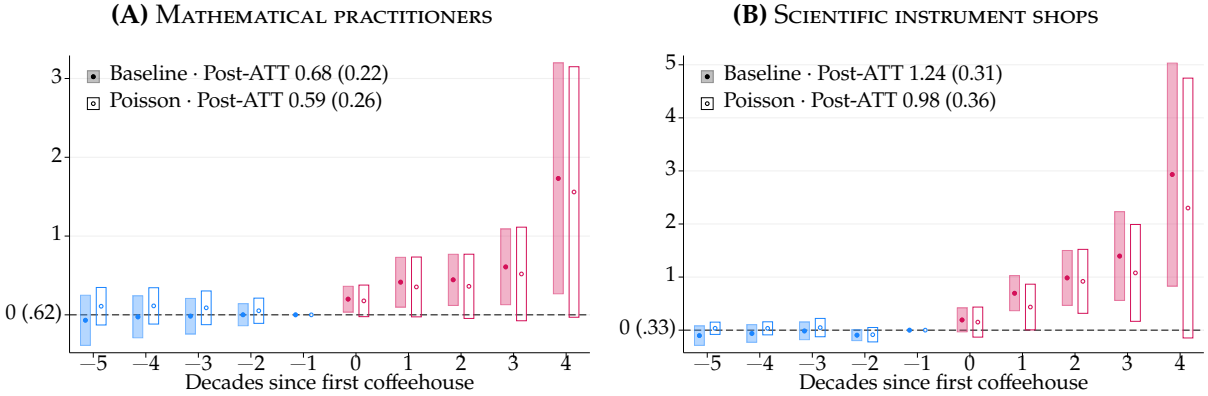


Figure C25. Effects on scientific activity: Poisson specification

Notes: Figure shows event study estimates and 95 percent confidence intervals of the effect of first coffeehouse opening on scientific activity, from the baseline linear specification in equations (1) and (2), filled markers and shaded intervals, and the Poisson specification in equation (3), hollow markers and outlined intervals. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Poisson estimates are average differences in predicted counts. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after. Standard errors clustered by parish. [Return to page OA-26]

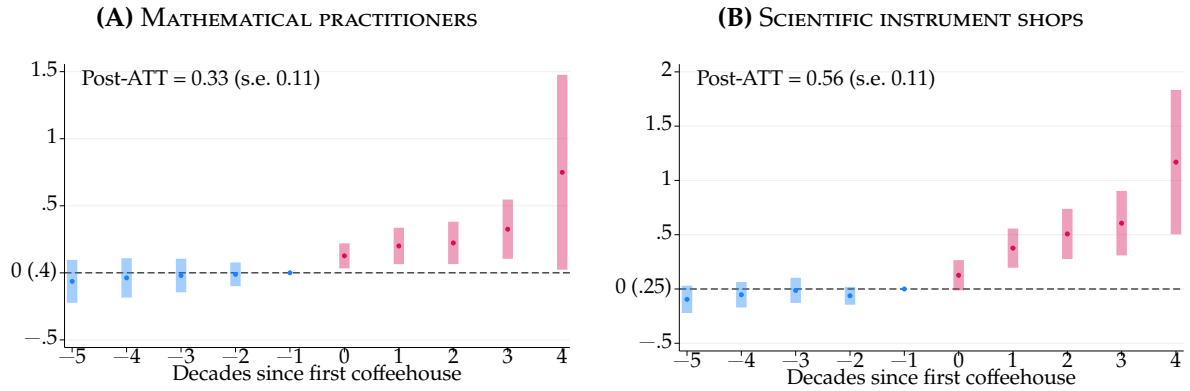


Figure C26. Effects on scientific activity: inverse hyperbolic sine

Notes: Figure shows event study estimates and 95 percent confidence intervals for the effect of first coffeehouse opening on scientific activity, obtained by estimating equations (1) and (2) with the inverse hyperbolic sine of the outcome. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Post-ATT is the average of the estimates from entry through four decades after, on the inverse hyperbolic sine scale. Standard errors clustered by parish. [Return to page OA-26]

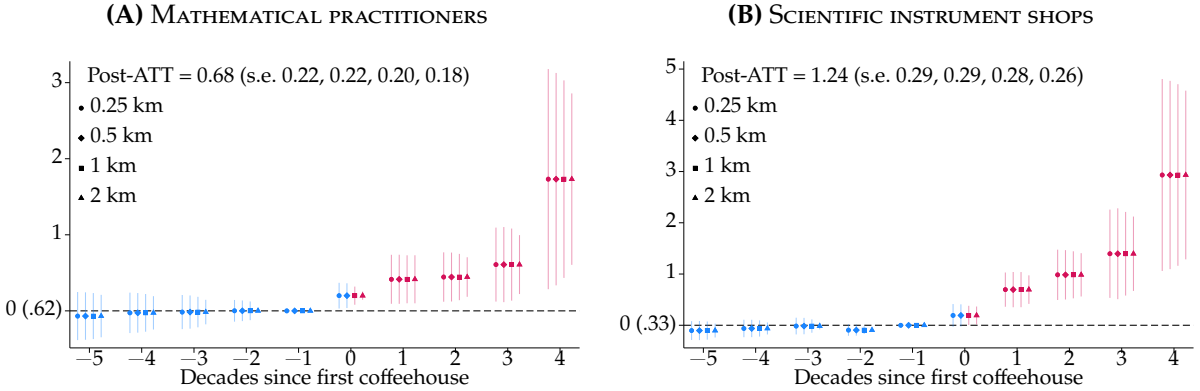


Figure C27. Effects on scientific activity: Conley (1999) standard errors

Notes: Figure shows event study estimates and 95 percent confidence intervals from equations (1) and (2) of the effect of first coffeehouse opening on scientific activity. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes all 162 parishes from the 1600s to the 1690s. Unit of observation is parish-decade. The parenthetical next to 0 on the vertical axis reports the sample outcome mean one decade before treatment. Standard errors follow Conley (1999): they allow for heteroskedasticity, for correlation between any two decades of the same parish, and for correlation within a decade between parishes whose centroids lie within the cutoff, with weights declining linearly in distance; the cutoffs are 0.25, 0.5, 1, and 2 kilometers. At 2 kilometers the estimated variance matrix is not positive semidefinite, and the interval two decades before opening cannot be computed. Post-ATT is the average of the estimates from entry through four decades after, with its standard error under each distance cutoff, in the order of the legend. [Return to page OA-26]

C.13. Tables

Table C1—Balance of pre-treatment levels

	Parishes			Normalized difference
	Nonmissing	Treatment	Control	
Panel A. Demographics				
Baptisms, 1600s–1640s	130	84.72 (120.74)	57.44 (113.62)	0.23
Baptisms per km^2, 1600s–1640s	130	493.76 (349.55)	634.63 (503.77)	−0.32
Deaths, 1600s–1640s	110	117.25 (174.38)	86.08 (159.55)	0.19
Deaths per km^2, 1600s–1640s	110	740.21 (564.89)	872.94 (665.37)	−0.22
Households, 1638	107	249.00 (329.67)	157.87 (255.37)	0.31
Households per km^2, 1638	107	3419.34 (1368.22)	4114.09 (2010.83)	−0.40
Panel B. Wealth				
Median tax paid, 1582	98	93.20 (87.91)	124.53 (132.58)	−0.28
Substantial households (%), 1638	92	26.45 (15.99)	25.97 (20.17)	0.03
Panel C. Social capital and commerce				
Apothecaries, 1617–1640s	162	0.12 (0.32)	0.03 (0.11)	0.39
Booksellers, 1600s–1640s	162	1.53 (3.29)	0.19 (0.37)	0.57
Clay-pipe finds, 1600s–1640s	162	0.50 (2.50)	0.39 (1.98)	0.05
Commercial premises, 1600s–1640s	162	0.50 (0.90)	0.06 (0.18)	0.68
Dissenting meetings, 1600s–1640s	162	0.33 (0.85)	0.06 (0.34)	0.41
Goldsmiths, 1600–1651	162	0.18 (1.18)	0.05 (0.41)	0.15
Luxury shops, 1600s–1640s	162	0.07 (0.20)	0.05 (0.17)	0.13
Taverns, 1600s–1640s	162	3.01 (3.63)	0.53 (1.21)	0.92
Theaters, 1600s–1640s	162	0.08 (0.23)	0.04 (0.19)	0.15
Tradesmen's tokens, 1648–1651	162	1.16 (1.88)	0.23 (1.02)	0.62
Panel D. Science before 1652				
Instrument shops, 1600s–1640s	162	0.15 (0.40)	0.05 (0.20)	0.32
Non-scientific letters, 1600s–1640s	162	3.87 (10.41)	1.09 (3.98)	0.35
Practitioners, 1600s–1640s	162	0.40 (0.95)	0.16 (0.48)	0.32
Scientific letters, 1600s–1640s	162	0.38 (1.08)	0.23 (1.38)	0.12
Panel E. Geography				
Area (km^2)	162	0.99 (4.23)	1.28 (4.37)	−0.07
City of London	162	0.80 (0.40)	0.63 (0.48)	0.38
Distance to Gresham College (km)	162	1.18 (1.02)	1.37 (1.20)	−0.18
Distance to Paternoster Row (km)	162	1.01 (0.88)	1.24 (1.12)	−0.24
Distance to the Royal Exchange (km)	162	1.01 (1.01)	1.22 (1.21)	−0.19
Inside the London Wall	162	0.66 (0.48)	0.56 (0.50)	0.19
Parishes	162	61	101	

Notes: Table compares London parishes with recorded coffeehouses in the seventeenth century (treatment) with parishes with no recorded coffeehouse (control). All characteristics predate the first London coffeehouse opening in 1652. The nonmissing column reports the number of parishes with a nonmissing value. Treatment and control columns report means, with standard deviations in parentheses. Values labeled 1600s–1640s are averages of observed decadal counts from 1600 through 1640, except scientific letters, non-scientific letters, and dissenting meetings, which are period totals. Normalized differences are the difference between the treatment and control means divided by the square root of the average sample variance. [Return to pages 18, 21, 24, OA-22, OA-28, OA-29, OA-44, OA-55]

Table C2—Balance of pre-treatment changes

	Observed parishes	Treatment parishes	Control parishes	Normalized difference
Panel A. Demographics				
Baptisms	130	31.49 (73.83)	17.93 (76.60)	0.18
Baptisms per km^2	130	104.57 (196.59)	107.73 (239.48)	−0.01
Deaths	91	26.44 (100.91)	7.08 (83.22)	0.21
Deaths per km^2	91	10.61 (183.58)	37.26 (286.36)	−0.11
Panel B. Social capital and commerce				
Booksellers	162	−0.04 (2.15)	−0.01 (0.56)	−0.02
Clay-pipe finds	162	0.16 (0.91)	0.26 (1.28)	−0.09
Commercial premises	162	0.50 (1.02)	0.10 (0.37)	0.52
Dissenting meetings	162	0.08 (0.41)	0.03 (0.17)	0.17
Luxury shops	162	0.11 (0.33)	0.09 (0.37)	0.06
Taverns	162	4.16 (4.67)	0.67 (1.63)	1.00
Theaters	162	0.02 (0.24)	−0.03 (0.16)	0.25
Panel C. Scientific activity before 1652				
Instrument shops	162	0.09 (0.32)	0.06 (0.36)	0.08
Non-scientific letters	162	0.68 (2.52)	0.24 (1.47)	0.21
Practitioners	162	0.07 (0.81)	0.10 (0.52)	−0.05
Scientific letters	162	0.03 (0.40)	−0.03 (0.68)	0.11
Parishes	162	61	101	

Notes: Table compares the change in each pre-treatment characteristic between the 1600s–1610s and the 1630s–1640s, for London parishes that received a coffeehouse and parishes that never did. Entries are mean changes with standard deviations in parentheses. Characteristics that are fixed or recorded once, reported in Table C1, have no change to measure. Apothecaries are omitted because the source begins in 1617. Normalized differences are the difference between the treatment and control mean changes divided by the square root of the average sample variance of the changes. [Return to pages 22, OA-22, OA-55]

Table C3—Covariate adjustment on the full sample and on common support

	All parishes		Common support	
	Practitioners	Shops	Practitioners	Shops
Unadjusted	0.68	1.24	0.46	0.85
	(0.22)	(0.31)	(0.22)	(0.29)
	[0.99]	[0.29]	[0.29]	[0.45]
Weighted	0.56	0.99	0.34	0.60
	(0.25)	(0.37)	(0.24)	(0.37)
	[0.89]	[0.45]	[0.63]	[0.46]
Score by decade	0.31	0.64	0.33	0.59
	(0.24)	(0.30)	(0.24)	(0.31)
	[0.46]	[0.58]	[0.62]	[0.53]
Pre-entry mean	0.62	0.33	0.56	0.29
Treated parishes	61	61	48	48
Control parishes	101	101	101	101

Notes: Table reports the equal-weighted average of the event study estimates from entry through four decades after, from equation (1) with never-treated controls. Unadjusted is the baseline. Weighted reweights control parishes by the odds of treatment from a probit propensity score for ever being treated on pre-1652 taverns, tradesmen's tokens (1648–1651), booksellers, and an indicator for the City of London, so that the estimate refers to the treated parishes; weights are not trimmed. Score by decade interacts the propensity score with decade fixed effects. Common support drops the treated parishes whose propensity score exceeds that of every control parish; no control parish falls below the smallest treated score. Pre-entry means are the mean of the outcome among treated parishes one decade before treatment, in the sample of the column. Outcomes are the decadal number of mathematical practitioners and scientific instrument shops in a parish. Sample includes the 162 parishes from the 1600s to the 1690s, less those a column drops. Unit of observation is parish-decade. Standard errors clustered by parish in parentheses; p-values of the joint test that the estimates two to five decades before entry are zero in brackets. [Return to pages 22, OA-22]

Table C4—Correlation between coffeehouses and taverns

	Coffeehouses (standardized)				Coffeehouses > 0			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Taverns (standardized)	0.408	0.264	0.412	0.251				
	(0.067)	(0.094)	(0.068)	(0.103)				
Taverns > 0					0.169	0.073	0.154	0.017
					(0.025)	(0.035)	(0.024)	(0.032)
Mean dep. var.	0	0	0	0	0.107	0.107	0.107	0.107
Observations	1620	1620	1620	1620	1620	1620	1620	1620
Parish FE		✓		✓		✓		✓
Decade FE			✓	✓			✓	✓

Notes: Table shows the relationship between coffeehouses and taverns. Columns 1–4 show effect sizes from regressions of the number of coffeehouses on the number of taverns, standardized to mean 0 and standard deviation 1. Beginning with the raw correlation in Column 1, the specifications add parish fixed effects, decade fixed effects, and both parish and decade fixed effects. Columns 5–8 show the corresponding extensive-margin regressions of indicators for coffeehouses and taverns with the same sequence of fixed effects. The sample includes all 162 parishes from the 1600s to the 1690s. The unit of observation is the parish-decade. Standard errors clustered by parish. [Return to page 24]

Table C5—Coffeehouse cities relative to comparison cities, alternative samples

	Pre-entry mean		Post-entry difference	
	Titles	Makers	Titles	Makers
Baseline	5.95	3.73	4.97	4.89
			(2.30)	(2.97)
Country-by-decade fixed effects	5.95	3.73	4.25	3.15
			(2.38)	(3.21)
Without London	5.22	2.42	1.67	0.98
			(1.29)	(0.49)
Without London, first two decades	5.22	2.42	2.29	0.91
			(1.29)	(0.53)
Country-by-decade fixed effects, without London	5.22	2.42	2.23	1.55
			(1.48)	(0.69)
Without Paris	5.56	3.17	4.26	4.73
			(2.26)	(3.05)
Without any capital	3.56	1.56	1.26	0.23
			(0.93)	(0.33)
Only France, Germany, the Netherlands, and the UK	6.96	4.67	5.18	5.92
			(1.42)	(0.38)

Notes: Table reports the equal-weighted post-entry difference from entry through three decades after, from equation (1) estimated at the city level with never-treated controls and log population in 1600 and growth from 1500 to 1600 by decade, the average of the estimates in Figure 13. The row marked first two decades averages from entry through two decades after instead, since the third decade rests on the seven coffeehouse cities other than London that opened by the 1660s. Without any capital drops the ten coffeehouse cities and eleven comparison cities that were seats of government. Pre-entry means are the mean of the outcome among coffeehouse cities in the decade before entry, in the sample of the row. Titles are applied mathematics titles; makers are scientific instrument makers. Sample includes all 200 cities from the 1600s to the 1690s, less those a row drops. Unit of observation is city-decade. Standard errors clustered by city in parentheses. [Return to pages 34, OA-27, OA-48]

Table C6—Coffeehouse cities relative to comparison cities, alternative entry decades

	Pre-entry mean		Post-entry difference	
	Titles	Makers	Titles	Makers
Baseline	5.95	3.73	4.97	4.89
			(2.30)	(2.97)
Earliest admissible decade	5.74	3.56	4.75	4.76
			(2.24)	(2.92)
Latest admissible decade	6.47	3.79	4.59	6.09
			(1.42)	(0.53)
Without the recoded cities	5.76	3.76	5.45	6.69
			(1.58)	(0.61)

Notes: Table reports post-entry differences as in Table C5 under alternative entry decades. The sources admit more than one entry decade for Rome (1650s–1690s), Venice (1680s or dropped), Utrecht (1670s or 1680s), Nuremberg (1680s or 1690s), Bremen (1660s or 1670s), Haarlem (1680s or never), Alkmaar (1680s or 1690s), and Antwerp (1680s or 1690s); the earliest and latest rows assign every one of them to the end of its interval, and the last row drops them together with The Hague and Leiden, whose dates were recoded on source grounds. Haarlem and Alkmaar are comparison cities in the baseline. Pre-entry means are the mean of the outcome among coffeehouse cities in the decade before entry, in the sample of the row. Titles are applied mathematics titles; makers are scientific instrument makers. Sample includes all 200 cities from the 1600s to the 1690s, less those the last row drops. Unit of observation is city-decade. Standard errors clustered by city in parentheses. [Return to pages 33, OA-27]

D. DATA APPENDIX

D.1. Summary Statistics

Table D1—Summary statistics, London

	Distribution						Units	
	Mean	SD	p25	p75	Max	N	Non-missing	Non-zero
Panel A. Main outcomes								
Mathematical practitioners	0.43	1.16	0	0	12	1,620	162	69
Scientific instrument shops	0.30	1.05	0	0	13	1,620	162	68
Guild-linked	0.23	0.87	0	0	11	1,620	162	54
Applied scientists	0.65	1.61	0	1	19	1,620	162	91
Panel B. Mechanism outcomes								
Below-median practitioners	0.21	0.63	0	0	6	1,620	162	53
Above-median practitioners	0.23	0.71	0	0	7	1,620	162	48
All connections	1.26	4.29	0	0	55	1,620	162	58
Between makers and theorists	0.58	2.12	0	0	33	1,620	162	52
Among makers	0.20	0.86	0	0	12	1,620	162	38
Among theorists	0.48	1.98	0	0	19	1,620	162	36
Experimental instrument shops	0.12	0.58	0	0	9	1,620	162	43
Practical instrument shops	0.17	0.65	0	0	9	1,620	162	53
Teachers and instrument masters	0.25	0.75	0	0	7	1,620	162	61
Instrument masters' apprentices	0.17	0.89	0	0	13	1,620	162	37
Senior-to-junior practitioner connections	0.57	1.99	0	0	19	1,620	162	51
Dated works	0.53	2.47	0	0	32	1,620	162	43
Distinct instrument classes	0.17	0.46	0	0	3	1,620	162	65
Royal Society fellows	0.21	1.12	0	0	20	1,620	162	45
Booksellers	0.83	2.50	0	1	27	1,620	162	99
Panel C. Treatment and placebo outcomes								
Coffeehouses open	0.28	1.23	0	0	16	1,620	162	61
Baptisms per km^2	566	447	289	747	3,972	910	130	130
Deaths per km^2	810	616	464	1,010	4,618	963	119	119
Luxury shops	0.15	0.60	0	0	7	1,620	162	45
Non-scientific letters	0.75	4.53	0	0	81	1,620	162	67
Taverns	1.82	3.92	0	2	47	1,620	162	108
Commercial premises	0.96	3.54	0	0	38	1,620	162	78
Panel D. Parishes								
Coffeehouse by the 1690s	0.38	0.49	0	1	1	162	162	61
City of London	0.70	0.46	0	1	1	162	162	113
Inside the London Wall	0.60	0.49	0	1	1	162	162	97
Exposed to the Great Fire	0.59	0.49	0	1	1	162	162	95
Area (km^2)	1.17	4.31	0.03	0.18	32.27	162	162	162

Notes: Table reports summary statistics for the 162 London parishes from the 1600s to the 1690s. The unit of observation is the parish-decade in Panels A to C and the parish in Panel D. Columns p25 and p75 report the 25th and 75th percentiles, and N the number of observations. Baptisms and deaths are recorded for fewer than the 1,620 parish-decades of the panel. The nonmissing and nonzero columns count the parishes with at least one recorded value and with at least one value above zero. Rows without units are counts, except the indicators of Panel D, which take the value 0 or 1. Below- and above-median practitioners split the practitioners at the median of $z(s)$ in equation (4). Applied scientists are the practitioners and makers of Section 7, with a person in both rosters counted once. Appendix D defines each variable.

Table D2—Summary statistics, European cities

	Distribution						Units	
	Mean	SD	p25	p75	Max	N	Non-missing	Non-zero
Panel A. Outcomes								
Applied mathematics titles	1.71	6.70	0	1	128	2,000	200	120
Scientific instrument makers	1.11	6.78	0	0	144	2,000	200	84
Panel B. Other								
Coffeehouse by the 1690s	0.18	0.39	0	0	1	200	200	37
Population, 1600 (thousands)	30.02	37.09	12	32	300	200	200	200
Population growth, 1500 to 1600 (log points)	0.32	0.42	0.09	0.56	1.61	200	200	193
Seat of government	0.10	0.31	0	0	1	200	200	21
Copy of *De revolutionibus*, 1620	0.09	0.28	0	0	1	200	200	17
Distance to the nearest coffee port (km)	448	327	174	666	1,317	200	200	200

Notes: Table reports summary statistics for the 200 European cities of Section 6 from the 1600s to the 1690s. The unit of observation is the city-decade in Panel A and the city in Panel B. Columns p25 and p75 report the 25th and 75th percentiles, and N the number of observations. The nonmissing and nonzero columns count the cities with at least one recorded value and with at least one value above zero. Rows without units are counts, except the indicators of Panel B, which take the value 0 or 1. Appendix D defines each variable. [Return to page 17]

Table D3—Summary statistics, Hooke's diary

	Distribution					
	Mean	SD	p25	p75	Max	N
Coffeehouse day	0.65	0.48	0	1	1	3,464
Other public house day	0.10	0.30	0	0	1	3,464
People recorded	4.71	3.81	2	7	24	3,464
In the network	1.86	1.77	0	3	11	3,464
Outside it	2.85	2.67	1	4	21	3,464

Notes: Table reports summary statistics for the 3,464 days of Hooke's diary from 10 March 1672 to 15 May 1683. The unit of observation is the day. Columns p25 and p75 report the 25th and 75th percentiles, and N the number of days. Coffeehouse and other public house days are indicators, which take the value 0 or 1, and people recorded are counts. People in the network sent at least one letter from London in the seventeenth century recorded in *Early Modern Letters Online*. Appendix D defines each variable. [Return to page 17]

D.2. Treatment Variable

Coffeehouses, 1652–1699 (Lillywhite, 1963, 1972). Defined as the number of coffeehouses established between 1652 and 1699 in a given parish, based on public houses identified as coffeehouses, excluding entries explicitly marked as duplicates. When the source is uncertain whether two mentions refer to the same establishment, both are retained as separate entries. The source data contain 287 coffeehouses first recorded before 1700. Don Saltero's coffeehouse in Chelsea, first recorded in 1695, lies outside the 162-parish study area and is therefore excluded, which leaves 286. Appendix Table D6 summarizes the historical sources that record them. For any year t, the count includes all coffeehouses whose recorded years of activity encompass t, as determined by their earliest and latest mentions. Of the 286, 107 are mentioned in a single year and count as open in that year only. Where only a decade is known (9 of the 286 coffeehouses), activity years are set to the full decade range (e.g., 1660s as 1660–1669). The count also

includes chocolate houses, which the source treats as one subject with coffeehouses and at times cannot separate, typing a house "Chocolate or Coffee-house?" Five of the 286 are recorded as chocolate houses, four of them in St. James Westminster, a parish treated from 1659 on Harper's Coffee House. The fifth, in Queen's Head Alley, is the earliest record in St. Botolph Bishopsgate, at 1657; without it that parish enters in the 1660s. Appendix D.11 assesses the completeness of these counts against independent records.

D.3. Outcome Variables

The two main outcomes are mathematical practitioners and scientific instrument shops. They measure applied scientific activity in a parish and decade. The remaining outcome variables support the mechanism analyses of Section 5 and the European comparison of Section 6.

Mathematical Practitioners, 1600–1699 (Taylor, 1954). Defined as the number of mathematical practitioners in a given parish and decade. This count encompasses all practitioners who have at least one workplace in London and whose recorded flourishing overlaps 1600–1699. Each practitioner contributes a record for every decade from the decade containing the first year of flourishing to the decade containing the last, and is assigned in each decade to the parish of each workplace recorded for that decade. Each workplace carries the years Taylor (1954) gives for it, and where she dates no move, the period of flourishing is split at its midpoint. Practitioners therefore count in two parishes only in the decade of a move or while two addresses overlap, in 28 of 670 practitioner-decades. In a given parish-decade, a practitioner is counted once, independently of how many workplaces the source records.

Connections Between Mathematical Practitioners, 1600–1699 (Taylor, 1954; Warren et al., 2016). Defined as the number of connections between mathematical practitioners in a given parish and decade. It counts the undirected pairs with $A_{ijt} = 1$ defined in Appendix D.4, each counted once in every parish where practitioner i or j works, so that a connection between a practitioner in one parish and a practitioner in another parish counts in both, and a connection between two practitioners in the same parish counts once. Connections are further split by whether each endpoint is a maker or a theorist, defined as any practitioner who is not a maker.

Scientific Instrument Shops, 1600–1699 (Clifton, 1995; Hay et al., 2025). Defined as the number of scientific instrument shops in a given parish and decade. Each shop is one maker at one recorded address over the years the source gives for it, so makers who move open a new shop, and the 252 makers in the panel operate 345 shops. In a given parish-decade, each shop is counted once, and a maker counts twice only where the source records two of their addresses in the same parish and decade, in 31 of 447 maker-parish-decades.

Practical Instrument Shops, 1600–1699 (Clifton, 1995; Hay et al., 2025). Defined as scientific instrument shops whose makers are recorded as producing mathematical, navigational, or surveying instruments, counted as above. This category includes the

tools used for measuring, calculating, and setting out, such as sectors, dividers, and slide rules. It also includes the tools of navigators, such as quadrants, nocturnals, and compasses, and those of surveyors, such as theodolites, circumferentors, levels, and waywisers.

Experimental Instrument Shops, 1600–1699 (Clifton, 1995; Hay et al., 2025). Defined as scientific instrument shops whose makers are recorded as producing optical or philosophical instruments, counted as above. This category includes optical instruments (microscopes, refracting and reflecting telescopes, and lenses) and philosophical instruments (air pumps, barometers, and thermometers).

Guild-Linked Instrument Shops, 1600–1699 (Clifton, 1995; Hay et al., 2025). Defined as scientific instrument shops restricted to makers with a recorded London guild, counted as above. Of the 252 makers active in the panel, 175 have a recorded guild. None of the London guilds were specifically dedicated to instrument making, so instrument makers could only join an existing guild, and most London makers did (Cormack, 2017, p. 79). Hence, the restriction keeps the makers who joined a guild and whose membership survives in the record.

Royal Society Fellows, 1660–1699 (The Royal Society, 2024). Defined as the number of Fellows of the Royal Society associated with a parish in a given decade, restricted to fellows whose recorded place of death or burial lies in London. This variable assigns fellows to their parish of death, or to their burial site when the parish of death is unknown. The variable counts each fellow for every decade from the decade of election through the last decade of recorded fellowship. That is, a fellow is placed where their life ended, not at their workplaces, and the variable is a long-run outcome that records where the membership eventually lived. Note that since the Royal Society was founded in 1660, this variable is by definition 0 before 1660.

Instrument Makers' Apprentices, 1600–1699 (Clifton, 1995). Defined as the number of apprentice bindings recorded to scientific instrument masters in a parish and decade. The source records each master's apprentices as a free-text list of names and years, which we transcribe. Apprentices with no recorded name or year are dropped, so the count is a lower bound. Apprentices named in two years, for instance at binding and again at turnover (when the apprentice is transferred to a new master), enter twice. That is, the variable counts binding-years rather than distinct individuals. Moreover, as the source records only the location of the master, the apprentice is assigned to each workplace the master had in the year of binding, so from 1600 to 1699 parish totals sum to 279 rather than to the 251 distinct binding-years recorded.

Teachers and Instrument Masters, 1600–1699 (Clifton, 1995; Taylor, 1954). Defined as the number of mathematical teachers recorded by Taylor (1954) and of scientific instrument makers who have bound at least one apprentice, in a given parish and decade. The makers share their records with the apprentices variable above.

Dated Works, 1600–1699 (Taylor, 1954). Defined as the number of titles listed by Taylor (1954) together with the distinct editions in the *English Short Title Catalogue* recorded under the same author authority string, placed at the workplace of the author rather than at the imprint, which gives the address of the bookseller.

Instrument Classes, 1600–1699 (Clifton, 1995; Hay et al., 2025). Defined as the number of distinct trades, mathematical, optical, or philosophical, recorded for the scientific instrument makers with a shop in a parish and decade.

Booksellers, 1600–1699 (Isaac et al., 2024). Defined as the number of members of the London book trades recorded at an address in a parish and decade, from the *British Book Trade Index*. Addresses are geocoded and assigned to parishes as described in Appendix D.12. A trader recorded more than once within the same parish is counted once, since repeated entries reflect alternative descriptions of a single address, and each trader contributes a record for every decade between the first and last recorded trading dates.

Senior-to-Junior Connections, 1600–1699 (Taylor, 1954; Warren et al., 2016). Defined as the connections above, restricted to those in which the practitioner assigned to the parish began flourishing in a later decade than the practitioner they are connected to, so each connection between a senior and a junior practitioner counts in the parish of the junior.

Applied Scientists, 1600–1699 (Clifton, 1995; Hay et al., 2025; Taylor, 1954). Defined as the number of mathematical practitioners and scientific instrument makers in a given parish and decade, with a person who appears in both sources counted once. Of the 252 makers, 93 are already among the 244 practitioners, so the roster holds 403 applied scientists. Matched people enter once, with the earlier first year and the later last year of the two sources and the addresses of both. Everyone is counted once in a parish and decade, so a scientist recorded in two parishes in a decade counts in each. This is the count of applied scientists in Section 7 and Appendix E.

Applied Mathematics Titles, European Cities, 1600–1699 (Kelly and Ó Gráda, 2022; Universal Short Title Catalogue [USTC], 2026). Defined as the number of applied mathematics titles printed in a city and decade, counted in the USTC and classified by the fourteen subject headings of the *English Short Title Catalogue* that Kelly and Ó Gráda (2022, p. 849) use to measure English practical mathematics. We apply the headings as keyword rules, in seven languages (English, Latin, French, German, Dutch, Italian, and Spanish), to every title the USTC classes as Science or Mathematics, which yields 3,415 titles printed in the 200 cities between 1600 and 1699: arithmetic (1,223), astronomical instruments (461), bookkeeping (55), compasses (148), geometry (882), gunnery (69), logarithms (155), mathematics (1,215), mathematical instruments (243), measuring (199), navigation (82), shipbuilding (4), surveying (101), and trigonometry (238). Of these, 996 satisfy more than one heading.

Scientific Instrument Makers, European Cities, 1600–1699 (Webster and Webster, 2007). Defined as the number of scientific instrument makers active in a city and decade. The source is a catalog of makers who signed instruments now held in collections worldwide. In other words, counts are of recorded makers with a located signature rather than of all instrument makers. Thus, there is measurement error, and coverage reflects which instruments survive and which collections Webster and Webster (2007) went through. Restricting to signatures whose recorded years of activity overlap 1600–1699 and that report an identifiable European city leaves 1,201 makers, of whom 309 worked in London, ahead of Paris (101), Nuremberg (89), Augsburg (55), and Amsterdam (45); nine further located records name a city outside Europe. Restricted to the British Isles instead, the source places 309 of 437 makers in London, or 71 percent, in the range of the share of about three-quarters that Appendix Figure D17 reports from an independent compilation. In London the source serves only as context and enters none of the parish estimates.

D.4. Practitioner Connections

Connections recorded by Taylor (1954) take various forms, including "friends," "master," "received advice from," "associated with," "visited," "employed or consulted," "corresponded with," and "mentioned by." Practitioners are recorded as connected whenever historical evidence indicates a social or intellectual association.

To extend this network, we turn to the *Six Degrees of Francis Bacon* (SDFB) database of Warren et al. (2016), which uses machine learning to infer influence or interaction among early modern individuals from mentions in *Oxford Dictionary of National Biography* (ODNB) biographies (Oxford Dictionary of National Biography, 2025). We identify ODNB entries for 75 of the 244 practitioners in our sample, all of whom are recorded in the SDFB.[62]

Together, the two sources record 1,200 directed ties among 293 individuals. Collapsing reciprocated pairs leaves 631 undirected connections, of which 475 are between two of the 244 practitioners in the panel (involving 204 of them). Taylor (1954) alone records 326 of the 475, the SDFB alone 83, and both sources 66. Both distributions are skewed: the most connected practitioner has 54 connections, and 18 percent of active practitioner-decades carry none. Fifty of the 475 pairs are never active in the same decade and so never enter A_{ijt}, among them the father-and-son pairs Taylor (1954) records. The remaining 425 pairs are jointly active in 1,053 pair-decades across the panel, against 670 practitioner-decades of activity.

Note that the data do not record when individuals became connected, and the direction of influence is uncertain. Thus, we treat all connections as undirected. In other words, we take a connection only as evidence that two individuals were socially or intellectually associated at some point. Formally, we set $A_{ij} = 1$ if practitioners i and j are ever connected in this sense, and 0 otherwise. To capture variation over time, we define $A_{ijt} = 1$ if $A_{ij} = 1$ and both i and j are active in period t, and 0 otherwise. This measure represents the maximum possible connectivity under the assumption that connections require both individuals to be active.[63]

[62]We identify ODNB entries by linking practitioners to Wikidata items that carry an ODNB index number. Of the 244 practitioners, 90 are linked to a Wikidata item and 75 of those items carry the identifier, so 75 is a lower bound on ODNB coverage in our sample.

[63]The set of practitioner dyads (i, j) for which $A_{ij} = 1$ includes biological ties such as "father" and

D.5. Covariates

The covariates are pre-treatment parish characteristics. They enter the balance comparisons in Tables C1 and C2, the propensity score of Appendix C.1, and, for several of them, the placebo outcomes reported in the appendix figures. Table D5 gives the source for each. Counts recorded as an interval of activity are assigned to every decade the interval spans, and addresses are geocoded and assigned to parishes as described in Appendix D.12.

Households and Baptisms and Deaths (Cummins et al., 2016). Defined as parish counts of households in 1638 and of baptisms and deaths by decade, taken from the parish register data. Densities divide each count by parish area in square kilometers. Baptisms and deaths are observed for 130 and 119 of the 162 parishes, respectively.

Median Tax Paid, 1582 (Cummins et al., 2016). Defined as the parish median assessment in the lay subsidy of 1582.

Substantial Households, 1638 (Cummins et al., 2016). Defined as the share of households living in properties with an annual rent of at least £20 in 1638.

Tradesmen's Tokens, 1648–1651 (Burn, 1855). Defined as the number of tradesmen's tokens issued in a parish between 1648 and 1651. Tokens were issued by individual traders as small change and are used here as a measure of the density of retail commerce immediately before the first coffeehouse opened.

Goldsmiths, 1600–1651 (Lillywhite, 1972). Defined as the number of goldsmiths recorded at an address in a parish before 1652.

Commercial Premises (Lillywhite, 1972). Defined as the number of signed premises recorded in a parish and decade, excluding taverns, inns, other pubs, and coffeehouses. From the 1600s to the 1690s the measure records 1,560 premises-decades. Booksellers account for 452 of them, goldsmiths for 200, grocers for 85, printers for 37, and mealmen for 29; the remaining 757 are spread over 226 other trades.

Taverns (Lillywhite, 1972). Defined as the number of taverns active in a parish and decade, counted in every decade between the first and last recorded mention. Houses count as taverns only if the source never records them as coffeehouses or under another type. We also count the taverns newly recorded in each decade, but the placebo figures and the balance tables use the active count. The tavern placebo treatment is the decade of the first seventeenth-century tavern recorded in a parish, so taverns first recorded before 1600 do not count as openings.

"son" recorded by Taylor (1954). Restricting the analysis to within-time connectivity, as defined by A_{ijt}, implicitly excludes such ties, since $A_{ij} = 1$ does not necessarily imply $A_{ijt} = 1$ for some t, and the fathers and sons in our dataset are not active in the same period. Hence, we restrict attention to non-familial connections.

Booksellers (Isaac et al., 2024). Defined among the outcomes above, where booksellers also appear in Section 5.

Dissenting Meetings (Hine, 1976). Defined as the number of dissenting meeting places first recorded in a parish and decade, from a manuscript index of dissenting chapels in the City of London held at the Guildhall Library under shelfmark SL 18. The index is closed access and was transcribed on site. Each meeting place is dated by its earliest known date, which the source records either to the year or to the decade. As end dates are not recorded, the variable only counts the meeting places that are newly recorded in a decade. That is, it is a flow and not a stock.

Clay-Pipe Finds (Museum of London, 2013). Defined as the number of excavated clay tobacco pipes assigned to a parish and decade. Each find is dated by the typological interval given in its record and is counted in every decade of that interval. Some records carry the interval 1580–1910, which says nothing about when the pipe was made. We exclude these records, as they would otherwise be counted in every decade of the panel.

Luxury Shops (Lillywhite, 1972). Defined as the number of shops in luxury trades recorded in a parish and decade, active in every decade between the first and last recorded mention, with trades read from the description the source records for each sign. It is used here as a measure of shops selling imported and fashionable goods, of which coffee itself was one. It counts grocers, comfit makers, confectioners, tobacconists, and pastry cooks; the silk trades (silk weavers, silk dyers, silk mercers, silkmen, and throwsters); mercers, lacemen and lace shops, milliners, and perfumers; cabinet makers and upholsterers; musical instrument makers and music sellers; and toy shops, wax chandlers, and glass sellers. It leaves out drinking and sociability venues, which lie too close to treatment; the book, print, map, instrument, and clock trades, which overlap the outcomes; goldsmith-bankers, which are financial rather than retail; and, as borderline, goldsmiths and silversmiths, apothecaries and druggists, hatters, glovers, calico printers, cheesemongers, and fruiterers. From the 1600s to the 1690s it records 246 premises-decades: grocers 128, mercers 32, confectioners and comfit makers 20, tobacconists 19, and milliners 12, with the remaining 35 spread over 13 other trades.

Apothecaries, 1617–1640s (Wallis and Webb, 2000). Defined as the number of distinct masters named in geocoded binding records of the Apothecaries' Company in a parish and decade. Note that the source records apprenticeship bindings, not all practicing apothecaries. Hence, the variable counts the masters who took an apprentice in the decade, and an apothecary without one in that decade is not counted. It begins in 1617, so the pre-treatment average excludes the 1600s.

Theaters (Wikipedia, 2024). Defined as the number of playhouses whose operating interval overlaps a given decade. The venue list is ours, built from the index of English Renaissance theatres on Wikipedia and the venue pages it links, with the first and second Blackfriars separated and omitted venues added. Each playhouse is dated by the end of ordinary or legal performance rather than by demolition. The list holds 19 venues, 18 inside the parish geography of the panel; the Hope, on Bankside, geocodes

just outside it. Eleven had closed before the Civil War, from the Red Lion in 1568 to the Swan around 1632, and the other eight are dated to the order of 2 September 1642 by which the Long Parliament suppressed stage plays. Illicit playing after it and the Restoration revival do not count, so no venue reaches the 1650s.

Scientific and Non-Scientific Letters (Hotson and Lewis, 2024). Defined as the number of letters sent from or received at an address in a parish in a given decade, recorded in *Early Modern Letters Online*, counting only letters whose location is recorded directly rather than interpolated. A letter is scientific when the description of its author or recipient contains one of ten strings, matched in lower case anywhere in the field: "cartographer", "meteorologist", "pharmacist", and the stems "astro", "natur", "experim", "math", "physic", "chem", and "botan", cut short to catch astronomer and astrologer, natural philosopher and naturalist, and the like. All other letters are non-scientific. Note that the classification is based on who wrote or received a letter and not on what it says. In other words, a scientific letter is one involving someone described in scientific terms, whatever its subject. The 1,220 non-scientific letter-author pairs recorded from the 1600s to the 1690s fall under clergy and religious (310); scholarship, letters, and education (266); nobility, royalty, and court (166); government and administration (154); law (93); five other occupations (126); and no recorded occupation (105).

Mathematical Practitioners and Scientific Instrument Shops Before 1652. Defined among the outcomes above, measured over the decades preceding the first coffeehouse.

City of London and London Wall (Cummins et al., 2016). Defined as indicators for location in the City and inside the London Wall. The City of London indicator covers all 113 parishes within the City. The Inside the London Wall indicator covers the 97 of these parishes located within the historic London Wall.

Distances and Area. Defined as the great-circle distance in kilometers from the parish centroid to the Royal Exchange, Gresham College, and Paternoster Row, and the parish area in square kilometers. Centroids and areas are taken from the parish geography of Cummins et al. (2016).

Exposure to the Great Fire. Defined as an indicator, constructed by hand for each parish, of whether the parish lay in the area destroyed by the Great Fire of 1666. We read the burnt area from the map of the fire's extent in Schofield (1984, pp. 172–173).

D.6. Hooke's Diary

Robert Hooke kept a memorandum book from 10 March 1672 to May 1683, now Guildhall Library MS 1758. Robinson and Adams (1935) print the entries from August 1672 to December 1680, and Henderson (2007) the months they omit, March to July 1672 and January 1681 to May 1683. We transcribe both editions by hand, with one row per printed entry, and check each row against the text of its printed page. Of the 2,950 rows from the first edition, 2,944 closely match a passage on the page, and so do 438

of the 509 rows from the second.[64] When an entry covers several days, we assign it to each of them. Dates keep the Old Style calendar, but with the year starting on 1 January. This gives 3,464 dated days.

Coffeehouse days are those whose entry names a coffeehouse or mentions coffee. We match each entry and its notes against regular expressions built from the spelling variants in the indexes of both editions and from the establishments that Brown et al. (2021) identify in the diary. On 2,193 days the entry names one of 57 coffeehouses, 3,097 times when each coffeehouse counts once a day. On 51 further days it mentions coffee or a coffeehouse outside the 57, and on six of these Hooke records no visit, as when he made coffee at home. Drinking houses, mostly taverns, are named on 337 days. We compare our counts with those of Brown et al. (2021). For the Intoxicating Spaces project, they compiled Hooke's use of coffee, alcohol, and other intoxicants from the same two editions, 2,637 coffeehouse visits in all. Their data have no entries for 1679, so the 535 mentions we find in that year are only in ours. In all other years our count of coffeehouse mentions is within 15 percent of their count of visits, and across years the two series correlate at 0.996. Garraway's, for instance, has 1,283 mentions in our data outside 1679 and 1,276 visits in theirs, and Jonathan's has 535 and 545. Including 1679, the two coffeehouses have 1,425 and 798 mentions (see Appendix Figure B6).[65]

We annotated all 3,464 days with coding agents built on large language models, run in Codex, in 55 batches of 16 to 100 days. Every person an entry names gets one row in the annotation (the name as written, whether Hooke met the person, the matching person in the index of the printed editions, and the passage behind each of these decisions). Before this, we merged the two indexes. The 397 people in the index of Henderson (2007) were linked to the 2,043 in the index of Robinson and Adams (1935) by first searching for candidates with the help of a language model and then checking every link by hand. Of the 22,132 mentions, 17,341 record a meeting, and in 16,435 of these the index identifies the person. If the entry for a day records more than one meeting with the same person, we count only one. This leaves 16,325 meetings with 1,426 distinct people on 3,045 days. By script, we confirm that each identified person appears in the printed indexes. For 172 days, or 5 percent, the annotations are still flagged for manual review. Their 1,101 certain meetings are kept. Encounters we are unsure of, and people we could not identify, are left out throughout. On the 2,166 coffeehouse days with a recorded meeting, a second model, GPT-5.4 mini (OpenAI, version of 17 March 2026), reads the whole entry and places each of the 12,767 meetings at the coffeehouse (2,896) or elsewhere (9,331), or leaves it uncertain (540). For 152 days, the output failed our checks, and a coding agent repaired it, changing 22 placements and adding 12 meetings the model had omitted. The 3,558 meetings on other days count as elsewhere.

People are in the Republic of Letters if the index links them to a writer of at least one letter sent from London in the seventeenth century in *Early Modern Letters Online* (Hotson and Lewis, 2024). Candidate links to the 1,581 such writers come from a search

[64] We search the machine-read page for long runs of identical words. Each match confirms the passage, not every character in it, and the 1935 edition is itself "corrupt in places, where words have been mistranscribed or left out" (Henderson, 2007, p. 133).

[65] Appendix Figure B6 places our mentions at the 32 coffeehouses that Brown et al. (2021) locate: 2,915 mentions, 2,233 of them within 400 meters of Hooke's lodgings at Gresham College in Bishopsgate. Using the data of Brown et al. (2021) directly instead of ours, we find 2,497 located visits to coffeehouses and a share within 1 kilometer of 77 percent, against 78 percent for our data.

on names, their variants, and life dates: 198 people in the index are linked to 199 writers, and 155 of the 1,426 people Hooke records meeting are among them.

We group the people Hooke records meeting by occupation from the notes in the index. Mathematical practitioners are the 55 people matched by name to Taylor (1954) or to SIMON, 29 of them instrument makers; each match was adjudicated individually, and a bare surname never suffices. The match is partly circular, since Taylor cites the diary in 58 entries. The index records no occupation for 902 of the 1,426 people. Coding by an independent language model agrees with these groups for 85 percent of people, and on whether an occupation lies in science for 94 percent.

D.7. First Coffeehouses in European Cities

To the best of our knowledge, no previous work attempts a comprehensive listing of the first coffeehouse of every European city. Table D4 reports the year, the decade, and the source for each of the 37 cities in which we find a first coffeehouse before 1700, when the panel ends.

The search made four passes over the 200 cities. The first was a systematic review of the historical scholarship on coffeehouses at the National Library of Sweden and Stockholm University Library, which have the major works in English, French, and German. The second was a systematic search on the web, focusing on the Internet Archive, in the language of each country: national and city histories of coffee and of sociability, municipal and guild records in print, digitized archival finding aids, and the secondary literature on coffeehouses. The third was algorithmic. Using regular expressions, we identified each record in the *Universal Short Title Catalogue* whose title mentions coffee in any of the catalog languages, which surfaced, among other things, ordinances regulating the premises, excise documents, and polemics naming a coffeehouse (which, for example, is what dates Middelburg to 1686). The fourth pass used Claude Code and Codex to search our candidate list for false positives, checking each candidate against the cited text and rejecting dates that record the arrival, sale, or first mention of coffee rather than a coffeehouse. Claude Code and Codex flagged candidates, which we used as a list for hand-coding. This fourth approach never supplied a date by itself: every date in Table D4 rests on a later-identified source, which is cited beside the entry. For example, Barcelona, where coffee is recorded in 1627 but no coffeehouse, is the kind of candidate we were able to reject.

Cities without a dated coffeehouse enter the data as never having had one in the seventeenth century, but an absent record is not an absent coffeehouse. Relatedly, Withington (2020) shows that in provincial England coffee was often sold in inns that left no coffeehouse record.

Two empirical checks support the dates. First, coffee entered Europe through Venice, Livorno, Marseille, London, and Amsterdam, and among the 33 cities whose source gives a year, the first coffeehouse opens 3.3 years later for every 100 kilometers of distance from the nearest of them (s.e. 0.8). See Panel A of Figure D1 for this check. Second, as can be seen in Panel B of Figure D1, across all 200 cities, the nearest third by that distance open coffeehouses first, the middle third overtake them in the 1690s, and the farthest third hardly open any before 1700. Seventeen of the 37 also printed a title on coffee before 1700, against 13 of the 163 comparison cities, and in 14 of the 17 the

first such title follows the first coffeehouse.[66]

[66]The three exceptions are academic: a Frankfurt dissertation of 1666, a Lübeck tea tract of 1694, and Daniel Wencker's Strasbourg dissertation *De potu café* of 1693, two years before the Magistrat's ordinance on the *maisons de café*.

Table D4—First coffeehouses by city in Europe

Country	City	Year	Decade	Source
Austria	Vienna	1685	1680s	Albrecht (1989)
Belgium	Antwerp	1690	1690s	Van Aert (2009)
	Kortrijk	1690	1690s	P. D. B. (1934)
Denmark	Copenhagen		1690s	Hoff (2016)
France	Angers	1693	1690s	Bertoldi (2013)
	Lyon		1670s	Grand-Carteret (1902); Van Damme (2005)
	Marseille	1671	1670s	Ellis (2004a)
	Paris	1671	1670s	Ellis (2004a); Leclant (1951) (1672)
	Strasbourg	1695	1690s	Perry (2011)
Germany	Bremen	1669	1660s	Ellis (2004a)
	Frankfurt am Main	1689	1680s	Cowan (2014)
	Hamburg	1677	1670s	Albrecht (1989); Robilliard (2024)
	Leipzig	1694	1690s	Ellis (2004a)
	Lübeck	1695	1690s	Meyer (2011)
	Munich	1699	1690s	Monacensia Literaturarchiv und Bibliothek (2019)
	Nuremberg	1686	1680s	Cowan (2014)
	Regensburg	1686	1680s	Cowan (2014)
	Würzburg	1697	1690s	Denzinger (1848)
Italy	Genoa	1661	1660s	Belgrano (1875)
	Rome		1650s	Lombardo (2016)
	Venice	1683	1680s	Ellis (2004a)
Netherlands	Amsterdam	1665	1660s	Stadsarchief Amsterdam (2019); Hell (2017)
	Groningen	1686	1680s	Kuiken (1982)
	Leiden	1685	1680s	van Oostrum (2006)
	Middelburg	1686	1680s	City of Middelburg (1686)
	Rotterdam	1666	1660s	Heise (1987)
	The Hague	1670	1670s	van Oostrum (2006); Betz (1900)
	Utrecht	1678	1670s	van Oostrum (2006)
Poland	Gdańsk	by 1697	1690s	Gedanopedia (2020)
Switzerland	Basel		1690s	Meier (1973)
	Geneva	c. 1690	1690s	Encyclopédie de Genève (1992)
UK	Bristol	1666	1660s	Pincus (1995)
	Edinburgh	1673	1670s	Pincus (1995)
	London	1652	1650s	Ellis (2004a)
	Newcastle upon Tyne	1692	1690s	Story (1692)
	Norwich	1676	1670s	Withington (2020)
	York	1669	1660s	Pincus (1995)

Notes: Table lists every city recorded with a first coffeehouse in the seventeenth century, as inferred from our systematic literature review. Year is the year the source establishes and is left blank where the source fixes only a decade, as for Rome, Copenhagen, Basel, and Lyon. Decade is the decade the source establishes. Cities are dated only from sources that name or regulate a coffeehouse, as against recording the arrival or sale of coffee. Cities whose entry decade could not be established on that rule are coded as never having had a coffeehouse in the seventeenth century. [Return to pages OA-59, OA-62, OA-63]

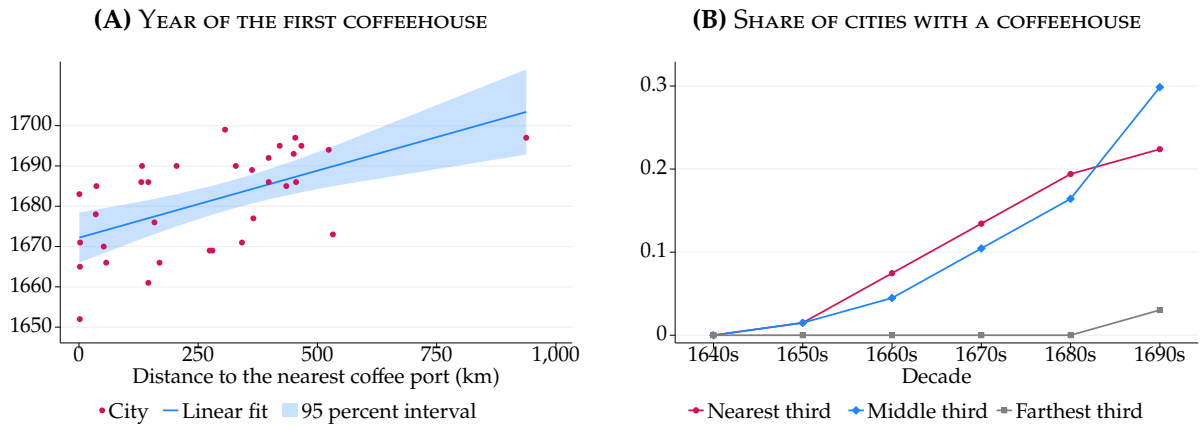


Figure D1. The spread of coffeehouses from the coffee ports

Notes: Figure plots the spread of coffeehouses against the distance from each city to the nearest of the five ports through which coffee entered Europe, Venice (1624), Livorno (1632), Marseille (1644), London (1650), and Amsterdam (1661), with the year coffee is first recorded there. Panel A plots the year of the first coffeehouse against distance for the 33 of the 37 coffeehouse cities whose source gives a year, with a linear fit of 3.3 years per 100 kilometers and its 95 percent confidence interval, from a robust standard error of 0.8. Panel B splits the 200 cities into thirds by that distance, within 223 kilometers, 224 to 555 kilometers, and more than 555 kilometers, and plots for each third the share of its cities with a coffeehouse by each decade, from the decades of Table D4; the thirds hold 15, 20, and 2 of the 37 coffeehouse cities. [Return to pages 17, OA-59]

D.8. Data Sources

Table D5—Data sources

Level	Source	Variables	Online
Parish	Lillywhite (1963)	Coffeehouses	Internet Archive
	Lillywhite (1972)	Coffeehouses, Taverns, Inns, Goldsmiths, Luxury Shops, Commercial Premises	Internet Archive
	Mackie (2013)	Recorded Uses of Coffeehouses	Academia.edu
	Taylor (1954)	Mathematical Practitioners, Their Connections, Dated Works	Internet Archive
	English Short Title Catalogue	Dated Works	British Library
	Warren et al. (2016)	Connections Between Practitioners	Six Degrees of Francis Bacon
	Oxford Dictionary of National Biography (2025)	Practitioners' Entries	Oxford University Press
	Wikidata	Links from Practitioners to the ODNB, Paternal Occupations	Wikidata
	Clifton (1995)	Scientific Instrument Shops, Makers' Trades, Apprentices	Internet Archive
	Hay et al. (2025)	Scientific Instrument Shops, Guilds, Instruments Known to Have Been Sold	National Museums Scotland
	The Royal Society (2024)	Fellows of the Royal Society	The Royal Society
	Fischer et al. (2020)	Practitioners Named in the *Philosophical Transactions*	CLARIN-D
	Isaac et al. (2024)	Booksellers	University of Oxford

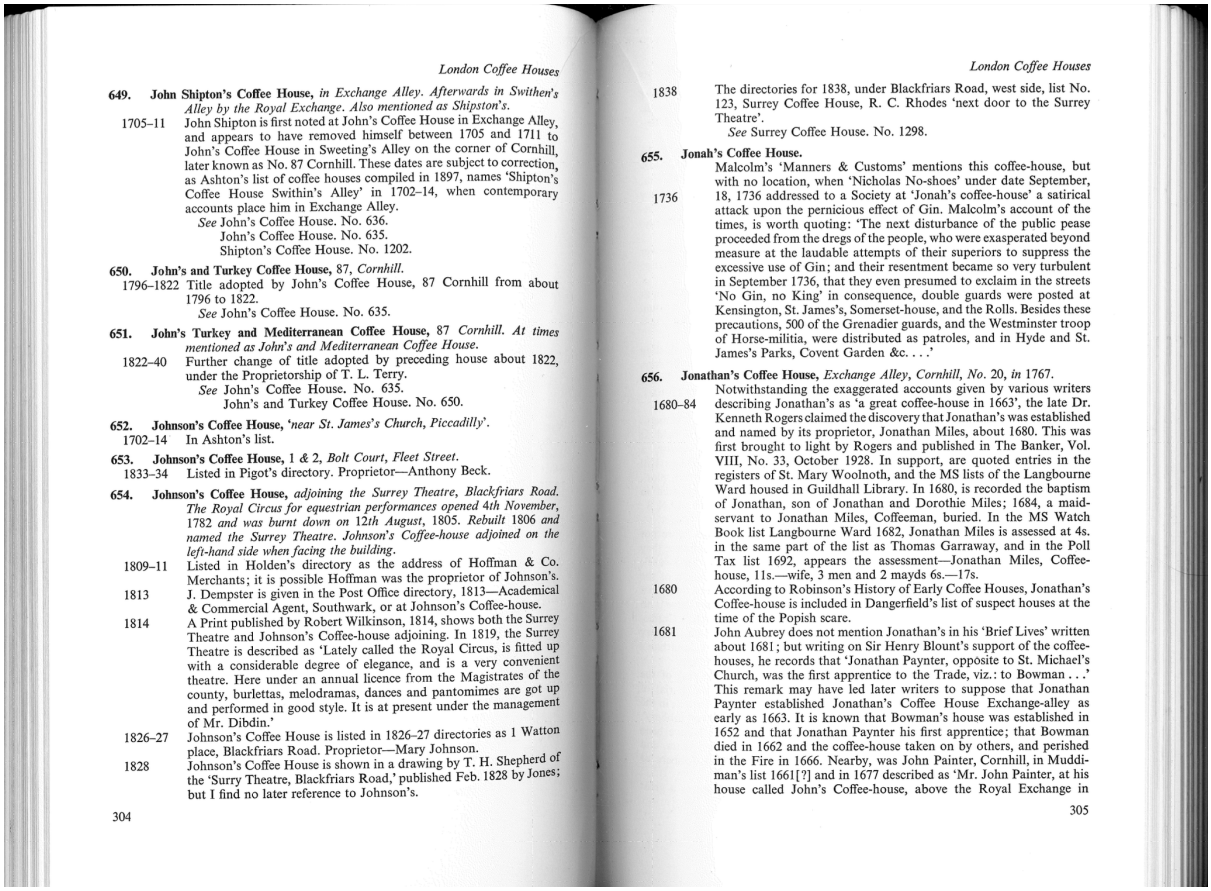
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Table D5—Data sources, continued

Level	Source	Variables	Online
	Clark and Cummins (2014)	Surname Counts Among Alumni of Cambridge and Oxford	Human Nature
	FamilySearch (2025)	Surname Counts Among English Couples Married 1538–1649	FamilySearch
	Cummins et al. (2016)	Median Tax 1582, Substantial Households 1638, Baptisms, Deaths, Parish Boundaries, City of London, London Wall	Economic History Review
	Schofield (1984)	Exposure to the Great Fire	Internet Archive
	Burn (1855)	Tradesmen's Tokens 1648–1651	Internet Archive
	Wallis and Webb (2000)	Apothecaries	LSE Research Online
	Hine (1976)	Dissenting Meeting Places	Guildhall Library
	Museum of London (2013)	Clay-Pipe Finds	Museum of London
	Wikipedia (2024)	Theaters	Wikipedia
	Hotson and Lewis (2024)	Scientific and Non-Scientific Letters, Republic of Letters in Hooke's Diary	Early Modern Letters Online
Diary	Robinson and Adams (1935)	Diary Entries, 1672–1680: Coffeehouse Days, Recorded Meetings	Internet Archive
	Henderson (2007)	Diary Entries, 1672 and 1681–1683: Coffeehouse Days, Recorded Meetings	Notes and Records of the Royal Society
	Brown et al. (2021)	Establishments Named in the Diary and Their Locations	Intoxicating Spaces
City	Bosker et al. (2013)	Cities and Their Populations	Review of Economics and Statistics
	Sources of Appendix Table D4	First Coffeehouses	Listed in the table
	Universal Short Title Catalogue [USTC] (2026)	Applied Mathematics Titles	University of St Andrews
	Webster and Webster (2007)	Scientific Instrument Makers	Adler Planetarium
	Gingerich (2002)	Surviving Copies of Copernicus's *De revolutionibus*	Brill
England	Kelly and Ó Gráda (2022)	Applied Mathematics Titles, Subject Headings for the European Titles	openICPSR
	Almelhem et al. (2026)	Average Progress Score	Quarterly Journal of Economics

Notes: Table lists the data sources used to construct the variables and exhibits, grouped by the level at which each enters the analysis: Parish covers London parishes and finer units such as addresses, shops, and practitioners; Diary the days of Robert Hooke's diary; City the European cities; and England the country as a whole. Online links go to the relevant catalogue, database, or publication. Sources used only to validate the coffeehouse records (Appendix D.11) or to geocode addresses (Appendix D.12) are cited there. [Return to page OA-55]

D.9. Pages of Original Historical Data



London Coffee Houses

649. John Shipton's Coffee House, *in Exchange Alley. Afterwards in Swithen's Alley by the Royal Exchange. Also mentioned as Shipston's.*

1705–11 John Shipton is first noted at John's Coffee House in Exchange Alley, and appears to have removed himself between 1705 and 1711 to John's Coffee House in Sweeting's Alley on the corner of Cornhill, later known as No. 87 Cornhill. These dates are subject to correction, as Ashton's list of coffee houses compiled in 1897, names 'Shipton's Coffee House Swithin's Alley' in 1702–14, when contemporary accounts place him in Exchange Alley.

See John's Coffee House. No. 636.
John's Coffee House. No. 635.
Shipton's Coffee House. No. 1202.

650. John's and Turkey Coffee House, 87, *Cornhill.*

1796–1822 Title adopted by John's Coffee House, 87 Cornhill from about 1796 to 1822.

See John's Coffee House. No. 635.

651. John's Turkey and Mediterranean Coffee House, 87 *Cornhill. At times mentioned as John's and Mediterranean Coffee House.*

1822–40 Further change of title adopted by preceding house about 1822, under the Proprietorship of T. L. Terry.

See John's Coffee House. No. 635.
John's and Turkey Coffee House. No. 650.

652. Johnson's Coffee House, *'near St. James's Church, Piccadilly'.*

1702–14 In Ashton's list.

653. Johnson's Coffee House, 1 & 2, *Bolt Court, Fleet Street.*

1833–34 Listed in Pigot's directory. Proprietor—Anthony Beck.

654. Johnson's Coffee House, *adjoining the Surrey Theatre, Blackfriars Road. The Royal Circus for equestrian performances opened 4th November,* 1782 *and was burnt down on* 12*th August,* 1805. *Rebuilt* 1806 *and named the Surrey Theatre. Johnson's Coffee-house adjoined on the left-hand side when facing the building.*

1809–11 Listed in Holden's directory as the address of Hoffman & Co. Merchants; it is possible Hoffman was the proprietor of Johnson's.

1813 J. Dempster is given in the Post Office directory, 1813—Academical & Commercial Agent, Southwark, or at Johnson's Coffee-house.

1814 A Print published by Robert Wilkinson, 1814, shows both the Surrey Theatre and Johnson's Coffee-house adjoining. In 1819, the Surrey Theatre is described as 'Lately called the Royal Circus, is fitted up with a considerable degree of elegance, and is a very convenient theatre. Here under an annual licence from the Magistrates of the county, burlettas, melodramas, dances and pantomimes are got up and performed in good style. It is at present under the management of Mr. Dibdin.'

1826–27 Johnson's Coffee House is listed in 1826–27 directories as 1 Watton place, Blackfriars Road. Proprietor—Mary Johnson.

1828 Johnson's Coffee House is shown in a drawing by T. H. Shepherd of the 'Surry Theatre, Blackfriars Road,' published Feb. 1828 by Jones; but I find no later reference to Johnson's.

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London Coffee Houses

1838 The directories for 1838, under Blackfriars Road, west side, list No. 123, Surrey Coffee House, R. C. Rhodes 'next door to the Surrey Theatre'.

See Surrey Coffee House. No. 1298.

655. Jonah's Coffee House.

1736 Malcolm's 'Manners & Customs' mentions this coffee-house, but with no location, when 'Nicholas No-shoes' under date September, 18, 1736 addressed to a Society at 'Jonah's coffee-house' a satirical attack upon the pernicious effect of Gin. Malcolm's account of the times, is worth quoting: 'The next disturbance of the public pease proceeded from the dregs of the people, who were exasperated beyond measure at the laudable attempts of their superiors to suppress the excessive use of Gin; and their resentment became so very turbulent in September 1736, that they even presumed to exclaim in the streets 'No Gin, no King' in consequence, double guards were posted at Kensington, St. James's, Somerset-house, and the Rolls. Besides these precautions, 500 of the Grenadier guards, and the Westminster troop of Horse-militia, were distributed as patroles, and in Hyde and St. James's Parks, Covent Garden &c. . . .'

656. Jonathan's Coffee House, *Exchange Alley, Cornhill, No.* 20, *in* 1767.

1680–84 Notwithstanding the exaggerated accounts given by various writers describing Jonathan's as 'a great coffee-house in 1663', the late Dr. Kenneth Rogers claimed the discovery that Jonathan's was established and named by its proprietor, Jonathan Miles, about 1680. This was first brought to light by Rogers and published in The Banker, Vol. VIII, No. 33, October 1928. In support, are quoted entries in the registers of St. Mary Woolnoth, and the MS lists of the Langbourne Ward housed in Guildhall Library. In 1680, is recorded the baptism of Jonathan, son of Jonathan and Dorothie Miles; 1684, a maid-servant to Jonathan Miles, Coffeeman, buried. In the MS Watch Book list Langbourne Ward 1682, Jonathan Miles is assessed at 4s. in the same part of the list as Thomas Garraway, and in the Poll Tax list 1692, appears the assessment—Jonathan Miles, Coffee-house, 11s.—wife, 3 men and 2 mayds 6s.—17s.

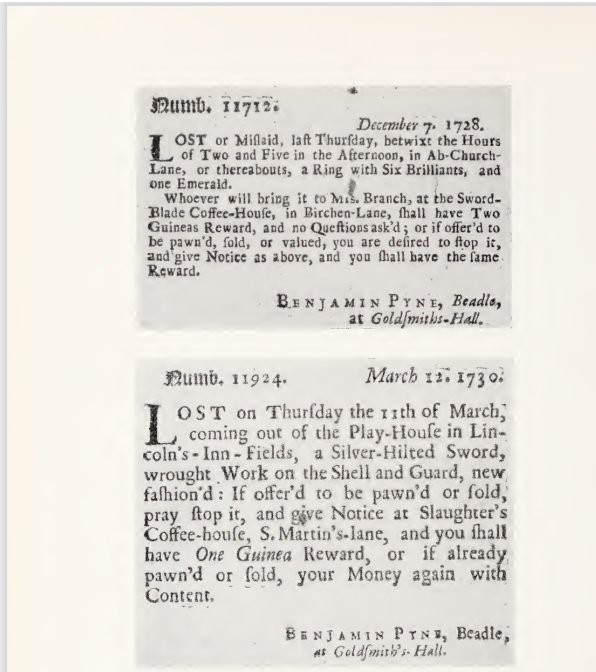
1680 According to Robinson's History of Early Coffee Houses, Jonathan's Coffee-house is included in Dangerfield's list of suspect houses at the time of the Popish scare.

1681 John Aubrey does not mention Jonathan's in his 'Brief Lives' written about 1681; but writing on Sir Henry Blount's support of the coffee-houses, he records that 'Jonathan Paynter, opposite to St. Michael's Church, was the first apprentice to the Trade, viz.: to Bowman . . .' This remark may have led later writers to suppose that Jonathan Paynter established Jonathan's Coffee House Exchange-alley as early as 1663. It is known that Bowman's house was established in 1652 and that Jonathan Paynter his first apprentice; that Bowman died in 1662 and the coffee-house taken on by others, and perished in the Fire in 1666. Nearby, was John Painter, Cornhill, in Muddiman's list 1661[?] and in 1677 described as 'Mr. John Painter, at his house called John's Coffee-house, above the Royal Exchange in

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Figure D2. Coffeehouses in London (Lillywhite, 1963, pp. 304–305)

Notes: Excerpt from Lillywhite (1963), showing London coffeehouse entries and their historical references. Entry 656 is Jonathan's Coffee House in Exchange Alley, Cornhill, first mentioned in 1680–1684. Entry 649 shows how the book links the names one coffeehouse went by: John Shipton's Coffee House is "also mentioned as Shipston's," with cross-references to John's Coffee House (entries 635 and 636) and to Shipton's (entry 1202). [Return to page 14]



Numb. 11712.

December 7. 1728.

LOST or Miſlaid, laſt Thurſday, betwixt the Hours of Two and Five in the Afternoon, in Ab-Church-Lane, or thereabouts, a Ring with Six Brilliants, and one Emerald.

Whoever will bring it to Mrs. Branch, at the Sword-Blade Coffee-Houſe, in Birchen-Lane, ſhall have Two Guineas Reward, and no Queſtions ask'd; or if offer'd to be pawn'd, ſold, or valued, you are deſired to ſtop it, and give Notice as above, and you ſhall have the ſame Reward.

BENJAMIN PYNE, *Beadle*, at *Goldſmiths-Hall.*

Numb. 11924. *March* 12. 1730.

LOST on Thurſday the 11th of March, coming out of the Play-Houſe in Lincoln's-Inn-Fields, a Silver-Hilted Sword, wrought Work on the Shell and Guard, new faſhion'd: If offer'd to be pawn'd or ſold, pray ſtop it, and give Notice at Slaughter's Coffee-houſe, S. Martin's-lane, and you ſhall have *One Guinea* Reward, or if already pawn'd or ſold, your Money again with Content.

BENJAMIN PYNE, Beadle, at *Goldſmith's-Hall.*

PLATE 16

Reward Notices issued by the Beadle at Goldsmiths-Hall advertising rewards paid for the recovery of Lost property. Sword-Blade Coffee-Houſe in Birchen Lane. Dec. 7 1728. Slaughter's Coffee-houſe S. Martin's-lane. March 12 1730.

1162 **Sandals** Coffee House "opposite" or "over against the Custom House" Thames St. 1702-14.
13056 **"Sandford** Coffee House Lawrence Lane" [Cheapside] 1673-74.
1163 **Santrys** Coffee House No. 245 Borough High Street 1838.

The SARACENS HEAD sign in London appears in the fourteenth century. In early contemporary records industrious scribes have produced some ingenious spelling, including—Sarasens Head, Sarasines heved, Sarazenshed, Saresyneshede, Sarazineshed, Saresynes heved, Sarrecyn Head, Sarisons Head, Sarozons Hedd, Sarsons Hedd, Sarsyns Heedd, Sarsynshede, Sarzynesheved, Sarsvnesheved, Sazzinhede, and Saracens Head. Possibly another in "Sareseyneshe in Churche Acton" in 1551. It is found in use by inn and tavern keepers, grocers, chandler, mercer, skinner, and a goldsmith. The sign seems to have disappeared in present-day London. There remains one at Kings Langley, and elsewhere in the country the Saracens Head survives.

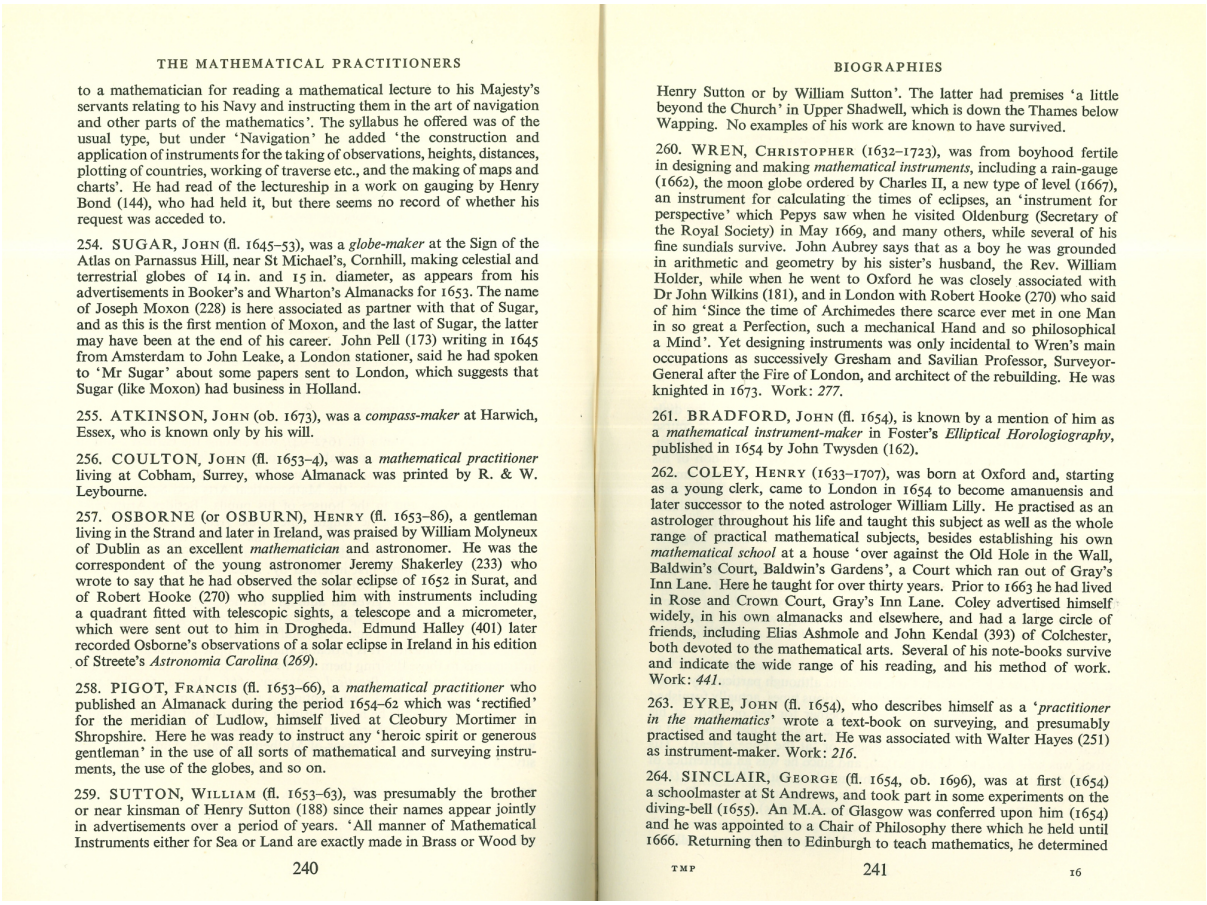
Saracen is a term used conveniently to denote non-European. Brewer gives various origins of the word; probably, he says, it is the Arabic sharakyoun or sharkeyn, the Eastern people, as opposed to Magharibe, the Western people, i.e. of Morocco. The Latin caracenus is derived from the Arabic shangri, meaning East. To the Romans, the Saracen denoted any of the nomadic tribes that raided the Syrian borders of their empire. In Britain, the word Saracen is an inheritance from the Crusades, a term used loosely to denote Easterner. Although applied mostly to Turks, it might be deemed to cover Muslims of many races.

According to Bagford's MS. (Harl. MSS. 5910) "Sarason Head" is the badge of "ye Ld. Audley and ye Ld. Cobham." John Selden writing about 1634-54, says: "When our countrymen came home from fighting the Saracens, and were beaten by them, they pictured them with huge, big, terrible faces (as you still see the sign of the Saracen's Head is) when, in truth, they were like other men. But this they did to save their own credit."

1164 **"Saresyneshede** wt ynne Algate" [Saracens Head within Aldgate]; "Sarozons Hedd within Aldgate" 1423-1539.
"The Sarasens Head within Algate". Chandler. c1648-60s; "Sarazens Head Inn Leadenhall St." 1677; "Sarazens-head within Aldgate" 1681-1804; "Saracens Head Tavern & Coffee-house Aldgate" 1809-11; "Saracens Head Inn, Tavern & Hotel" 1831; "Saracens Head Inn formerly opposite Aldgate Pump" 1855-56.
Saracens Head "in Northumberland Alley" 1904; No. 92 Fenchurch Street 1935.
13057 **Saracens Head** inn Camomile Street Bishopsgate c1670s-1851; No. 7 Camomile Street 1826.
13058 **Saracens Head** "at Bowe Bridge" [Bow, Middlesex] c1648-72.
13059 **Saracens Head** "in Iewen Street" [Jewin St. Cripplegate]. Grocer. 1667.
13060 **"Saracens Head** on the west part of the Back Alley or approach to the Tavern commonly called the Popes Head" [Popes Head Alley Cornhill]. Skinner. 1582.
13061 **"Sarazineshed** in the parish of St. Vedast" [Cheapside]. Tenement. 1356.
13062 **"Sarsynshede** in Fletestrete". Hostel. 1424.
13063 **"Saracens Head** in Gracious Street" [Gracechurch Street]. Inn. 1637.
13064 **"Sarasines heved** at the end of the lane called St. Clements in the parish of St. Edmund" [St. Clements Lane Lombard Street] 1380-82; 1414-15 ?
13065 **"Sazzinhede"** "Sarazenshed" Friday Street. Tenement. 1377-1401; 1518-32 [?]; "Sarazens heade Friday Street" 1549-1666 Inn consumed in the Fire.
"Sarisons head Inne in ffryday street next St. Mathews Church" 1669; Sarazens Head Inn west side of Friday Street 1677-c1844-50.

FIGURE D3. SIGNS IN LONDON (LILLYWHITE, 1972, PP. 480–481)

Notes: Excerpt from Lillywhite (1972), showing information about London signs. Numbers up to 2,034 are those of Lillywhite (1963), so entry 1163, Santry's Coffee House in Borough High Street, is in both, while entry 13056, the Sandford Coffee House on Lawrence Lane in Cheapside, recorded in 1673–1674, is a seventeenth-century coffeehouse the earlier book does not list. [Return to page 14]



THE MATHEMATICAL PRACTITIONERS

to a mathematician for reading a mathematical lecture to his Majesty's servants relating to his Navy and instructing them in the art of navigation and other parts of the mathematics'. The syllabus he offered was of the usual type, but under 'Navigation' he added 'the construction and application of instruments for the taking of observations, heights, distances, plotting of countries, working of traverse etc., and the making of maps and charts'. He had read of the lectureship in a work on gauging by Henry Bond (144), who had held it, but there seems no record of whether his request was acceded to.

254. SUGAR, JOHN (fl. 1645–53), was a *globe-maker* at the Sign of the Atlas on Parnassus Hill, near St Michael's, Cornhill, making celestial and terrestrial globes of 14 in. and 15 in. diameter, as appears from his advertisements in Booker's and Wharton's Almanacks for 1653. The name of Joseph Moxon (228) is here associated as partner with that of Sugar, and as this is the first mention of Moxon, and the last of Sugar, the latter may have been at the end of his career. John Pell (173) writing in 1645 from Amsterdam to John Leake, a London stationer, said he had spoken to 'Mr Sugar' about some papers sent to London, which suggests that Sugar (like Moxon) had business in Holland.

255. ATKINSON, JOHN (ob. 1673), was a *compass-maker* at Harwich, Essex, who is known only by his will.

256. COULTON, JOHN (fl. 1653–4), was a *mathematical practitioner* living at Cobham, Surrey, whose Almanack was printed by R. & W. Leybourne.

257. OSBORNE (or OSBURN), HENRY (fl. 1653–86), a gentleman living in the Strand and later in Ireland, was praised by William Molyneux of Dublin as an excellent *mathematician* and astronomer. He was the correspondent of the young astronomer Jeremy Shakerley (233) who wrote to say that he had observed the solar eclipse of 1652 in Surat, and of Robert Hooke (270) who supplied him with instruments including a quadrant fitted with telescopic sights, a telescope and a micrometer, which were sent out to him in Drogheda. Edmund Halley (401) later recorded Osborne's observations of a solar eclipse in Ireland in his edition of Streete's *Astronomia Carolina* (*269*).

258. PIGOT, FRANCIS (fl. 1653–66), a *mathematical practitioner* who published an Almanack during the period 1654–62 which was 'rectified' for the meridian of Ludlow, himself lived at Cleobury Mortimer in Shropshire. Here he was ready to instruct any 'heroic spirit or generous gentleman' in the use of all sorts of mathematical and surveying instruments, the use of the globes, and so on.

259. SUTTON, WILLIAM (fl. 1653–63), was presumably the brother or near kinsman of Henry Sutton (188) since their names appear jointly in advertisements over a period of years. 'All manner of Mathematical Instruments either for Sea or Land are exactly made in Brass or Wood by

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BIOGRAPHIES

Henry Sutton or by William Sutton'. The latter had premises 'a little beyond the Church' in Upper Shadwell, which is down the Thames below Wapping. No examples of his work are known to have survived.

260. WREN, CHRISTOPHER (1632–1723), was from boyhood fertile in designing and making *mathematical instruments*, including a rain-gauge (1662), the moon globe ordered by Charles II, a new type of level (1667), an instrument for calculating the times of eclipses, an 'instrument for perspective' which Pepys saw when he visited Oldenburg (Secretary of the Royal Society) in May 1669, and many others, while several of his fine sundials survive. John Aubrey says that as a boy he was grounded in arithmetic and geometry by his sister's husband, the Rev. William Holder, while when he went to Oxford he was closely associated with Dr John Wilkins (181), and in London with Robert Hooke (270) who said of him 'Since the time of Archimedes there scarce ever met in one Man in so great a Perfection, such a mechanical Hand and so philosophical a Mind'. Yet designing instruments was only incidental to Wren's main occupations as successively Gresham and Savilian Professor, Surveyor-General after the Fire of London, and architect of the rebuilding. He was knighted in 1673. Work: *277*.

261. BRADFORD, JOHN (fl. 1654), is known by a mention of him as a *mathematical instrument-maker* in Foster's *Elliptical Horologiography*, published in 1654 by John Twysden (162).

262. COLEY, HENRY (1633–1707), was born at Oxford and, starting as a young clerk, came to London in 1654 to become amanuensis and later successor to the noted astrologer William Lilly. He practised as an astrologer throughout his life and taught this subject as well as the whole range of practical mathematical subjects, besides establishing his own *mathematical school* at a house 'over against the Old Hole in the Wall, Baldwin's Court, Baldwin's Gardens', a Court which ran out of Gray's Inn Lane. Here he taught for over thirty years. Prior to 1663 he had lived in Rose and Crown Court, Gray's Inn Lane. Coley advertised himself widely, in his own almanacks and elsewhere, and had a large circle of friends, including Elias Ashmole and John Kendal (393) of Colchester, both devoted to the mathematical arts. Several of his note-books survive and indicate the wide range of his reading, and his method of work. Work: *441*.

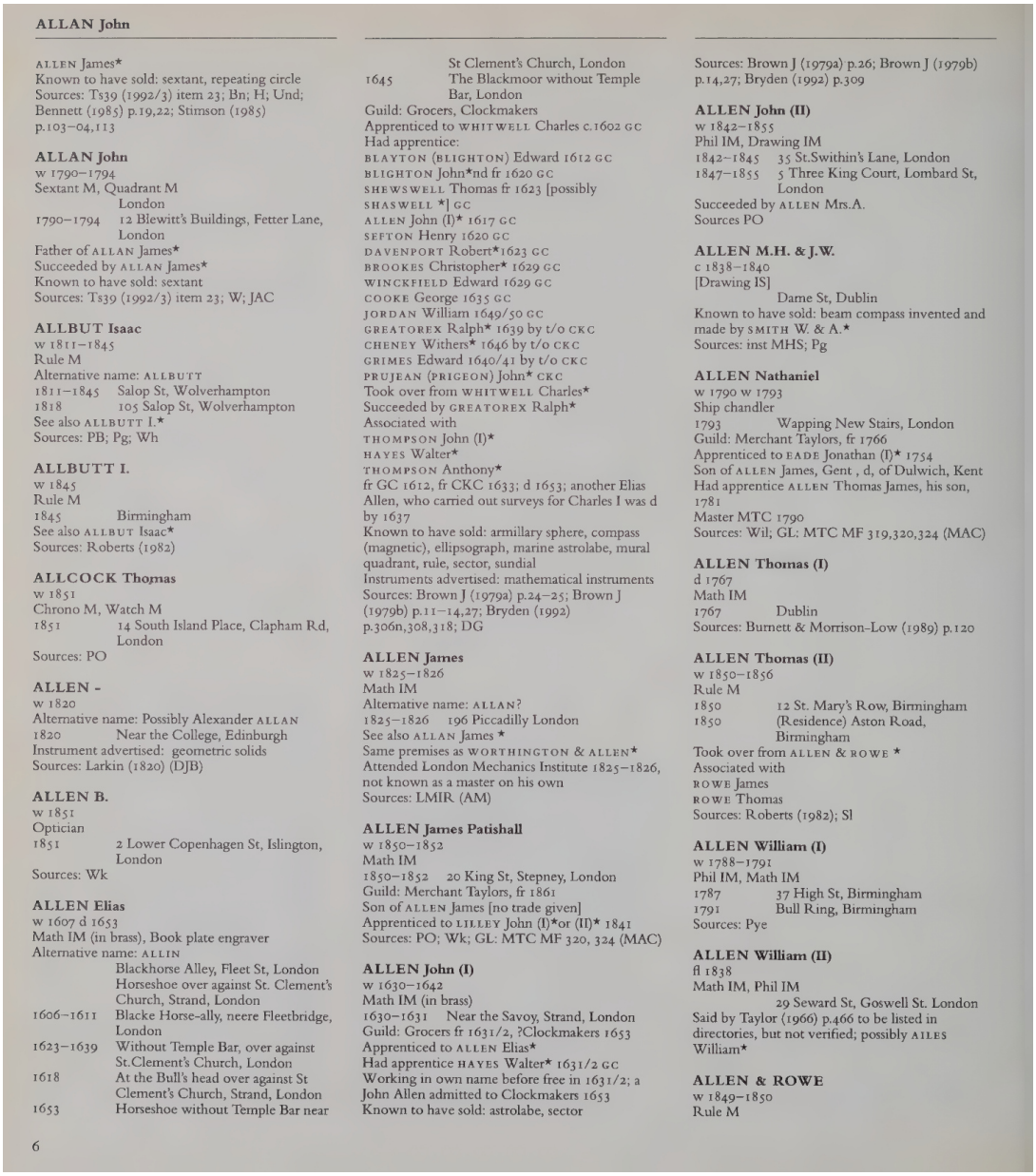
263. EYRE, JOHN (fl. 1654), who describes himself as a '*practitioner in the mathematics*' wrote a text-book on surveying, and presumably practised and taught the art. He was associated with Walter Hayes (251) as instrument-maker. Work: *216*.

264. SINCLAIR, GEORGE (fl. 1654, ob. 1696), was at first (1654) a schoolmaster at St Andrews, and took part in some experiments on the diving-bell (1655). An M.A. of Glasgow was conferred upon him (1654) and he was appointed to a Chair of Philosophy there which he held until 1666. Returning then to Edinburgh to teach mathematics, he determined

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FIGURE D4. MATHEMATICAL PRACTITIONERS IN ENGLAND (TAYLOR, 1954, PP. 240–241)

Notes: Excerpt from Taylor (1954), showing biographical entries of mathematical practitioners. Entry 260 is Christopher Wren, whom Taylor (1954) describes as "fertile in designing and making mathematical instruments" and Clifton (1995) does not list as a maker. [Return to pages 15, 16]



ALLAN John

ALLEN James*
Known to have sold: sextant, repeating circle
Sources: Ts39 (1992/3) item 23; Bn; H; Und; Bennett (1985) p.19,22; Stimson (1985) p.103–04,113

ALLAN John
w 1790–1794
Sextant M, Quadrant M
London
1790–1794 12 Blewitt's Buildings, Fetter Lane, London
Father of ALLAN James*
Succeeded by ALLAN James*
Known to have sold: sextant
Sources: Ts39 (1992/3) item 23; W; JAC

ALLBUT Isaac
w 1811–1845
Rule M
Alternative name: ALLBUTT
1811–1845 Salop St, Wolverhampton
1818 105 Salop St, Wolverhampton
See also ALLBUTT I.*
Sources: PB; Pg; Wh

ALLBUTT I.
w 1845
Rule M
1845 Birmingham
See also ALLBUT Isaac*
Sources: Roberts (1982)

ALLCOCK Thomas
w 1851
Chrono M, Watch M
1851 14 South Island Place, Clapham Rd, London
Sources: PO

ALLEN -
w 1820
Alternative name: Possibly Alexander ALLAN
1820 Near the College, Edinburgh
Instrument advertised: geometric solids
Sources: Larkin (1820) (DJB)

ALLEN B.
w 1851
Optician
1851 2 Lower Copenhagen St, Islington, London
Sources: Wk

ALLEN Elias
w 1607 d 1653
Math IM (in brass), Book plate engraver
Alternative name: ALLIN
Blackhorse Alley, Fleet St, London
Horseshoe over against St. Clement's Church, Strand, London
1606–1611 Blacke Horse-ally, neere Fleetbridge, London
1623–1639 Without Temple Bar, over against St.Clement's Church, London
1618 At the Bull's head over against St Clement's Church, Strand, London
1653 Horseshoe without Temple Bar near St Clement's Church, London
1645 The Blackmoor without Temple Bar, London
Guild: Grocers, Clockmakers
Apprenticed to WHITWELL Charles c.1602 GC
Had apprentice:
BLAYTON (BLIGHTON) Edward 1612 GC
BLIGHTON John*nd fr 1620 GC
SHEWSWELL Thomas fr 1623 [possibly SHASWELL *] GC
ALLEN John (I)* 1617 GC
SEFTON Henry 1620 GC
DAVENPORT Robert*1623 GC
BROOKES Christopher* 1629 GC
WINCKFIELD Edward 1629 GC
COOKE George 1635 GC
JORDAN William 1649/50 GC
GREATOREX Ralph* 1639 by t/o CKC
CHENEY Withers* 1646 by t/o CKC
GRIMES Edward 1640/41 by t/o CKC
PRUJEAN (PRIGEON) John* CKC
Took over from WHITWELL Charles*
Succeeded by GREATOREX Ralph*
Associated with
THOMPSON John (I)*
HAYES Walter*
THOMPSON Anthony*
fr GC 1612, fr CKC 1633; d 1653; another Elias Allen, who carried out surveys for Charles I was d by 1637
Known to have sold: armillary sphere, compass (magnetic), ellipsograph, marine astrolabe, mural quadrant, rule, sector, sundial
Instruments advertised: mathematical instruments
Sources: Brown J (1979a) p.24–25; Brown J (1979b) p.11–14,27; Bryden (1992) p.306n,308,318; DG

ALLEN James
w 1825–1826
Math IM
Alternative name: ALLAN?
1825–1826 196 Piccadilly London
See also ALLAN James *
Same premises as WORTHINGTON & ALLEN*
Attended London Mechanics Institute 1825–1826, not known as a master on his own
Sources: LMIR (AM)

ALLEN James Patishall
w 1850–1852
Math IM
1850–1852 20 King St, Stepney, London
Guild: Merchant Taylors, fr 1861
Son of ALLEN James [no trade given]
Apprenticed to LILLEY John (I)*or (II)* 1841
Sources: PO; Wk; GL: MTC MF 320, 324 (MAC)

ALLEN John (I)
w 1630–1642
Math IM (in brass)
1630–1631 Near the Savoy, Strand, London
Guild: Grocers fr 1631/2, ?Clockmakers 1653
Apprenticed to ALLEN Elias*
Had apprentice HAYES Walter* 1631/2 GC
Working in own name before free in 1631/2; a John Allen admitted to Clockmakers 1653
Known to have sold: astrolabe, sector
Sources: Brown J (1979a) p.26; Brown J (1979b) p.14,27; Bryden (1992) p.309

ALLEN John (II)
w 1842–1855
Phil IM, Drawing IM
1842–1845 35 St.Swithin's Lane, London
1847–1855 5 Three King Court, Lombard St, London
Succeeded by ALLEN Mrs.A.
Sources PO

ALLEN M.H. & J.W.
c 1838–1840
[Drawing IS]
Dame St, Dublin
Known to have sold: beam compass invented and made by SMITH W. & A.*
Sources: inst MHS; Pg

ALLEN Nathaniel
w 1790 w 1793
Ship chandler
1793 Wapping New Stairs, London
Guild: Merchant Taylors, fr 1766
Apprenticed to EADE Jonathan (I)* 1754
Son of ALLEN James, Gent , d, of Dulwich, Kent
Had apprentice ALLEN Thomas James, his son, 1781
Master MTC 1790
Sources: Wil; GL: MTC MF 319,320,324 (MAC)

ALLEN Thomas (I)
d 1767
Math IM
1767 Dublin
Sources: Burnett & Morrison-Low (1989) p.120

ALLEN Thomas (II)
w 1850–1856
Rule M
1850 12 St. Mary's Row, Birmingham
1850 (Residence) Aston Road, Birmingham
Took over from ALLEN & ROWE *
Associated with
ROWE James
ROWE Thomas
Sources: Roberts (1982); Sl

ALLEN William (I)
w 1788–1791
Phil IM, Math IM
1787 37 High St, Birmingham
1791 Bull Ring, Birmingham
Sources: Pye

ALLEN William (II)
fl 1838
Math IM, Phil IM
29 Seward St, Goswell St. London
Said by Taylor (1966) p.466 to be listed in directories, but not verified; possibly AILES William*

ALLEN & ROWE
w 1849–1850
Rule M

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Figure D5. Scientific instrument makers in the British Isles (Clifton, 1995, p. 6)

Notes: Excerpt from Clifton (1995), showing entries on scientific instrument makers in the British Isles, among them Elias Allen (c. 1588–1653) at "Blacke Horse-ally, neere Fleetbridge, London" from 1606 to 1611. [Return to page 16]

D.10. Primary and Secondary Sources for Main Variables

The works by Lillywhite (1963, 1972) draw on a wide range of primary sources. For 1652 to 1672, these mainly include catalogs of tokens issued by London coffeehouses (Appendix Figure D6). For the period between 1660 and 1669, another key source is the diary of Samuel Pepys. More broadly, Lillywhite also relies extensively on contemporary advertisements (see Appendix Figure D7 for a prominent example) and on a wide range of archival materials on London history held in the Guildhall Library in London. Appendix Table D6 more systematically groups the 617 sources cited for the 286 coffeehouses of our London panel by type of source and reports how many coffeehouses each type documents.

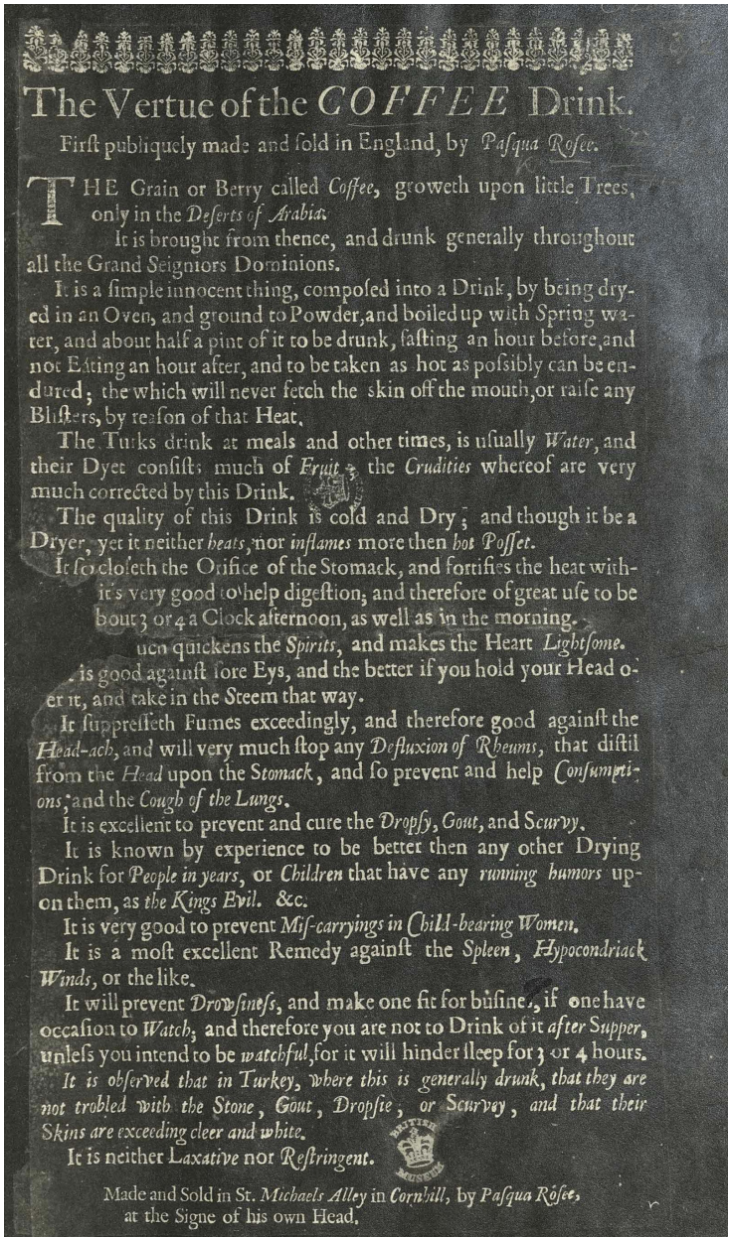
Taylor (1954) is based on a broad set of primary and secondary sources, detailed in Appendix Figure D8. The 628 works on applied mathematics from about 1400 to 1715 are not listed here, as they are already cataloged in her study.

The underlying bibliography for the data on scientific instrument shops and makers in Hay et al. (2025) is available at https://toolsofknowledge.org/sources/. It covers 441 primary and secondary sources, with Clifton (1995) and its cited bibliographies serving as key references. Examples include trade cards, such as Appendix Figure D9, and signed instruments, such as those in Appendix Figure D10. These are often supplemented by later identification in guild records, since most scientific instrument makers belonged to a guild, although none was dedicated specifically to instrument making (Cormack, 2017, p. 79).



Figure D6. The Turk's Head coffeehouse token, 1669

Notes: Copper alloy trade token issued by Nicholas Strange in 1669 for his coffeehouse in St. Ann's Lane, now part of Gresham Street, Aldersgate Ward, City of London. The obverse bears the inscription "NICH. STRAINGE. AT. YE. COFFEE" surrounding a Turk's head device. The reverse reads "HOVSE.IN.ST.ANNS.LANE.69" and shows a hand pouring coffee into a cup. London Museum, object ID NN18344. [Return to page OA-67]



The Vertue of the *COFFEE* Drink.

First publiquely made and sold in England, by *Pasqua Rosee*.

THE Grain or Berry called *Coffee*, groweth upon little Trees, only in the *Deserts of Arabia*.

It is brought from thence, and drunk generally throughout all the Grand Seignors Dominions.

It is a simple innocent thing, composed into a Drink, by being dryed in an Oven, and ground to Powder, and boiled up with Spring water, and about half a pint of it to be drunk, fasting an hour before, and not Eating an hour after, and to be taken as hot as possibly can be endured; the which will never fetch the skin off the mouth, or raise any Blisters, by reason of that Heat.

The Turks drink at meals and other times, is usually *Water*, and their Dyet consists much of *Fruit*; the *Crudities* whereof are very much corrected by this Drink.

The quality of this Drink is cold and Dry; and though it be a Dryer, yet it neither *heats*, nor *inflames* more then *hot Posset*.

It so closeth the Orifice of the Stomack, and fortifies the heat within, it's very good to help digestion, and therefore of great use to be taken about 3 or 4 a Clock afternoon, as well as in the morning.

It quickens the *Spirits*, and makes the Heart *Lightsome*.

It is good against sore Eys, and the better if you hold your Head over it, and take in the Steem that way.

It suppresseth Fumes exceedingly, and therefore good against the *Head-ach*, and will very much stop any *Defluxion of Rheums*, that distil from the *Head* upon the *Stomack*, and so prevent and help *Consumptions*, and the *Cough of the Lungs*.

It is excellent to prevent and cure the *Dropsy*, *Gout*, and *Scurvy*.

It is known by experience to be better then any other Drying Drink for *People in years*, or *Children* that have any *running humors* upon them, as *the Kings Evil*. &c.

It is very good to prevent *Mis-carryings in Child-bearing Women*.

It is a most excellent Remedy against the *Spleen*, *Hypocondriack Winds*, or the like.

It will prevent *Drowsinesse*, and make one fit for business, if one have occasion to *Watch*, and therefore you are not to Drink of it *after* Supper, unless you intend to be *watchful*, for it will hinder sleep for 3 or 4 hours.

It is observed that in Turkey, where this is generally drunk, that they are not troubled with the Stone, Gout, Dropsie, or Scurvey, and that their Skins are exceeding cleer and white.

It is neither Laxative nor *Restringent*.

Made and Sold in St. *Michaels Alley* in *Cornhill*, by *Pasqua Rosee*, at the Signe of his own Head.

FIGURE D7. THE VERTUE OF THE COFFEE DRINK, 1652

Notes: This handbill by Rosée (1652), "The Vertue of the COFFEE Drink," is the earliest known advertisement for coffee in England. The final lines identify the coffeehouse as Pasqua Rosée's Coffee House, located in St. Michael's Alley in Cornhill. Reproduced by Williams (1936) from the original held at the British Museum. [Return to page OA-67]

BIBLIOGRAPHY OF SECONDARY WORKS

The Works listed in Part III provide the main source material for the book, and in addition a large number of contemporary works (including annual almanacks) compiled by or referred to by the Mathematical Practitioners have been examined for biographical details. The manuscript material used is mainly that in the British Museum, supplemented by the Ashmolean MSS. in the Bodleian Library, and the Minutes and Letter Books (with a few miscellaneous original Papers) of the Royal Society.

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TAYLOR, E. G. R. *Late Tudor and Early Stuart Geography*, 1935.

TAYLOR, E. G. R. Contributions (since 1928) to the *Geographical Journal*, *Imago Mundi*, *Journal of the Institute of Navigation* and *Mariner's Mirror*.

TURNBULL, H. W. *James Gregory Tercentenary Memorial Volume*, 1939.

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FIGURE D8. PRIMARY AND SECONDARY SOURCES USED BY TAYLOR (1954)

Notes: Selection of primary and secondary sources cited in Taylor (1954). [Return to page OA-68]

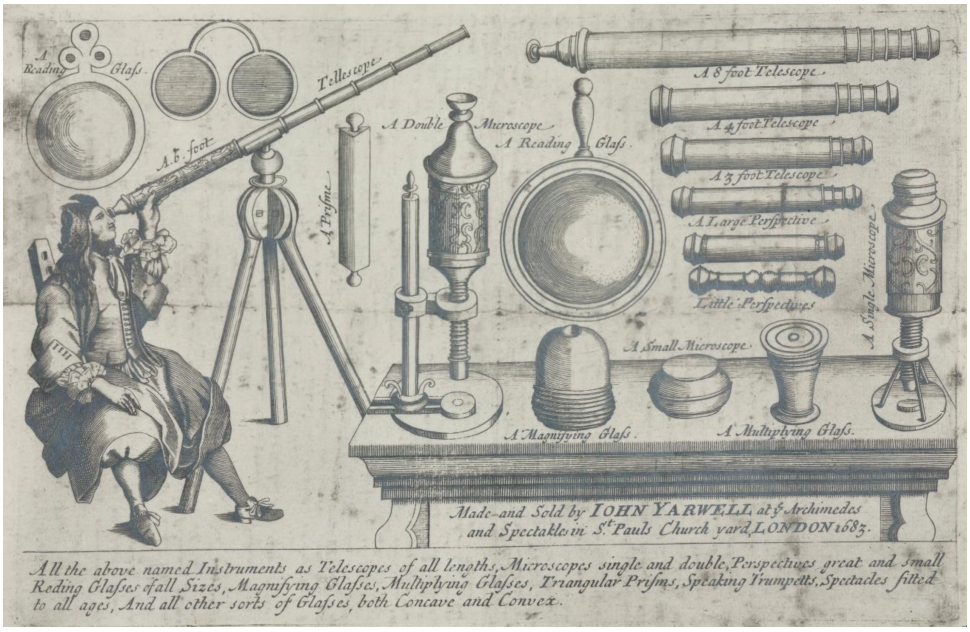


Figure D9. Trade card of John Yarwell, London, 1683

Notes: Trade card of the optical instrument maker John Yarwell, St. Paul's Churchyard, London, 1683. Science Museum Group Collection, object no. 1951-687/45. [Return to page OA-68]

(A) Gunter sector, 1623



(B) Compendium, 1630–1653



(C) Compound microscope, c. 1665



(D) Portable barometer, 1695–1705



Figure D10. Practical and experimental scientific instruments

Notes: Panels A and B show practical instruments and Panels C and D experimental ones, the two groups defined in Appendix D.3. Panel A: brass Gunter sector signed "Elias Allen fecit 1623," London, Science Museum Group Collection, object no. 1976-638. Panel B: compendium of sundial, compass, and calendar indices inscribed "Elias Allen fecit," London, 1630–1653, Science Museum Group Collection, object no. 1883-135. Panel C: compound microscope of Robert Hooke's design made by Christopher Cock, London, Billings Microscope Collection, National Museum of Health and Medicine, no. M-030.00276. Panel D: portable barometer by Daniel Quare, Exchange Alley, London, 1695–1705, Science Museum Group Collection, object no. 1948-227. [Return to page OA-68]

D.11. Data Validation

Coffeehouses. First, we assess the completeness of the coffeehouse dataset by benchmarking it against counts from the City of London Magistrates (1663) survey and the 1692–1698 poll tax returns reported by Cowan (2005). Both count coffeehouses in wards of the City of London only, so we compare them with the records in the same wards. The 1663 survey lists 82 coffeehouses in 20 wards, where Lillywhite (1963, 1972) records 24 in 1663.[67] The 1692–1698 poll tax lists 90 coffeehouses in 13 of 26 wards for which data are available, while 1701 administrative records note 34 more in 7 of the 13 previously missing wards, giving about 124 coffeehouses in 20 wards, where Lillywhite (1963, 1972) records 75 over 1692–1698, three-fifths of the count. This pattern suggests that Lillywhite (1963, 1972) covers late seventeenth-century coffeehouses more comprehensively than those from mid-century, likely reflecting the loss of records associated with the 1666 Great Fire. Observation delays also contribute. "Henry Willington" in "Dowgate" is listed in the 1663 survey, with "H. Wellington" in "Dowgate" first noted in a 1665 token by Lillywhite (1963, 1972). Similarly, Lillywhite (1963, 1972) may have ceased observing a coffeehouse before 1663. To facilitate a broader 1663 comparison, we consider a margin of error: allowing a margin of ±1 year around 1663 results in 28 coffeehouses recorded by Lillywhite (1963, 1972) in the survey's wards, ±2 years in 31, and ±3 years in 43, between a third and a half of the survey's count.[68]

Second, Mackie (2013) attempts to extend Lillywhite (1963) using modern searchable databases, including Electronic Enlightenment, Old Bailey Online, and British Periodicals.[69] This effort yields only a small number of additional and often ambiguous cases. We conduct a parallel search using two Gale resources, the *Seventeenth and Eighteenth Century Nichols Newspapers Collection* and the *Seventeenth and Eighteenth Century Burney Newspapers Collection*, focusing on mentions of "coffee" and its variants. These sources reference coffeehouses less frequently than would be expected based on Lillywhite (1963, 1972). Furthermore, when "coffee" turns up beside a place that Lillywhite does not list, it is often unclear whether the venue was a coffeehouse, a tavern, or an inn. Moreover, claims that thousands of coffeehouses operated in London by the late seventeenth or early eighteenth century (e.g., Iliffe, 1995) rest mostly on secondary sources, not on primary documents. In fact, the first systematic count dates from 1739, when William Maitland recorded 551 coffeehouses for his *History of London*, a count that took him eleven months (Ellis, 2006b, pp. xxix–xxx).

Third, Appendix Figure D11 plots the number of coffeehouses in seventeenth-century London in the dataset. The series exhibits discrete shifts that align with major historical events. The first coffeehouse is recorded in 1652. The count then jumps from 12 in 1659 to 27 in 1660, the year of the Stuart Restoration. The Great Fire destroyed nearly all of London within the walls in 1666. Yet that year the recorded count rises from 35 to 51, and in 1667 it falls back to 45. Of the 19 coffeehouses first recorded in 1666, at least six are on trade tokens dated that year, and seven are recorded in that year only. That is, the spike seems to reflect when coffeehouses were documented, not when they opened

[67] Lillywhite (1963, 1972) does not mention City of London Magistrates (1663), likely because the survey lists coffeehouses only by owner and ward, without names or specific addresses.

[68] The sharp increase under the ±3 margin comes from 1666, when the number of recorded coffeehouses spikes because many are documented that year, often on dated trade tokens, rather than because they opened (Appendix Figure D11).

[69] Mackie (2013) does not draw on Lillywhite (1972).

or closed. The number of new coffeehouses increases sharply following the Rebuilding Acts of 1666 and 1670, and the upward trend persists through the end of the century.

Fourth, Appendix Figure D12 plots the frequency of coffeehouse-related terms in the British English corpus from the Google Books Ngram Viewer. Because most coffeehouses in the British Isles were located in London (Cowan, 2005), movements in the corpus likely reflect developments in London. The close alignment between the two series suggests that Lillywhite (1963, 1972) provides a reasonably representative account of the historically observed universe of coffeehouses. Mentions in the early seventeenth century, prior to the first London coffeehouse opening in 1652, likely reflect the emergence of discourse about coffee and coffeehouses rather than physical establishments (Smith, 2001).

Mathematical Practitioners. To our knowledge, no independent source exists to cross-verify the set of so-called mathematical practitioners compiled by Taylor (1954). A simple internal validity exercise nonetheless lends credibility to the dataset. Appendix Figure D13 reports, by decade, the number of connections held by the most connected practitioner. The names that come up are the ones that accounts of seventeenth-century London science would lead us to expect. Before the prominence of the polymath Robert Hooke, known for his frequent coffeehouse visits and his sociable way with other scientists, the leading instrument maker Elias Allen ranks among the most connected practitioners decade after decade. Allen had an extensive clientele, including Kings James I and Charles I, and maintained ties with prominent mathematicians such as Edmund Gunter (1581–1626) and William Oughtred (1574–1660), inventor of the slide rule and the multiplication sign. Alongside these practitioners appears William Leybourne (1626–1716), an active mathematician, land surveyor, author, printer, and bookseller.

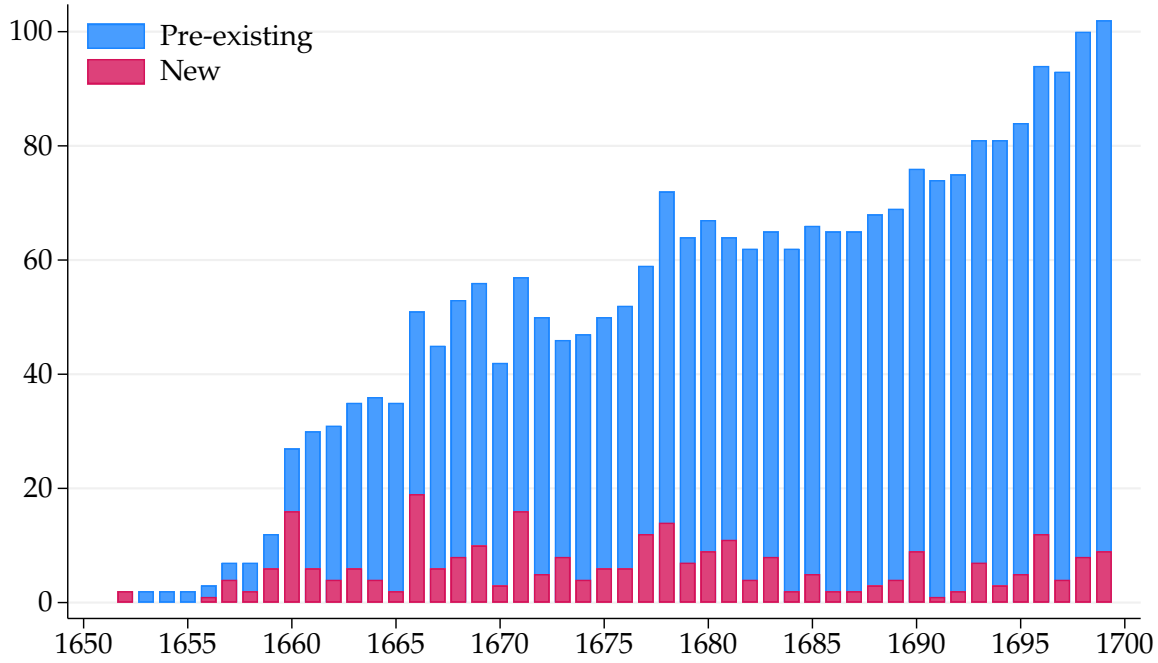


Figure D11. Coffeehouses in London over time

Notes: Figure plots the annual number of coffeehouses in London from 1652, when the first opened, to 1699, distinguishing between those already established and those newly opened. Data from Lillywhite (1963, 1972). [Return to page OA-72]

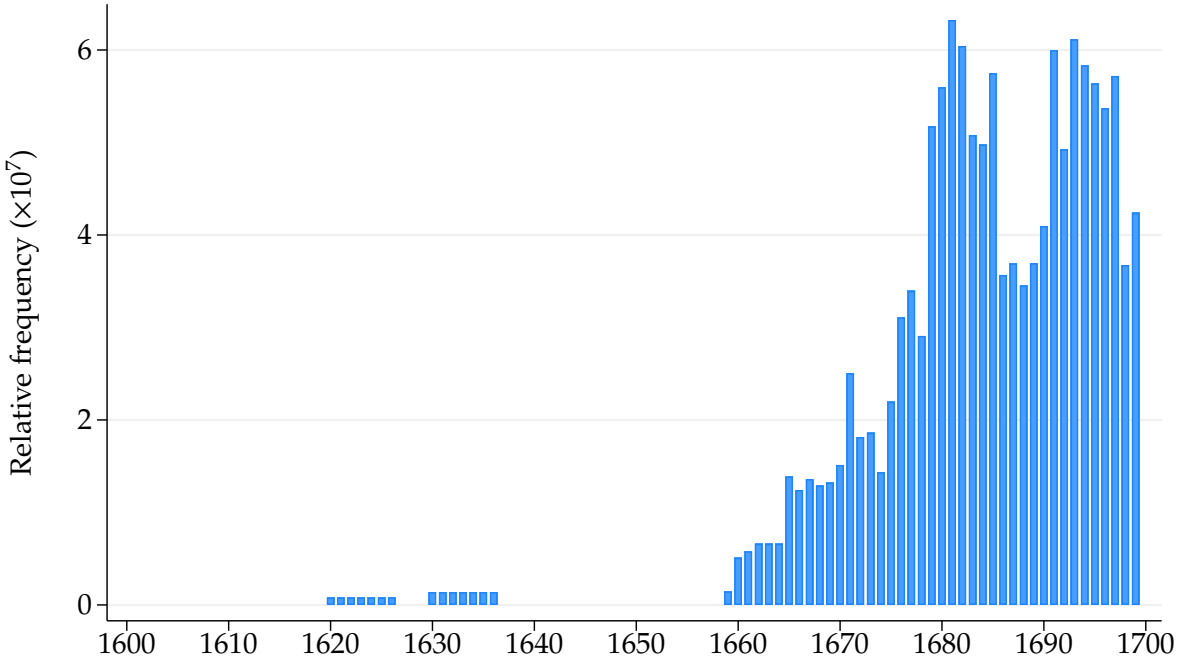


Figure D12. Frequency of n-grams containing coffeehouse terms over time

Notes: Figure plots the annual relative case-insensitive frequency of n-grams containing the terms "coffee house" and "coffeehouse" from 1600 to 1699. Data from Google Books Ngram Viewer, British English corpus, accessed November 5, 2025. [Return to page OA-73]

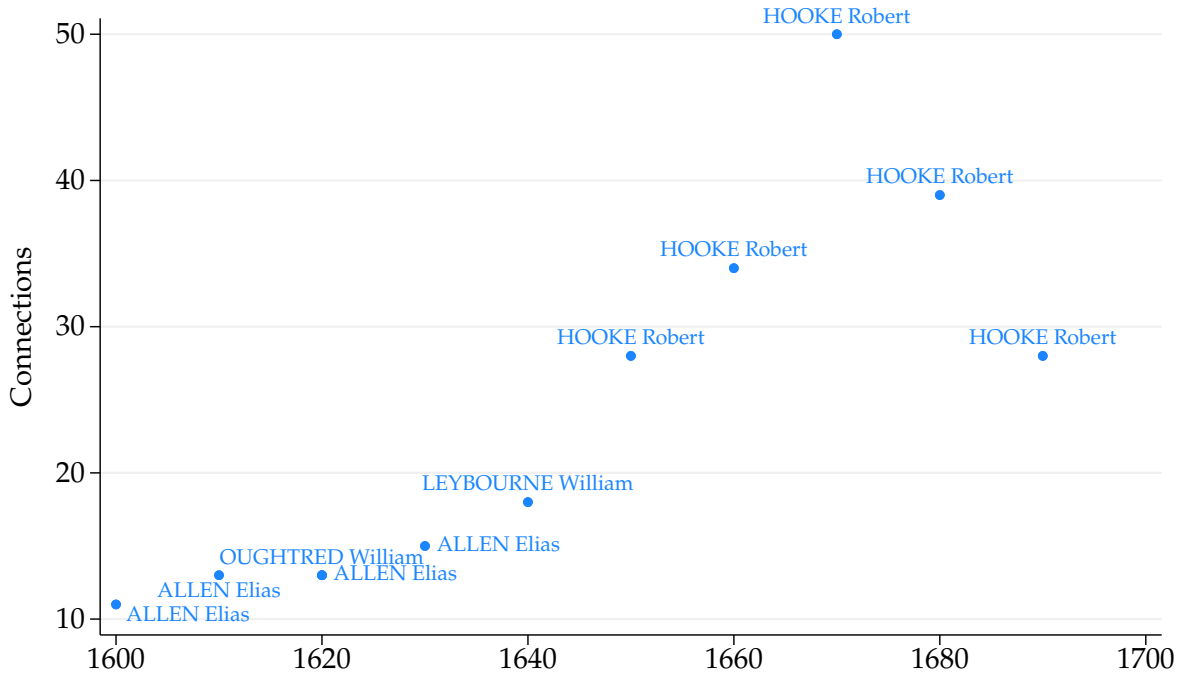


Figure D13. Most connected mathematical practitioner over time

Notes: Figure shows, for each decade, the number of connections of the most connected mathematical practitioner. In the 1620s, William Oughtred and Elias Allen are tied with 13 connections each. [Return to pages 17, OA-73]

D.12. Geocoding

D.12.1 Procedure

Each historical address is assigned a geographic coordinate through a two-step, manually performed process aided by digital tools:

1. The address is located on a historical map of London.
    - Digitized historical maps of London are available on the Grub Street Project website (https://www.grubstreetproject.net/). Several of these maps support searchable places. See Figure D14.[70]
    - If the address cannot be found on a historical map of London, we use contextual information from the source or additional resources (e.g., Wikipedia, historical gazetteers, historical works on London) to identify either a nearby address that can be located on a historical map of London or, failing that, the smallest containing geography that can be so located, typically the street.
2. The geographic coordinate of the location identified in Step 1 is estimated by visually overlaying the historical map onto a contemporary Google map of London, aligning key geographic features (e.g., rivers, streets, and churches) that survive in both. Note that the earliest topographic survey of London precise enough

[70] A digital gazetteer of locations from the Woodcut Map of London (early 1560s) has been created on the Map of Early Modern London website (https://mapoflondon.uvic.ca/index.htm), which was occasionally used for hard-to-geocode addresses.

to be georeferenced comprehensively against modern maps is John Rocque's map of 1746. Hence, for the seventeenth century, we align single features whose present-day position we know independently, and the alignment is bound to be imperfect.[71]

We also use two other sources. Taylor (1954) maps about 100 London workplaces, and we transfer her plotted points to coordinates with the overlay described in Step 2. For roughly 600 addresses, the *Early Modern Letters Online* project (Hotson and Lewis, 2024) already supplies coordinates directly. All coordinates are manually verified.

D.12.2 Worked Examples

Below we geocode four historical addresses, ordered from the most to the least straightforward, to demonstrate the procedure.

Direct match, no modern name. Geocode "Jewen St," recorded as the address of a scientific instrument maker active in 1671.

1. Strype's 1720 survey and accompanying map, reproduced in Figure D14, record Jewen (Jewin) Street running east from Aldersgate Street to Redcross Street, immediately north of the churchyard of St. Giles-without-Cripplegate.[72]

2. Unlike the cases below, the street has no modern counterpart that can be matched by name: Jewin Street and the neighboring Redcross Street were demolished in the twentieth century for the construction of the Barbican Estate.[73] The coordinate is therefore obtained by overlaying the historical map onto a contemporary Google map and aligning two features whose present-day position is known, the church of St. Giles-without-Cripplegate and the line of Aldersgate Street. The midpoint of the street yields the coordinate (51.51955, −0.09577).

Direct match, surviving name. Geocode "St. Katharine's Stairs."[74]

1. The Grub Street Project provides points on digitized maps of London from 1553 to 1736 indicating the location of "St. Katherine's Stairs."[75]

2. The 1736 map shows that the location lies just southeast of the Tower of London, next to the Thames. Because the name survives, the corresponding modern location is identified directly on Google Maps as "St. Katharine Docks," and the overlay of Step 2 serves only to confirm the match against the Tower and the river frontage. This yields the coordinate (51.50640, −0.07187).

[71] Cf. *Locating London's Past: Recreating Rocque, London 1746*, available at https://locatinglondonspast.wordpress.com/2011/06/22/recreating-rocque-london-1746, accessed September 5, 2025.

[72] Strype describes the yard of the Castle Inn on Aldersgate Street as having "a passage into Jewen street" (Strype, 1720). See *The Grub Street Project :: Places :: Castle and Falcon*, available at https://www.grubstreetproject.net/places/945/, accessed July 27, 2026.

[73] *Jewin Street*, London Picture Archive, The London Archives, available online, accessed July 27, 2026.

[74] Spelling varies across sources between "Katharine" and "Katherine"; we retain each source's form when quoting it.

[75] *The Grub Street Project :: Places :: St. Katherine's Stairs*, available at https://www.grubstreetproject.net/places/4318/, accessed September 4, 2025.

Nearby landmark. Geocode "Pasqua Rosée's Coffee House" in "St. Michael's Alley, Cornhill."

1. The location refers to a medieval alley next to St. Michael's Church in Cornhill.[76] The original church, destroyed in the Great Fire of London (1666), was replaced in 1670 by the present church on the same site.[77]

2. The exact position of the coffeehouse within the alley cannot be recovered, so we substitute the adjacent church, which Google Maps locates directly. This yields the coordinate (51.51325, −0.08556).[78]

Containing street. Geocode "Pilkington Court."

1. The location refers to a court in Little Britain, according to a contemporary obituary register kept by the London book collector and antiquary Richard Smyth.[79]

2. We are unable to identify the exact location of Pilkington Court within Little Britain, and no nearby address is recoverable, so we fall back on the containing street. Little Britain is a sufficiently precise reference, being a short and well-known street in seventeenth-century London, and its Wikipedia entry directly provides the coordinate (51.51699, −0.09780).[80]

[76] *The Grub Street Project :: Places :: St. Michael's Alley*, available at https://www.grubstreetproject.net/places/4421/, accessed August 5, 2025.

[77] *St Michael, Cornhill*, Wikipedia, available at https://en.wikipedia.org/wiki/St_Michael,_Cornhill, accessed August 5, 2025.

[78] *St Michael Cornhill Saint Michael's Alley, London* on Google Maps, available at https://maps.app.goo.gl/9DJKJm9cwTVkz1fN7, accessed August 5, 2025.

[79] Smyth's 1661 entry records "Mr. Franck, a juryman in Pilkington Court in Little Brittain" (Smyth, 1849, p. 53). The register was published posthumously in 1849.

[80] *Little Britain, London*, Wikipedia, available at https://en.wikipedia.org/wiki/Little_Britain,_London, accessed September 5, 2025.



FIGURE D14. LONDON IN 1720 (STRYPE, 1720)

Notes: Digitized 1720 map of London with a geocoded layer of streets, roads, thoroughfares, public markets, bodies of water, and places, from the Grub Street Project at the University of Saskatchewan, based on *A New Plan of the City of London, Westminster, and Southwark* in Strype (1720). [Return to pages OA-75, OA-76]

D.13. Figures

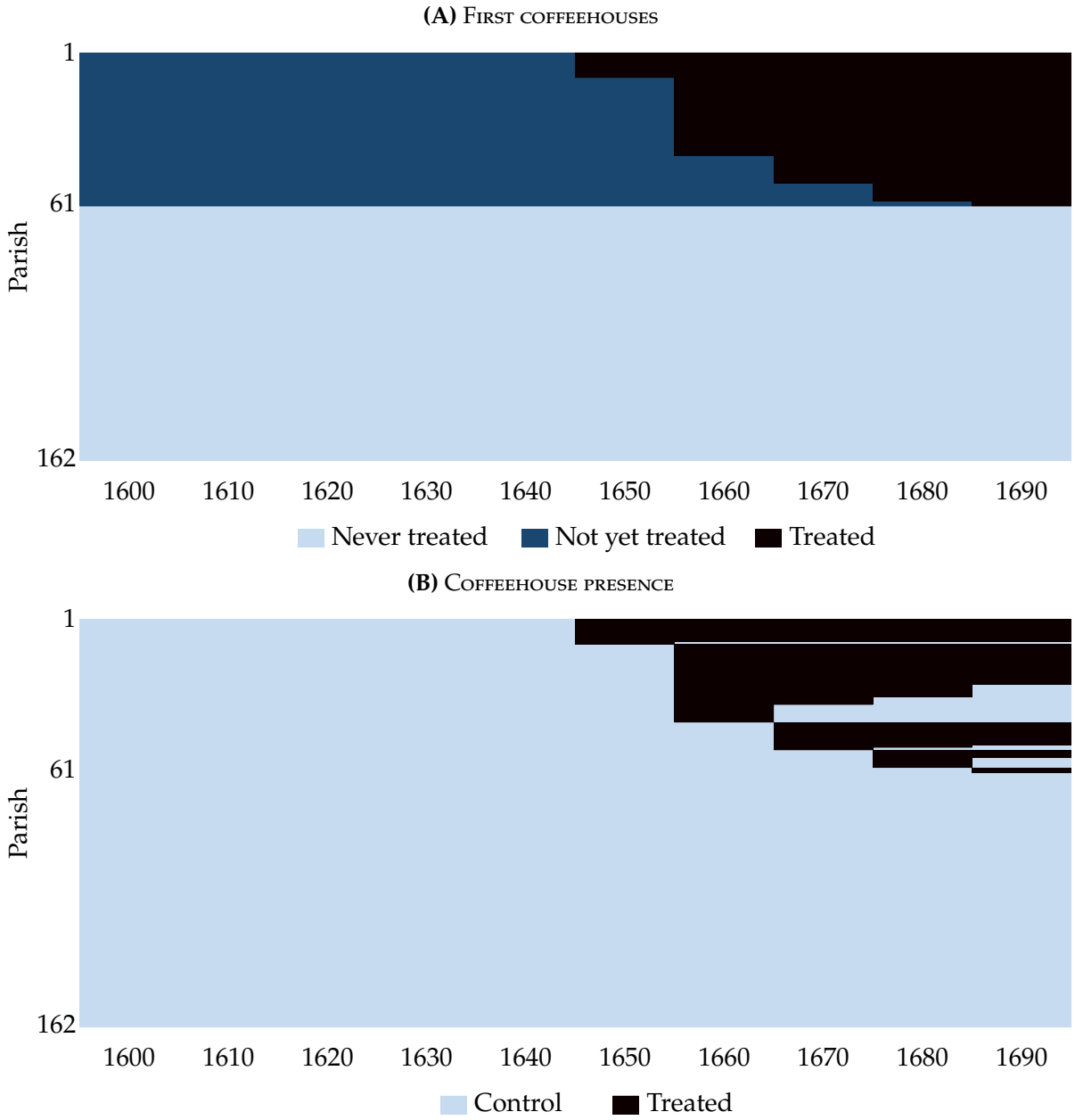


Figure D15. Treatment rollout

Notes: Panel A shows the decades in which the first coffeehouse opened across all 162 parishes, and Panel B the decades in which a coffeehouse is open. Parishes are grouped by decade of first opening and ordered from earliest to latest, followed by those with no coffeehouse openings. [Return to pages 19, OA-25]

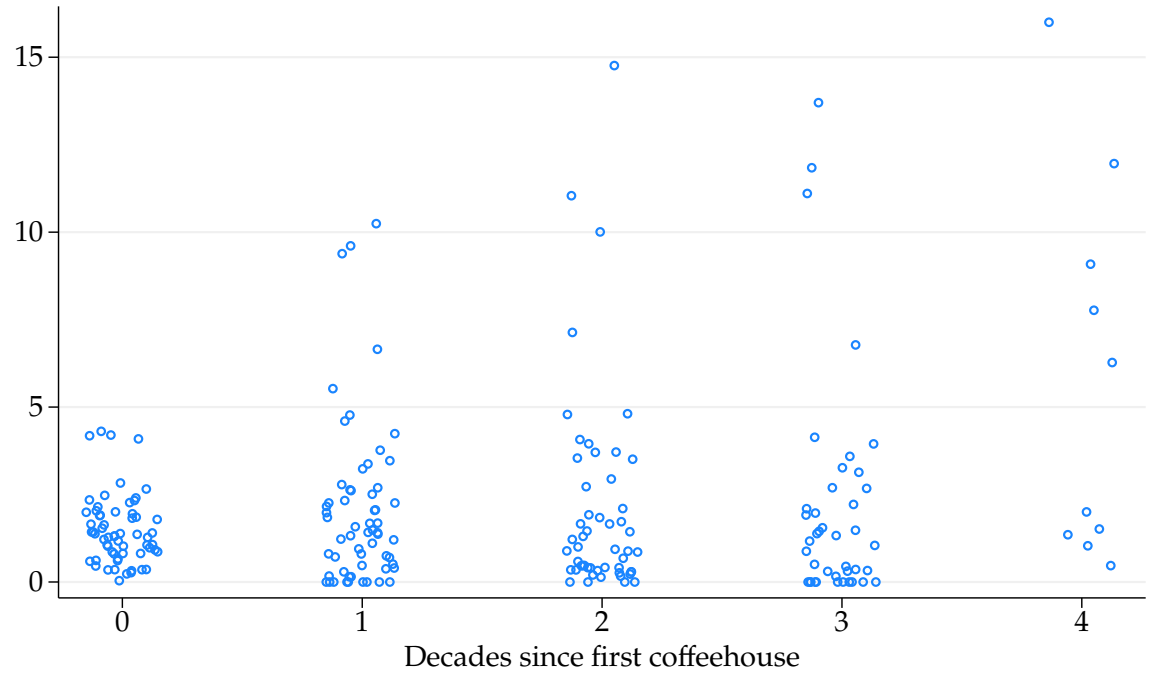


FIGURE D16. COFFEEHOUSES BY DECADES SINCE FIRST OPENING

Notes: Figure shows a jittered strip plot of the number of coffeehouses by decades since the first coffeehouse opened. Sample includes the 61 parishes that ever have a coffeehouse from the 1600s to the 1690s. [Return to page 19]

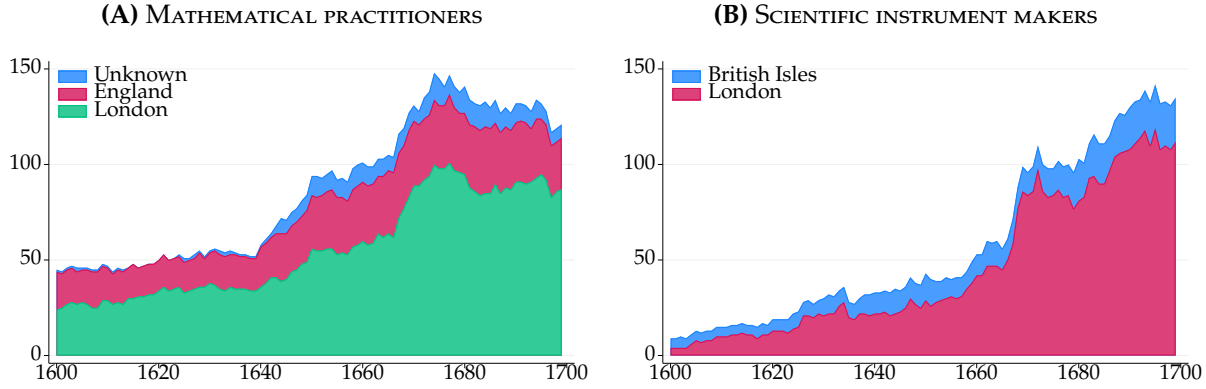


FIGURE D17. SCIENCE IN LONDON RELATIVE TO ENGLAND AND THE BRITISH ISLES OVER TIME

Notes: Panel A plots the annual number of mathematical practitioners in seventeenth-century England, separated by whether they were ever active in London or only outside it. Unknowns were active in England, but their London activity is unknown. Panel B plots the annual number of scientific instrument makers in the seventeenth-century British Isles and London. Data from Clifton (1995); Hay et al. (2025); Taylor (1954). [Return to pages 16, 25, OA-54]

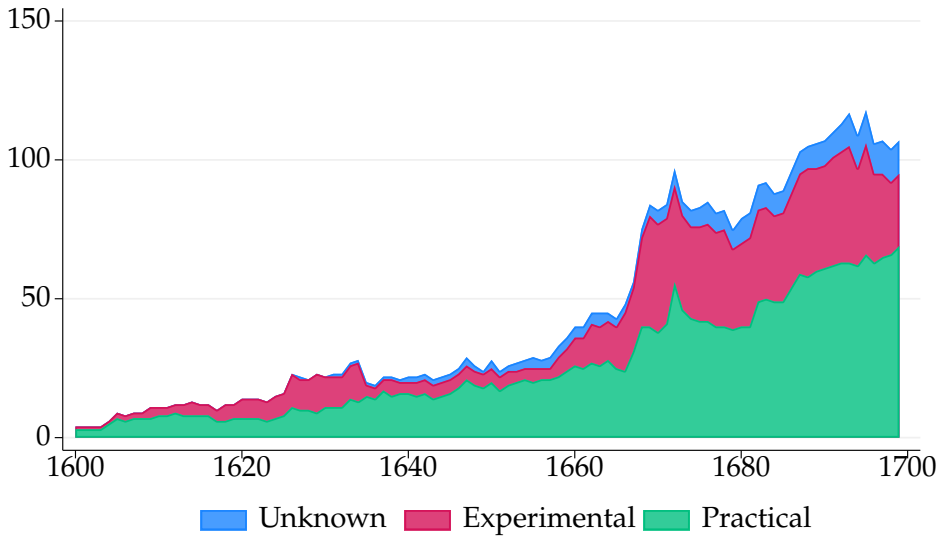


Figure D18. Scientific instrument makers in London over time by type

Notes: Figure plots the annual number of scientific instrument makers in seventeenth-century London by type. Experimental makers produced optical (e.g., telescopes, microscopes) and philosophical (e.g., air pumps, barometers, thermometers) instruments. Practical makers produced mathematical (e.g., dividers, sectors, scales), navigational (e.g., compasses, astrolabes), and surveying (e.g., theodolites, circumferentors) instruments. Data from Clifton (1995); Hay et al. (2025). [Return to page 16]

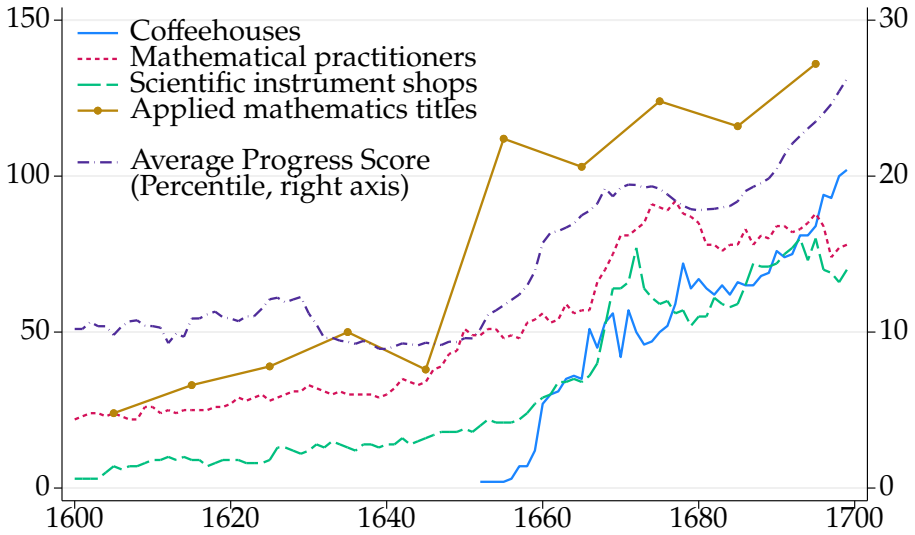


Figure D19. Coffeehouses, science, mathematical titles, and belief in progress

Notes: Figure repeats the three series of Figure 1 and overlays two national series from published work. Applied mathematics titles count the books in English published in each decade, excluding reprints, in the replication files of Kelly and Ó Gráda (2022). These are decade totals, so their level is not comparable to the annual counts plotted beside them. The average progress score follows the construction of Almelhem et al. (2026): the score of each volume on their main progress dictionary is converted to its percentile rank across the 264,433 English-language volumes in their replication data, and the line plots, for each year, the mean percentile among volumes published within ten years of it. Data from Almelhem et al. (2026); Clifton (1995); Hay et al. (2025); Kelly and Ó Gráda (2022); Lillywhite (1963, 1972); Taylor (1954). [Return to page 2]

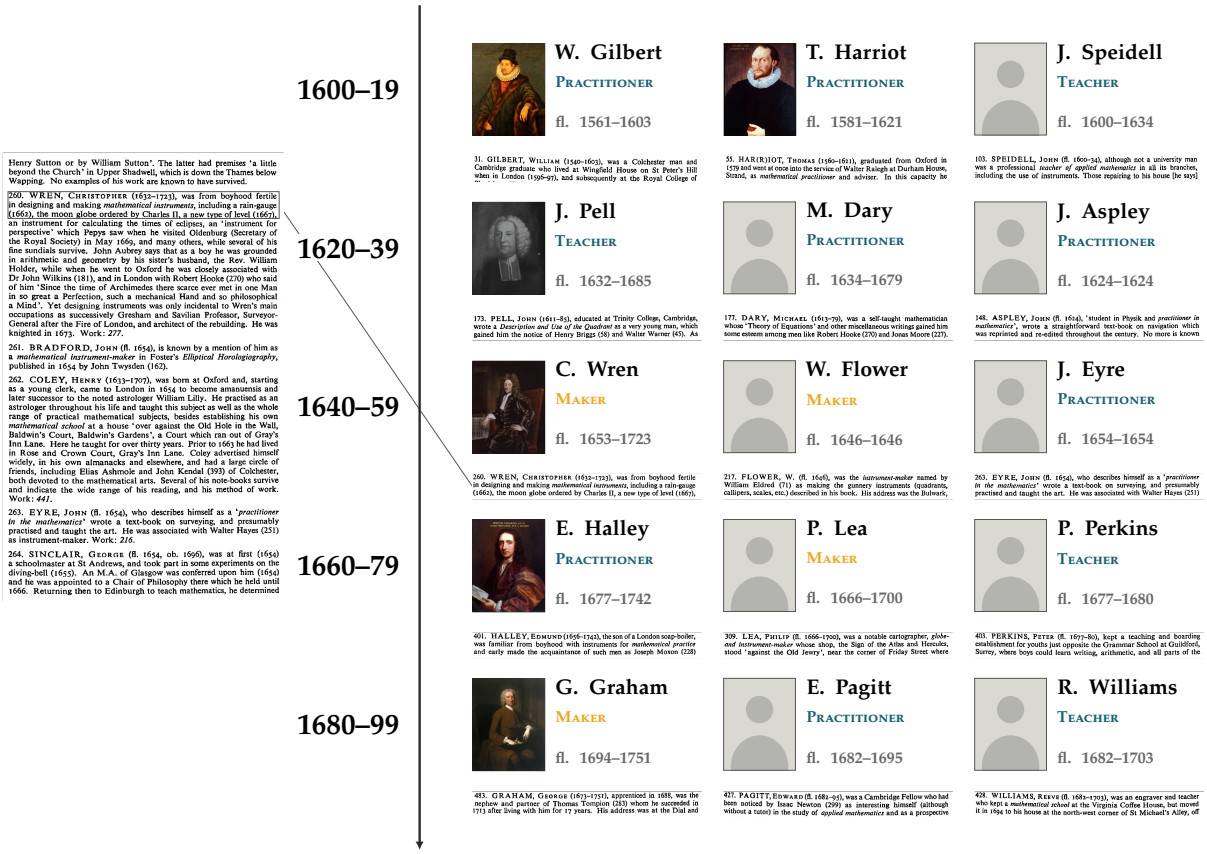
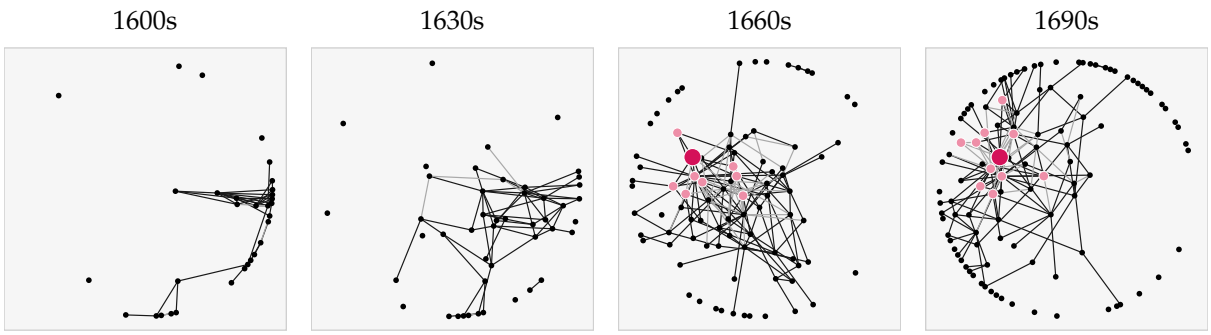


FIGURE D20. EXAMPLES OF MATHEMATICAL PRACTITIONERS (TAYLOR, 1954)

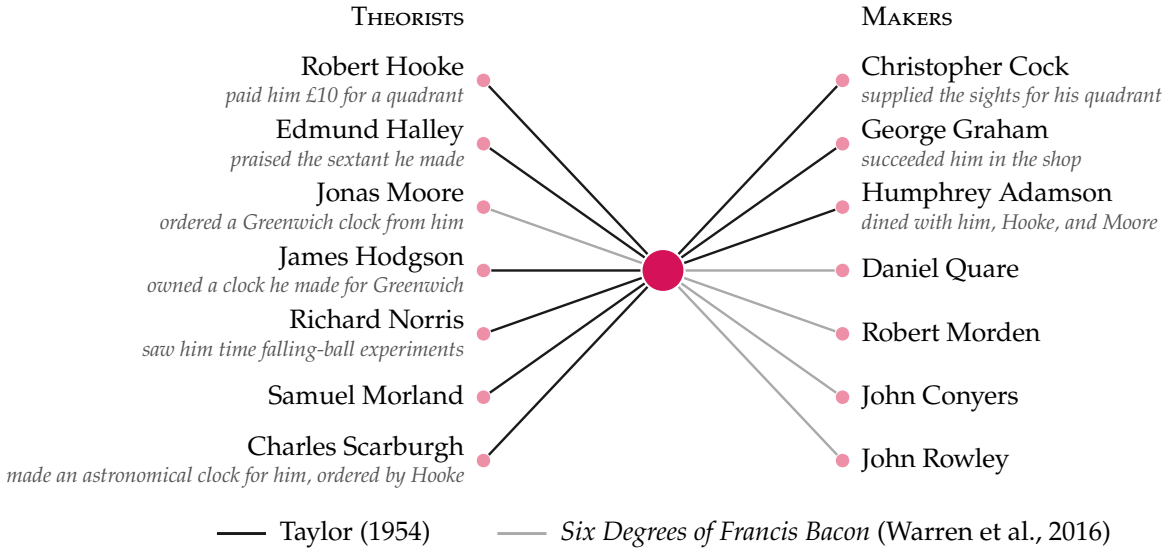
Notes: Figure shows three mathematical practitioners for each twenty-year cohort of first flourishing in the London sample described in Section 3, labeled by the years the cohort spans. Portrait slots go to practitioners matched to an entry in the Oxford Dictionary of National Biography (2025) and use images from Wikipedia; their number rounds the cohort's matched share to thirds, and the remaining slots name a practitioner and show a silhouette. Beneath each practitioner is a facsimile of the opening lines of their entry in Taylor (1954), and Christopher Wren's entry is boxed on the page reproduced at left. Orange marks instrument makers. [Return to page 15]

(A) Connections by decade



Taylor (1954) — *Six Degrees of Francis Bacon* (Warren et al., 2016)

(B) Connections of Thomas Tompion



Taylor (1954) — *Six Degrees of Francis Bacon* (Warren et al., 2016)

Figure D21. Connections among mathematical practitioners

Notes: Panel A draws the mathematical practitioners active in London in four decades and the connections among them (see Section 3), with the clockmaker Thomas Tompion highlighted as the large red node and his connections in each decade in pink. Panel B shows his 14 connections, divided into theorists and makers. Glosses paraphrase passages of Taylor (1954) on nine of the connections. The *Six Degrees of Francis Bacon* database records no such text and gives only the connections. [Return to page 16]

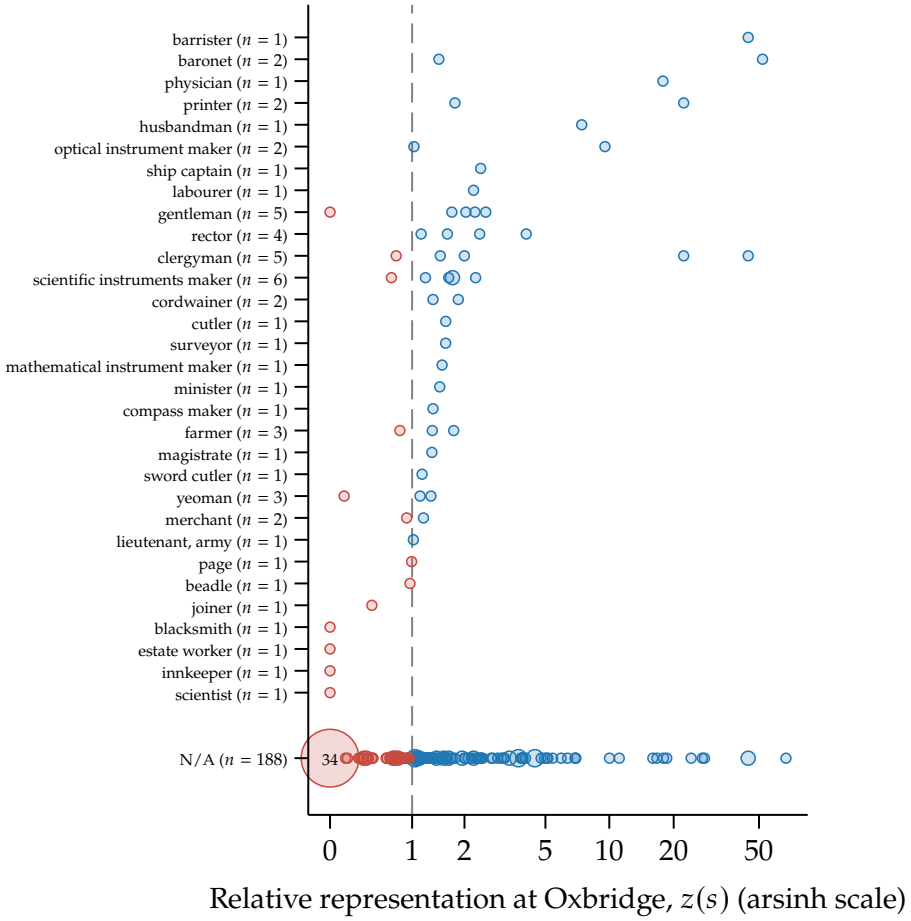


FIGURE D22. RELATIVE OXBRIDGE REPRESENTATION BY FATHER'S OCCUPATION

Notes: Figure plots relative Oxbridge representation by father's occupation for the 244 mathematical practitioners in the London sample described in Section 3. The horizontal axis shows relative surname representation among pre-1650 Oxbridge alumni, $z(s)$, on an inverse hyperbolic sine (arsinh) scale. Each circle is one value of $z(s)$ within a category, with area proportional to the number of practitioners sharing that value, and counts are printed inside circles drawn large enough to hold them. Blue circles have $z(s) > 1$ and red circles $z(s) \leq 1$, with the dashed line at $z(s) = 1$. Numbers in parentheses give the number of practitioners in each category, and the 31 observed occupations are ordered by their median $z(s)$. The bottom row holds the 188 practitioners whose paternal occupation is unobserved, 34 of whom carry a surname that never appears among pre-1650 Oxbridge alumni. The median $z(s)$ in that row is 1.14, against a median of 1.51 across the observed occupation medians. Occupations are coded from fathers' occupational titles using the PST system developed by Wrigley (2010). Data from the authors' dataset. [Return to page 26]

D.14. Tables

Table D6—Coffeehouse source categories

	Any source		Only source	
	Coffeehouses	Per coffeehouse	Coffeehouses	Per coffeehouse
Panel A. Source categories				
Published and private	158	0.55	67	0.23
Printed books, pamphlets, and literary works	47	0.16	9	0.03
Newspapers and periodicals	44	0.15	7	0.02
Secondary histories and reference works	40	0.14	8	0.03
Manuscripts and private papers	36	0.13	13	0.05
Diaries, memoirs, and personal writings	32	0.11	6	0.02
Advertisements, notices, and ephemera	31	0.11	9	0.03
Catalogues, sales, and auctions	8	0.03	2	0.01
Material and visual	98	0.34	44	0.15
Trade tokens	65	0.23	34	0.12
Maps, views, inscriptions, and topographical evidence	36	0.13	10	0.03
Administrative and official	90	0.31	27	0.09
Parish, civic, and local records	44	0.15	13	0.05
Company, commercial, and financial records	34	0.12	7	0.02
State, legal, and court records	33	0.12	6	0.02
Unknown	52	0.18	50	0.17
No source, unidentified, or unclear	52	0.18	50	0.17

Panel B. Summary statistics	Total	Per coffeehouse
Coffeehouses	286	1
Sources	617	2.16
Sources by finer categories	502	1.76
Sources by broader categories	398	1.39

Notes: Panel A reports source-category coverage for distinct coffeehouses. Under Any source, the first column counts the coffeehouses with at least one source in the category, and the second divides that count by the number of distinct coffeehouses. Only source does the same for coffeehouses whose sources all fall in the category. For broad rows, this means no source in another broad category, and for indented rows no source in another finer category. Fine rows need not sum to broad rows because a coffeehouse can appear in multiple finer categories. Panel B reports summary totals and averages per coffeehouse. [Return to pages 14, OA-50, OA-67]

Table D7—Detailed types of mathematical practitioners

Occupation	Distinct practitioners
All practitioners	244
Mathematical practitioners (proper)	69
Mathematical practitioner	28

Continued on next page

Table D7 continued

Occupation	Distinct practitioners
Surveyor	10
Hydrographer	4
Land surveyor	4
Mathematician	4
Astrologer	3
Amateur mathematician	2
Engineer	2
Applied mathematics student	1
Astronomer	1
Bookseller	1
Cartographer	1
Magnetism researcher	1
Marine hydrographer	1
Marine surveyor	1
Master of the mint	1
Master printer	1
Mathematical bookseller	1
Mathematics promoter	1
Mathematics student	1
Navigational instrument seller	1
Navigator	1
Operator to the Royal Society	1
Physician	1
Professional surveyor	1
Teachers	54
Mathematics teacher	24
Mathematics professor	6
Mathematics schoolmaster	6
Navigation teacher	4
Practical mathematics teacher	3
Astronomy professor	2
Geometry professor	2
Mathematics lecturer	2
Applied mathematics teacher	1
Mathematics school founder	1
Mathematics teacher or lecturer	1
Mathematics tutor	1
Practical mathematics and navigation teacher	1
Makers	130
Instrument maker	46
Mathematical instrument maker	28
Optical instrument maker	19
Dial maker	6
Globe maker	6
Chart maker	5
Clockmaker	5

Continued on next page

Table D7 continued

Occupation	Distinct practitioners
Compass maker	4
Engraver	3
Glass grinder	3
Almanac maker	2
Astronomical instrument maker	1
Calendar maker	1
Craftsman	1
Instrument designer	1
Instrument repairer	1
Master craftsman	1
Mechanic	1
Nautical instrument maker	1
Smith	1

Notes: Counts are distinct mathematical practitioners in the London sample described in Section 3, by the occupational titles that Taylor (1954) records for them. Indented rows are titles, harmonized from the raw occupation strings, and headers group them. A practitioner with several titles is counted under each, so the rows of a group can sum to more than its header, and the headers to more than the 244 practitioners. [Return to page 15]

E. MODEL APPENDIX

E.1. Environment

Decades are indexed by t and parishes by $p = 1, \ldots, N$ with $N \geq 2$, and $d_{pq} \geq 0$ is the distance in kilometers between parishes p and q.[81] $S_{pt} > 0$, S for scientists, is the number of applied scientists in parish p in decade t, in the model an expected count whose realization is the observed count.[82] $S_t = \sum_p S_{pt}$ is London's total and $\sigma_{pt} = S_{pt}/S_t$ parish p's share of it. A pool of $\overline{L} > 0$ potential entrants into science makes $\pi_t = S_t/\overline{L}$ the science share of the pool. Treatment $D_{pt} \in \{0, 1\}$ indicates a coffeehouse in parish p in decade t, and $m_{pt} = e^{\phi D_{pt}}$ is the factor by which it scales meetings between applied scientists.

The parameters are $\phi > 0$, $\delta > 0$, $\eta > 0$, $\gamma \geq 0$, and the Fréchet shapes $\varepsilon_P, \varepsilon_S$ of Assumption E.2: ϕ is the coffeehouse effect on meetings, δ the decay of meetings with distance, η the return to access, and γ the dispersion force. The fundamentals, taken as given, are $\psi_{pt} > 0$ and $\overline{u} > 0$: ψ_{pt} is what makes parish p attractive apart from access and $\overline{u}$ the payoff of the trade outside science.

Definition E.1 (Access)**.** The access in count form of parish p in decade t is

$$K_{pt} = m_{pt} \sum_q e^{-\delta d_{pq}} m_{qt} S_{qt}. \tag{E.1}$$

The access in share form of parish p in decade t is

$$\kappa_{pt}(\boldsymbol{\sigma}_t) = m_{pt} \sum_q e^{-\delta d_{pq}} m_{qt} \sigma_{qt}, \tag{E.2}$$

with $\boldsymbol{\sigma}_t = (\sigma_{1t}, \ldots, \sigma_{Nt})$ the vector of shares, written κ_{pt} when the argument is clear.

Access, K for the knowledge within an applied scientist's reach, is the agglomeration force of the quantitative urban model (Redding, 2025, §4). There productivity rises with the employment nearby, discounted by travel time, through production externalities such as knowledge spillovers (Redding, 2025, §4.2, eq. (9)). Here the externality is the meeting rate: access is the distance-discounted sum of applied scientists, with the coffeehouse as the shifter m_{pt} at each end.

Lemma E.1 (The aggregate factors out of access)**.** $K_{pt} = S_t \, \kappa_{pt}(\boldsymbol{\sigma}_t)$.

[81] Distances d_{pq} run between the centroids of parishes p and q. For $q = p$, $d_{pp} > 0$ is instead two thirds of the radius of a disk of its area, which is equal to the average distance from the center of such a disk to the points in it.

[82] A parish with no applied scientist in a decade is the limit of the model as its fundamental ψ_{pt} goes to zero. By (E.9) its share is then zero in the observed equilibrium and in every counterfactual, and by (E.1) it adds nothing to the access of others, so Procedure E.4 keeps it at zero.

Proof. Using $S_{qt} = \sigma_{qt} S_t$, we have

$$\begin{aligned} K_{pt} &= m_{pt} \sum_q e^{-\delta d_{pq}} m_{qt} S_{qt} \\ &= m_{pt} \sum_q e^{-\delta d_{pq}} m_{qt}\, \sigma_{qt} S_t \\ &= S_t\, m_{pt} \sum_q e^{-\delta d_{pq}} m_{qt} \sigma_{qt} \\ &= S_t\, \kappa_{pt}(\boldsymbol{\sigma}_t). \end{aligned}$$

□

Definition E.2 (Return)**.** The return to practicing science in parish p in decade t is

$$R_{pt} = \psi_{pt}\, K_{pt}^{\eta}\, S_{pt}^{-\gamma}. \tag{E.3}$$

The dispersion force γ is, in Redding (2025, §4), an inelastic supply of land: the applied scientists of a parish compete for its premises, whose supply is fixed, so the price of floor space rises with S_{pt} and the return net of that price falls at elasticity γ, the share of income spent on premises.

Definition E.3 (Composite coefficient)**.** The composite coefficient at elasticity ε is

$$\beta(\varepsilon) = \frac{\varepsilon\eta}{1 + \gamma\varepsilon}. \tag{E.4}$$

Furthermore, set $\beta_P = \beta(\varepsilon_P)$ and $\beta_S = \beta(\varepsilon_S)$.

Lemma E.2 (β is increasing)**.** *If* $0 < \varepsilon_1 \leq \varepsilon_2$ *then* $0 < \beta(\varepsilon_1) \leq \beta(\varepsilon_2)$.

Proof. Positivity follows from $\varepsilon\eta > 0$ and $1 + \gamma\varepsilon > 0$. Now,

$$\begin{aligned} \beta(\varepsilon_1) \leq \beta(\varepsilon_2) &\iff \varepsilon_1\eta(1 + \gamma\varepsilon_2) \leq \varepsilon_2\eta(1 + \gamma\varepsilon_1) \\ &\iff \varepsilon_1\eta + \gamma\eta\varepsilon_1\varepsilon_2 \leq \varepsilon_2\eta + \gamma\eta\varepsilon_1\varepsilon_2 \\ &\iff \eta(\varepsilon_2 - \varepsilon_1) \geq 0, \end{aligned}$$

which holds because $\eta > 0$ and $\varepsilon_1 \leq \varepsilon_2$. □

E.2. Meetings and Gravity

Assumption E.1 (Meetings)**.** Each applied scientist in p meets each applied scientist in q at Poisson rate

$$\lambda_{pqt} = \chi\, m_{pt}\, e^{-\delta d_{pq}}\, m_{qt}, \tag{E.5}$$

with $\chi > 0$, independently across pairs. Each meeting is documented with probability $\rho_t \in (0, 1]$, independently of everything else.

Assumption E.1 is the gravity equation of quantitative urban models applied to meetings (Redding, 2025, §2.4, §5.2). The flow between two parishes rises with the mass at either end, as interaction rises with the mass of people nearby in the classical account

(e.g., Glaeser et al., 1992), and falls with distance. In our application, the added part is the coffeehouse, which raises the rate given that mass and enters as the shifter m_{pt} at each end of a pair.

Lemma E.3 (Superposition). *If $X_1, \dots, X_N$ are independent Poisson counts with rates $r_1, \dots, r_N$, then $X_1 + \cdots + X_N$ is a Poisson count with rate $r_1 + \cdots + r_N$.*

Proof. See the Superposition Theorem in Kingman (1993, p. 16, §2.2). □

Lemma E.4 (Thinning). *If the number of events is Poisson with rate r, and each event is kept with probability ρ, independently of the other events and of their number, then the number of events kept is Poisson with rate ρr.*

Proof. See the Colouring Theorem in Kingman (1993, p. 53, §5.1). □

Theorem E.1 (Gravity). *Under Assumption E.1 the number of documented connections T_{pqt} between parishes $p \neq q$ in decade t is Poisson with mean*

$$\mathbb{E}[T_{pqt}] = (\chi \rho_t)\,(m_{pt} S_{pt})\, e^{-\delta d_{pq}}\, (m_{qt} S_{qt}). \tag{E.6}$$

Proof. Since the $S_{pt} S_{qt}$ pairs of an applied scientist in p and one in q meet independently, Lemma E.3 gives that the total number of meetings is Poisson with rate $\lambda_{pqt} S_{pt} S_{qt}$. By Lemma E.4, documentation with probability ρ_t thins it to a Poisson count with rate $\rho_t \lambda_{pqt} S_{pt} S_{qt}$, which is the display once (E.5) is substituted. □

E.3. The Fréchet Distribution

The choice model of the next subsection rests on three standard properties of the Fréchet distribution. We found no textbook that proves them in the forms in which we use them, so we prove them here.

Definition E.4 (Fréchet distribution). A random draw z is Fréchet with shape $\varepsilon > 0$ and scale $A > 0$ if

$$\mathbb{P}[z \le x] = F_{\varepsilon,A}(x) = \exp(-A x^{-\varepsilon}), \qquad x > 0,$$

with density

$$f_{\varepsilon,A}(x) = A\varepsilon\, x^{-\varepsilon-1} e^{-A x^{-\varepsilon}}, \qquad x > 0.$$

Definition E.5 (Unit Fréchet distribution). A random draw z is unit Fréchet with shape ε if it is Fréchet with shape ε and scale $A = 1$.

Lemma E.5 (Scaling). *If z is unit Fréchet with shape ε, then Rz with $R > 0$ is Fréchet with shape ε and scale R^{ε}.*

Proof. For $x > 0$,

$$\begin{aligned}\mathbb{P}[Rz \le x] &= \mathbb{P}[z \le x/R] \\ &= \exp\left(-(x/R)^{-\varepsilon}\right) \\ &= \exp\left(-R^{\varepsilon}x^{-\varepsilon}\right) = F_{\varepsilon,R^{\varepsilon}}(x).\end{aligned}$$

□

Lemma E.6 (Max-stability). *If $u_1, \dots, u_N$ are independent Fréchet draws with common shape ε and scales $A_1, \dots, A_N$, then $\max_p u_p$ is Fréchet with shape ε and scale $\sum_{p=1}^{N} A_p$.*

Proof. For $x > 0$,

$$\begin{aligned}\mathbb{P}\Big[\max_p u_p \le x\Big] &= \mathbb{P}\big[u_1 \le x, \dots, u_N \le x\big] \\ &= \prod_{p=1}^{N} \mathbb{P}[u_p \le x] && \text{(independence)} \\ &= \prod_{p=1}^{N} \exp\left(-A_p x^{-\varepsilon}\right) \\ &= \exp\Big(-\sum_{p=1}^{N} A_p\, x^{-\varepsilon}\Big) = F_{\varepsilon,\sum_p A_p}(x).\end{aligned}$$

□

Lemma E.7 (Choice probability). *Let $u_1, \dots, u_N$ be independent Fréchet with common shape ε and scales $A_1, \dots, A_N$, and $S = \sum_k A_k$. Then*

$$\mathbb{P}[u_p = \max_k u_k] = A_p/S.$$

Proof. Let $M = \max_{k \ne p} u_k$. M is a function of draws independent of u_p, so M and u_p are independent. By Lemma E.6, the distribution function of M is $F_{\varepsilon,S-A_p}$. Thus,

$$\begin{aligned}\mathbb{P}[u_p = \max_k u_k] = \mathbb{P}[M \le u_p] &= \mathbb{E}\big[\mathbb{1}\{M \le u_p\}\big] \\ &= \mathbb{E}\Big[\,\mathbb{E}\big[\mathbb{1}\{M \le u_p\} \,\big|\, u_p\big]\Big] && \text{(iterated expectations)} \\ &= \mathbb{E}\big[F_{\varepsilon,S-A_p}(u_p)\big] && (M \text{ independent of } u_p) \\ &= \int_0^{\infty} F_{\varepsilon,S-A_p}(x)\, f_{\varepsilon,A_p}(x)\, dx \\ &= \int_0^{\infty} e^{-(S-A_p)x^{-\varepsilon}} \cdot A_p \varepsilon x^{-\varepsilon-1} e^{-A_p x^{-\varepsilon}}\, dx \\ &= \frac{A_p}{S} \int_0^{\infty} S\varepsilon x^{-\varepsilon-1} e^{-Sx^{-\varepsilon}}\, dx \\ &= \frac{A_p}{S} \underbrace{\int_0^{\infty} f_{\varepsilon,S}(x)\, dx}_{=1} \\ &= \frac{A_p}{S}.\end{aligned}$$

□

E.4. Choice

Assumption E.2 (Choice model)**.** In decade t each of $\overline{L}$ potential entrants v makes two choices in sequence.

1. *Whether to practice.* The outside trade yields entrant v the payoff $\overline{u}\zeta_{0v}$ and practicing the payoff $V_t\zeta_{1v}$, where (ζ_{0v}, ζ_{1v}) are independent unit Fréchet draws with shape ε_S. The entrant practices if $V_t\zeta_{1v} > \overline{u}\zeta_{0v}$.
2. *Where to practice.* Practicing in parish p yields the payoff $u_{pv} = R_{pt}\xi_{pv}$, the parish's return scaled by an idiosyncratic draw, where $(\xi_{1v}, \ldots, \xi_{Nv})$ are independent unit Fréchet draws with shape ε_P. The entrant picks the parish with the largest payoff, $\arg\max_p u_{pv}$.

Draws are independent across entrants and across the two choices, and $0 < \varepsilon_S \leq \varepsilon_P$.

Assumption E.2 is the Fréchet choice model of quantitative urban models (Redding, 2025, §4.1), in which a worker chooses where to live and work. Here the entrant makes two choices, whether to practice and where, each with its own dispersion parameter. The restriction $0 < \varepsilon_S \leq \varepsilon_P$ is the consistency condition of a nested choice (McFadden, 1978; Train, 2009): the two choices together are one nested maximization with inclusive-value coefficient $\varepsilon_S/\varepsilon_P$, which must lie in the unit interval for the probabilities to come from utility maximization. This means that entering science is no easier than moving parish. With Lemma E.2, the restriction gives $0 < \beta_S \leq \beta_P$.

Theorem E.2 (Shares and total)**.** *Under Assumption E.2,*

$$\sigma_{pt} = \frac{R_{pt}^{\varepsilon_P}}{\sum_k R_{kt}^{\varepsilon_P}}, \quad V_t = \left(\sum_k R_{kt}^{\varepsilon_P}\right)^{1/\varepsilon_P}, \quad S_t = \overline{L}\,\frac{V_t^{\varepsilon_S}}{\overline{u}^{\varepsilon_S} + V_t^{\varepsilon_S}}, \quad \frac{\partial \ln S_t}{\partial \ln V_t} = \varepsilon_S(1 - \pi_t).$$

Proof. By Lemma E.5 the payoffs $u_{pv} = R_{pt}\xi_{pv}$ are independent Fréchet with shape ε_P and scales $R_{pt}^{\varepsilon_P}$. An entrant who practices picks the parish with the largest payoff, so by Lemma E.7 parish p is chosen with probability

$$\sigma_{pt} = \frac{R_{pt}^{\varepsilon_P}}{\sum_k R_{kt}^{\varepsilon_P}}. \tag{E.7}$$

By Lemma E.6 the best payoff $\max_p u_{pv}$ is Fréchet with shape ε_P and scale $\sum_k R_{kt}^{\varepsilon_P} = V_t^{\varepsilon_P}$, that is, by Lemma E.5 read backwards, distributed as $V_t\tilde{z}$ with $\tilde{z}$ unit Fréchet with shape ε_P. The entrant practices when $V_t\zeta_{1v} > \overline{u}\zeta_{0v}$. By Lemma E.5 these two are independent Fréchet with shape ε_S and scales $V_t^{\varepsilon_S}$ and $\overline{u}^{\varepsilon_S}$, so by Lemma E.7 with two alternatives the entrant practices with probability

$$\pi_t = \frac{V_t^{\varepsilon_S}}{\overline{u}^{\varepsilon_S} + V_t^{\varepsilon_S}}. \tag{E.8}$$

Each of the $\overline{L}$ entrants practices with probability π_t, so the expected number who practice is $S_t = \overline{L}\pi_t$, and by the independence of the two choices each practices in parish

p with probability $\sigma_{pt}\pi_t$, so the expected number there is $S_{pt} = \sigma_{pt}S_t$. Finally, taking logarithms of S_t and differentiating with respect to $\ln V_t$,

$$\ln S_t = \ln \overline{L} + \varepsilon_S \ln V_t - \ln\left(\overline{u}^{\varepsilon_S} + V_t^{\varepsilon_S}\right)$$
$$\implies \quad \frac{\partial \ln S_t}{\partial \ln V_t} = \varepsilon_S - \frac{\varepsilon_S V_t^{\varepsilon_S}}{\overline{u}^{\varepsilon_S} + V_t^{\varepsilon_S}} = \varepsilon_S(1-\pi_t). \qquad \square$$

E.5. Block Recursion

Theorem E.3 (Block recursion)**.**

$$\ln \sigma_{pt} = \beta_P \ln \kappa_{pt}(\boldsymbol{\sigma}_t) + \ln \tilde{\psi}_{pt} + c_t, \tag{E.9}$$
$$\ln V_t = (\eta - \gamma)\ln S_t + \ln W_t, \tag{E.10}$$
$$\ln S_t = \ln \overline{L} + \varepsilon_S \ln V_t - \ln\left(\overline{u}^{\varepsilon_S} + V_t^{\varepsilon_S}\right), \tag{E.11}$$

where $\tilde{\psi}_{pt} = \psi_{pt}^{\varepsilon_P/(1+\gamma\varepsilon_P)}$ *and*

$$c_t = \frac{\varepsilon_P(\eta-\gamma)\ln S_t - \varepsilon_P \ln V_t}{1+\gamma\varepsilon_P}, \quad V_t^{\varepsilon_P} = \sum_k R_{kt}^{\varepsilon_P}, \quad W_t = \left(\sum_k \left(\psi_{kt}\kappa_{kt}^{\eta}\sigma_{kt}^{-\gamma}\right)^{\varepsilon_P}\right)^{1/\varepsilon_P}.$$

Proof. By Lemma E.1 and $S_{pt} = \sigma_{pt}S_t$,

$$\begin{aligned} R_{pt} &= \psi_{pt} K_{pt}^{\eta} S_{pt}^{-\gamma} \\ &= \psi_{pt}\left(S_t\, \kappa_{pt}(\boldsymbol{\sigma}_t)\right)^{\eta}\left(\sigma_{pt}S_t\right)^{-\gamma} \\ &= \psi_{pt}\, \kappa_{pt}^{\eta}\, \sigma_{pt}^{-\gamma}\, S_t^{\eta-\gamma}. \end{aligned}$$

Taking logarithms of the share equation of Theorem E.2, with $V_t^{\varepsilon_P} = \sum_k R_{kt}^{\varepsilon_P}$, and collecting the $\ln \sigma_{pt}$ terms,

$$\begin{aligned} \sigma_{pt} &= \frac{R_{pt}^{\varepsilon_P}}{V_t^{\varepsilon_P}} \\ \implies \quad \ln \sigma_{pt} &= \varepsilon_P \ln R_{pt} - \varepsilon_P \ln V_t \\ &= \varepsilon_P\left(\ln \psi_{pt} + \eta \ln \kappa_{pt} - \gamma \ln \sigma_{pt} + (\eta-\gamma)\ln S_t\right) - \varepsilon_P \ln V_t \\ \implies \quad (1+\gamma\varepsilon_P)\ln \sigma_{pt} &= \varepsilon_P \eta \ln \kappa_{pt} + \varepsilon_P \ln \psi_{pt} + \left(\varepsilon_P(\eta-\gamma)\ln S_t - \varepsilon_P \ln V_t\right) \\ \implies \quad \ln \sigma_{pt} &= \frac{\varepsilon_P \eta}{1+\gamma\varepsilon_P}\ln \kappa_{pt} + \frac{\varepsilon_P}{1+\gamma\varepsilon_P}\ln \psi_{pt} + c_t, \qquad (\varepsilon_P\eta/(1+\gamma\varepsilon_P) = \beta_P) \\ c_t &= \frac{\varepsilon_P(\eta-\gamma)\ln S_t - \varepsilon_P \ln V_t}{1+\gamma\varepsilon_P}, \end{aligned}$$

which is (E.9), as $\frac{\varepsilon_P}{1+\gamma\varepsilon_P}\ln\psi_{pt} = \ln\tilde{\psi}_{pt}$. For (E.10), by the same factoring,

$$\begin{aligned} V_t^{\varepsilon_P} &= \sum_k R_{kt}^{\varepsilon_P} \\ &= \sum_k \left(\psi_{kt}\kappa_{kt}^{\eta}\sigma_{kt}^{-\gamma}\right)^{\varepsilon_P} S_t^{(\eta-\gamma)\varepsilon_P} \\ &= S_t^{(\eta-\gamma)\varepsilon_P} W_t^{\varepsilon_P} \\ \Longrightarrow \qquad \ln V_t &= (\eta-\gamma)\ln S_t + \ln W_t. \end{aligned}$$

Equation (E.11) is the total of Theorem E.2 in logs. □

Corollary E.1 (The total in levels). *Let* $\overline{\kappa}_t = \left(\sum_k \tilde{\psi}_{kt}\kappa_{kt}^{\beta_P}\right)^{1/\beta_P}$, *and* $\overline{K}_t = S_t\overline{\kappa}_t$, *London's average access. In equilibrium* $W_t = \overline{\kappa}_t^{\eta}$, *so that*

$$\ln V_t = \eta\ln\overline{K}_t - \gamma\ln S_t, \qquad \ln S_t = \beta_S\ln\overline{K}_t + \overline{c}_t, \qquad \overline{c}_t = \frac{\ln\overline{L} - \varepsilon_S\ln\overline{u} + \ln(1-\pi_t)}{1+\gamma\varepsilon_S},$$

and $\overline{c}_t$ *is fixed by* $\overline{L}$ *and* $\overline{u}$ *as* $\pi_t \to 0$. *If a counterfactual holds the fundamentals fixed, then* $\overline{\kappa}_t'/\overline{\kappa}_t = \left(\sum_k \sigma_{kt}(\kappa_{kt}'/\kappa_{kt})^{\beta_P}\right)^{1/\beta_P}$.

Proof. By (E.9), $\sigma_{kt} = \tilde{\psi}_{kt}\kappa_{kt}^{\beta_P}e^{c_t}$, and since the shares sum to one, $e^{c_t} = 1/\sum_k \tilde{\psi}_{kt}\kappa_{kt}^{\beta_P} = \overline{\kappa}_t^{-\beta_P}$. Since $\beta_P(1+\gamma\varepsilon_P) = \varepsilon_P\eta$,

$$\begin{aligned} \psi_{kt}^{\varepsilon_P}\kappa_{kt}^{\eta\varepsilon_P} &= \left(\tilde{\psi}_{kt}\kappa_{kt}^{\beta_P}\right)^{1+\gamma\varepsilon_P} = \left(\sigma_{kt}\overline{\kappa}_t^{\beta_P}\right)^{1+\gamma\varepsilon_P} \\ \Longrightarrow \qquad W_t^{\varepsilon_P} &= \sum_k \psi_{kt}^{\varepsilon_P}\kappa_{kt}^{\eta\varepsilon_P}\sigma_{kt}^{-\gamma\varepsilon_P} = \overline{\kappa}_t^{\eta\varepsilon_P}\sum_k \sigma_{kt} = \overline{\kappa}_t^{\eta\varepsilon_P}, \end{aligned}$$

so (E.10) reads $\ln V_t = (\eta-\gamma)\ln S_t + \eta\ln\overline{\kappa}_t = \eta\ln\overline{K}_t - \gamma\ln S_t$. By Theorem E.2, $1-\pi_t = \overline{u}^{\varepsilon_S}/(\overline{u}^{\varepsilon_S} + V_t^{\varepsilon_S})$, so (E.11) reads

$$\begin{aligned} \ln S_t &= \ln\overline{L} - \varepsilon_S\ln\overline{u} + \ln(1-\pi_t) + \varepsilon_S\ln V_t \\ &= \ln\overline{L} - \varepsilon_S\ln\overline{u} + \ln(1-\pi_t) + \varepsilon_S\eta\ln\overline{K}_t - \varepsilon_S\gamma\ln S_t, \end{aligned}$$

and solving for $\ln S_t$ gives the second display equation, with $\varepsilon_S\eta/(1+\gamma\varepsilon_S) = \beta_S$. Last, with $\tilde{\psi}_{kt}$ fixed and $\sigma_{kt} = \tilde{\psi}_{kt}\kappa_{kt}^{\beta_P}/\overline{\kappa}_t^{\beta_P}$,

$$\left(\frac{\overline{\kappa}_t'}{\overline{\kappa}_t}\right)^{\beta_P} = \sum_k \frac{\tilde{\psi}_{kt}\kappa_{kt}^{\beta_P}}{\overline{\kappa}_t^{\beta_P}}\left(\frac{\kappa_{kt}'}{\kappa_{kt}}\right)^{\beta_P} = \sum_k \sigma_{kt}\left(\frac{\kappa_{kt}'}{\kappa_{kt}}\right)^{\beta_P}.$$

□

Theorem E.4 (The aggregate fixed point). *If* $\beta_P < 1$, *then for given shares* $\boldsymbol{\sigma}_t$ *equations* (E.9)–(E.11) *give exactly one solution in* $\ln S_t$.

Proof. Write $z = \ln S_t$. Substituting (E.10), $\ln V_t = (\eta - \gamma)z + \ln W_t$, into (E.11),

$$\begin{aligned} & z = \ln \overline{L} + \varepsilon_S\big((\eta-\gamma)z + \ln W_t\big) - \ln\big(\overline{u}^{\varepsilon_S} + e^{\varepsilon_S(\eta-\gamma)z} W_t^{\varepsilon_S}\big) \\ \iff \quad & 0 = (1-a)z - b + \ln\big(c + de^{az}\big) =: h(z), \end{aligned}$$

with constants

$$a = \varepsilon_S(\eta - \gamma), \qquad b = \ln \overline{L} + \varepsilon_S \ln W_t, \qquad c = \overline{u}^{\varepsilon_S}, \qquad d = W_t^{\varepsilon_S},$$

so the solutions are the zeros of h. Suppose first that $a < 1$. With $w = de^{az}/(c + de^{az}) \in (0,1)$,

$$h'(z) = (1-a) + \frac{a\, de^{az}}{c + de^{az}} = 1 - a(1-w) > 0,$$

so h is strictly increasing. Since $h(z) \geq z + \min(\ln c, \ln d) - b$ for $z \geq 0$, which tends to $+\infty$ as $z \to +\infty$, and $h(z) \leq \min(1, 1-a)\, z + \ln(c+d) - b$ for $z \leq 0$, which tends to $-\infty$ as $z \to -\infty$, the intermediate value theorem gives a zero and strict monotonicity its uniqueness. It remains to see that $\beta_P < 1$ gives $a < 1$. Since $\beta_S = \varepsilon_S \eta/(1 + \gamma\varepsilon_S)$,

$$\beta_S < 1 \iff \varepsilon_S \eta < 1 + \gamma\varepsilon_S \iff \varepsilon_S(\eta - \gamma) < 1 \iff a < 1,$$

and $\beta_S \leq \beta_P < 1$. □

E.6. Equilibrium in Levels

Write $\boldsymbol{\kappa}_t = (\kappa_{1t}, \ldots, \kappa_{Nt})$ for the vector of access in share form, beside $\boldsymbol{\sigma}_t$.

Lemma E.8 (The fixed point in $\boldsymbol{\kappa}_t$)**.** *The share block* (E.9) *is*

$$\sigma_{pt} = C_t\, \tilde{\psi}_{pt}\, \kappa_{pt}(\boldsymbol{\sigma}_t)^{\beta_P}, \qquad C_t = e^{c_t}, \tag{E.12}$$

and $\boldsymbol{\kappa}_t = \boldsymbol{\kappa}_t(\boldsymbol{\sigma}_t)$ *then solves a fixed point in* $\boldsymbol{\kappa}_t$ *alone,*

$$\kappa_{pt} = \sum_q Q_{pqt}\, \kappa_{qt}^{\beta_P}, \qquad Q_{pqt} = C_t\, m_{pt} e^{-\delta d_{pq}} m_{qt} \tilde{\psi}_{qt} > 0. \tag{E.13}$$

Proof. Exponentiating (E.9) gives (E.12). Substituting it into the access in share form (E.2),

$$\begin{aligned} \kappa_{pt}(\boldsymbol{\sigma}_t) &= m_{pt} \sum_q e^{-\delta d_{pq}} m_{qt} \sigma_{qt} \\ &= m_{pt} \sum_q e^{-\delta d_{pq}} m_{qt}\, C_t \tilde{\psi}_{qt} \kappa_{qt}^{\beta_P} && \text{(by (E.12))} \\ &= \sum_q Q_{pqt}\, \kappa_{qt}^{\beta_P}. \end{aligned}$$

□

Theorem E.5 (Existence and uniqueness)**.** *Let* $Q_{pqt} > 0$ *and* $0 \leq \beta_P < 1$*. Then* (E.13) *has exactly one strictly positive solution, and iterating the system in log coordinates from any*

start converges to it at rate β_P^k after k iterations. The constant C_t is pinned by $\sum_p \sigma_{pt} = 1$: scaling Q by c scales the solution and the shares by $c^{1/(1-\beta_P)}$, so exactly one $c > 0$ normalizes them.

Proof. The fixed point and the rate. In log coordinates $x_p = \ln \kappa_{pt}$ the system is $\boldsymbol{x} = T(\boldsymbol{x})$ with $T(\boldsymbol{x})_p = \ln \sum_q Q_{pqt} e^{\beta_P x_q}$. If $x_q \le y_q + d$ for all q, then

$$\begin{aligned} T(\boldsymbol{x})_p &= \ln \sum_q Q_{pqt} e^{\beta_P x_q} \\ &\le \ln \sum_q Q_{pqt} e^{\beta_P (y_q + d)} && (\beta_P \ge 0, \ln \text{ increasing}) \\ &= \ln\Big(e^{\beta_P d} \sum_q Q_{pqt} e^{\beta_P y_q} \Big) && (e^{\beta_P d} \text{ common to every term}) \\ &= \beta_P d + \ln \sum_q Q_{pqt} e^{\beta_P y_q} = T(\boldsymbol{y})_p + \beta_P d, \end{aligned}$$

and with the roles exchanged, T is β_P-Lipschitz for the sup metric, so a contraction on the complete space $\mathbb{R}^N$ since $\beta_P < 1$. Banach's theorem gives a unique fixed point $\boldsymbol{x}^*$, so $\boldsymbol{\kappa}_t = e^{\boldsymbol{x}^*}$ is the only strictly positive solution, and $\operatorname{dist}(T^k \boldsymbol{x}_0, \boldsymbol{x}^*) \le \beta_P^k \operatorname{dist}(\boldsymbol{x}_0, \boldsymbol{x}^*)$.

The constant. For $c > 0$,

$$\begin{aligned} & \big(c^{1/(1-\beta_P)} \kappa_{qt}\big)^{\beta_P} = c^{\beta_P/(1-\beta_P)} \kappa_{qt}^{\beta_P} \\ \Longrightarrow \qquad & \sum_q (c Q_{pqt}) \big(c^{1/(1-\beta_P)} \kappa_{qt}\big)^{\beta_P} = c \cdot c^{\beta_P/(1-\beta_P)} \sum_q Q_{pqt} \kappa_{qt}^{\beta_P} = c^{1/(1-\beta_P)} \kappa_{pt}, \end{aligned}$$

so $c^{1/(1-\beta_P)} \boldsymbol{\kappa}_t$ solves the system with kernel cQ, and, with C_t absorbed into c, the shares $c\tilde{\psi}_{pt} (c^{1/(1-\beta_P)} \kappa_{pt})^{\beta_P}$ sum to $c^{1/(1-\beta_P)} \sum_p \tilde{\psi}_{pt} \kappa_{pt}^{\beta_P}$, which equals one for exactly one $c > 0$. □

Theorem E.6 (Inversion). *For any strictly positive data (S_{pt}, K_{pt}) with $S_t = \sum_p S_{pt}$ and any constant c_t,*

$$\ln \psi_{pt} = \frac{1 + \gamma \varepsilon_P}{\varepsilon_P} \ln S_{pt} - \eta \ln K_{pt} + c_t \tag{E.14}$$

defines a strictly positive ψ_{pt} that satisfies the share equation of Theorem E.2 exactly, and every ψ_{pt} that satisfies it is of this form. The constant scales every ψ_{pt} of the decade by the same factor e^{c_t}, so the fundamentals are recovered up to a scale per decade.

Proof. The formula works. The ψ_{pt} it defines is positive, being an exponential. Exponentiating (E.14) gives $\psi_{pt} = e^{c_t} S_{pt}^{(1+\gamma\varepsilon_P)/\varepsilon_P} K_{pt}^{-\eta}$, so in the return (E.3) the access cancels,

$$\begin{aligned} R_{pt} &= \psi_{pt} K_{pt}^{\eta} S_{pt}^{-\gamma} \\ &= e^{c_t} S_{pt}^{(1+\gamma\varepsilon_P)/\varepsilon_P} K_{pt}^{-\eta} K_{pt}^{\eta} S_{pt}^{-\gamma} && \text{(by (E.14))} \\ &= e^{c_t} S_{pt}^{(1+\gamma\varepsilon_P)/\varepsilon_P - \gamma} = e^{c_t} S_{pt}^{1/\varepsilon_P}. \end{aligned}$$

Hence,

$$R_{pt}^{\varepsilon_P} = e^{\varepsilon_P c_t} S_{pt}$$

$$\Longrightarrow \qquad \frac{R_{pt}^{\varepsilon_P}}{\sum_k R_{kt}^{\varepsilon_P}} = \frac{e^{\varepsilon_P c_t} S_{pt}}{e^{\varepsilon_P c_t} \sum_k S_{kt}} = \frac{S_{pt}}{S_t} = \sigma_{pt}, \qquad (\textstyle\sum_k S_{kt} = S_t)$$

which is the share equation of Theorem E.2, whatever the value of c_t.

Nothing else works. Conversely, let $\psi_{pt} > 0$ satisfy that share equation. Then $R_{pt}^{\varepsilon_P} = \sigma_{pt} \sum_k R_{kt}^{\varepsilon_P} = (S_{pt}/S_t) \sum_k R_{kt}^{\varepsilon_P}$, and solving (E.3) for the fundamental in logarithms,

$$\begin{aligned}
\ln \psi_{pt} &= \ln R_{pt} - \eta \ln K_{pt} + \gamma \ln S_{pt} && \text{(by (E.3))} \\
&= \tfrac{1}{\varepsilon_P} \ln\Big(\frac{S_{pt}}{S_t} \sum_k R_{kt}^{\varepsilon_P}\Big) - \eta \ln K_{pt} + \gamma \ln S_{pt} && \text{(the share equation)} \\
&= \frac{1 + \gamma \varepsilon_P}{\varepsilon_P} \ln S_{pt} - \eta \ln K_{pt} + \tfrac{1}{\varepsilon_P} \ln\Big(\sum_k R_{kt}^{\varepsilon_P} / S_t\Big),
\end{aligned}$$

which is (E.14) with $c_t = \frac{1}{\varepsilon_P} \ln\big(\sum_k R_{kt}^{\varepsilon_P}/S_t\big)$, the same number for every parish of the decade. Two constants thus give fundamentals differing by the common factor $e^{c_t - c_t'}$, which is the scale per decade. □

The fit of the model in levels thus tests nothing. What identifies β_P is how a parish's share moves when a coffeehouse arrives and its neighbors' do not, the fundamentals held fixed.

Corollary E.2 (Inversion in β_P). *In terms of $\tilde{\psi}_{pt}$, the shares, and access in share form, Theorem E.6 reads*

$$\ln \tilde{\psi}_{pt} = \ln \sigma_{pt} - \beta_P \ln \kappa_{pt}(\boldsymbol{\sigma}_t) + \tilde{c}_t, \qquad \tilde{c}_t = (1 - \beta_P) \ln S_t + \frac{\varepsilon_P\, c_t}{1 + \gamma \varepsilon_P},$$

with $\tilde{c}_t$ common to all parishes.

Proof. By Theorem E.6, with $S_{pt} = \sigma_{pt} S_t$ and $K_{pt} = S_t \kappa_{pt}(\boldsymbol{\sigma}_t)$ from Lemma E.1,

$$\begin{aligned}
\ln \tilde{\psi}_{pt} &= \frac{\varepsilon_P}{1 + \gamma \varepsilon_P} \ln \psi_{pt} \\
&= \ln S_{pt} - \frac{\varepsilon_P \eta}{1 + \gamma \varepsilon_P} \ln K_{pt} + \frac{\varepsilon_P\, c_t}{1 + \gamma \varepsilon_P} \\
&= \ln \sigma_{pt} + \ln S_t - \beta_P \big(\ln S_t + \ln \kappa_{pt}(\boldsymbol{\sigma}_t)\big) + \frac{\varepsilon_P\, c_t}{1 + \gamma \varepsilon_P} \\
&= \ln \sigma_{pt} - \beta_P \ln \kappa_{pt}(\boldsymbol{\sigma}_t) + (1 - \beta_P) \ln S_t + \frac{\varepsilon_P\, c_t}{1 + \gamma \varepsilon_P} \\
&= \ln \sigma_{pt} - \beta_P \ln \kappa_{pt}(\boldsymbol{\sigma}_t) + \tilde{c}_t.
\end{aligned}$$

□

E.7. Equilibrium in Changes

A counterfactual is a second geography $\boldsymbol{D}' = (D_{pt}')$ with the same fundamentals ψ_{pt} and $\overline{u}$ and the same pool $\overline{L}$. When $\beta_P < 1$ its equilibrium exists and is unique, the

shares by Theorem E.5 and the total by Theorem E.4, so we can introduce the following notation: $\widehat{x} = x'/x$ is the ratio of a counterfactual value to its observed value.

Definition E.6 (Baseline access shares)**.** Given (ϕ, δ) and an observed equilibrium, we define the baseline access share of parish q in the access of parish p as

$$\omega_{pqt} = \frac{e^{-\delta d_{pq}} m_{qt} S_{qt}}{\sum_k e^{-\delta d_{pk}} m_{kt} S_{kt}}. \tag{E.15}$$

Theorem E.7 (Access in changes)**.** $\widehat{K}_{pt} = \widehat{m}_{pt} \sum_q \omega_{pqt}\, \widehat{m}_{qt} \widehat{S}_{qt}$.

Proof. We have

$$\begin{aligned}
\widehat{K}_{pt} = \frac{K'_{pt}}{K_{pt}} &= \frac{m'_{pt} \sum_q e^{-\delta d_{pq}} m'_{qt} S'_{qt}}{m_{pt} \sum_k e^{-\delta d_{pk}} m_{kt} S_{kt}} \\
&= \frac{m'_{pt}}{m_{pt}} \sum_q \frac{e^{-\delta d_{pq}} m'_{qt} S'_{qt}}{\sum_k e^{-\delta d_{pk}} m_{kt} S_{kt}} \\
&= \frac{m'_{pt}}{m_{pt}} \sum_q \frac{e^{-\delta d_{pq}} m_{qt} S_{qt}}{\sum_k e^{-\delta d_{pk}} m_{kt} S_{kt}} \cdot \frac{m'_{qt} S'_{qt}}{m_{qt} S_{qt}} \\
&= \widehat{m}_{pt} \sum_q \omega_{pqt}\, \widehat{m}_{qt} \widehat{S}_{qt}.
\end{aligned}$$

□

Theorem E.8 (Exact hat and sufficiency)**.** *In a counterfactual,*

$$\widehat{K}_{pt} = \widehat{m}_{pt} \sum_q \omega_{pqt} \widehat{m}_{qt} \widehat{S}_{qt}, \qquad \widehat{R}_{pt} = \widehat{K}_{pt}^{\eta} \widehat{S}_{pt}^{-\gamma}, \qquad \widehat{\sigma}_{pt} = \frac{\widehat{R}_{pt}^{\varepsilon_P}}{\sum_k \sigma_{kt} \widehat{R}_{kt}^{\varepsilon_P}},$$

$$\widehat{S}_t = \frac{\widehat{V}_t^{\varepsilon_S}}{(1-\pi_t) + \pi_t \widehat{V}_t^{\varepsilon_S}}, \qquad \widehat{S}_{pt} = \widehat{\sigma}_{pt} \widehat{S}_t,$$

with $\widehat{V}_t^{\varepsilon_P} = \sum_k \sigma_{kt} \widehat{R}_{kt}^{\varepsilon_P}$. *No level of* ψ *or* $\overline{u}$ *is needed, and* $\overline{L}$ *enters only through* π_t. *The fundamental is absent from* $\widehat{R}_{pt}$ *because it is held fixed and enters the return multiplicatively,*

$$\widehat{R}_{pt} = \frac{\psi_{pt} K'^{\eta}_{pt} S'^{-\gamma}_{pt}}{\psi_{pt} K^{\eta}_{pt} S^{-\gamma}_{pt}} = \widehat{K}^{\eta}_{pt} \widehat{S}^{-\gamma}_{pt}.$$

Moreover, whatever the value of π_t, *the counterfactual shares solve*

$$\widehat{\sigma}_{pt} = \frac{\widehat{\kappa}_{pt}^{\beta_P}}{\sum_k \sigma_{kt} \widehat{\kappa}_{kt}^{\beta_P}}, \qquad \widehat{\kappa}_{pt} = \widehat{m}_{pt} \sum_q \omega_{pqt} \widehat{m}_{qt} \widehat{\sigma}_{qt},$$

in which $(\eta, \gamma, \varepsilon_P)$ *appear only through* β_P.

Proof. Access is Theorem E.7, and the return ratio is the display. For the shares, dividing the two Fréchet share equations of Theorem E.2,

$$\begin{aligned}\widehat{\sigma}_{pt} = \frac{\sigma'_{pt}}{\sigma_{pt}} &= \frac{R'^{\varepsilon_P}_{pt}/\sum_k R'^{\varepsilon_P}_{kt}}{R^{\varepsilon_P}_{pt}/\sum_k R^{\varepsilon_P}_{kt}} \\ &= \frac{\widehat{R}^{\varepsilon_P}_{pt}}{\sum_k R'^{\varepsilon_P}_{kt}/\sum_k R^{\varepsilon_P}_{kt}} \\ &= \frac{\widehat{R}^{\varepsilon_P}_{pt}}{\sum_k \left(R^{\varepsilon_P}_{kt}/\sum_q R^{\varepsilon_P}_{qt}\right)\widehat{R}^{\varepsilon_P}_{kt}} = \frac{\widehat{R}^{\varepsilon_P}_{pt}}{\sum_k \sigma_{kt}\widehat{R}^{\varepsilon_P}_{kt}},\end{aligned}$$

and the denominator is $\widehat{V}^{\varepsilon_P}_t = V'^{\varepsilon_P}_t / V^{\varepsilon_P}_t = \sum_k R'^{\varepsilon_P}_{kt}/\sum_k R^{\varepsilon_P}_{kt}$. For the total, with $\pi_t = V^{\varepsilon_S}_t/(\overline{u}^{\varepsilon_S} + V^{\varepsilon_S}_t)$ from (E.8) and $\overline{u}, \overline{L}$ unchanged,

$$\begin{aligned}\widehat{S}_t = \frac{S'_t}{S_t} &= \frac{\overline{L}V'^{\varepsilon_S}_t/(\overline{u}^{\varepsilon_S} + V'^{\varepsilon_S}_t)}{\overline{L}V^{\varepsilon_S}_t/(\overline{u}^{\varepsilon_S} + V^{\varepsilon_S}_t)} \\ &= \widehat{V}^{\varepsilon_S}_t \frac{\overline{u}^{\varepsilon_S} + V^{\varepsilon_S}_t}{\overline{u}^{\varepsilon_S} + V^{\varepsilon_S}_t \widehat{V}^{\varepsilon_S}_t} \\ &= \frac{\widehat{V}^{\varepsilon_S}_t}{(1-\pi_t) + \pi_t \widehat{V}^{\varepsilon_S}_t}.\end{aligned}$$

For sufficiency, by Lemma E.1 $\widehat{K}_{pt} = \widehat{S}_t \widehat{\kappa}_{pt}$ with

$$\widehat{\kappa}_{pt} = \kappa_{pt}(\boldsymbol{\sigma}'_t)/\kappa_{pt}(\boldsymbol{\sigma}_t) = \widehat{m}_{pt} \sum_q \omega_{pqt}\widehat{m}_{qt}\widehat{\sigma}_{qt}$$

(the computation of Theorem E.7 with σ in place of S), and $\widehat{S}_{pt} = \widehat{\sigma}_{pt}\widehat{S}_t$, so

$$\begin{aligned}&\widehat{R}_{pt} = \left(\widehat{S}_t\widehat{\kappa}_{pt}\right)^{\eta}\left(\widehat{\sigma}_{pt}\widehat{S}_t\right)^{-\gamma} = \widehat{\kappa}^{\eta}_{pt}\widehat{\sigma}^{-\gamma}_{pt}\widehat{S}^{\eta-\gamma}_t \\ \Longrightarrow\quad &\widehat{\sigma}_{pt} = \frac{\widehat{\kappa}^{\eta\varepsilon_P}_{pt}\widehat{\sigma}^{-\gamma\varepsilon_P}_{pt}\widehat{S}^{(\eta-\gamma)\varepsilon_P}_t}{\sum_k \sigma_{kt}\widehat{\kappa}^{\eta\varepsilon_P}_{kt}\widehat{\sigma}^{-\gamma\varepsilon_P}_{kt}\widehat{S}^{(\eta-\gamma)\varepsilon_P}_t} = \frac{\widehat{\kappa}^{\eta\varepsilon_P}_{pt}\widehat{\sigma}^{-\gamma\varepsilon_P}_{pt}}{B_t}, \qquad B_t = \sum_k \sigma_{kt}\widehat{\kappa}^{\eta\varepsilon_P}_{kt}\widehat{\sigma}^{-\gamma\varepsilon_P}_{kt} \\ \Longrightarrow\quad &\widehat{\sigma}^{1+\gamma\varepsilon_P}_{pt} = \frac{\widehat{\kappa}^{\eta\varepsilon_P}_{pt}}{B_t} \\ \Longrightarrow\quad &\widehat{\sigma}_{pt} = A\,\widehat{\kappa}^{\beta_P}_{pt}, \qquad A = B_t^{-1/(1+\gamma\varepsilon_P)}. \qquad (\eta\varepsilon_P/(1+\gamma\varepsilon_P) = \beta_P)\end{aligned}$$

Thus, using that the shares sum to one in both worlds,

$$1 = \sum_k \sigma_{kt}\widehat{\sigma}_{kt} = A\sum_k \sigma_{kt}\widehat{\kappa}^{\beta_P}_{kt} \quad\Longrightarrow\quad A = \frac{1}{\sum_k \sigma_{kt}\widehat{\kappa}^{\beta_P}_{kt}}.$$

□

The system of Theorem E.8 is solved by iterating it from $\widehat{\boldsymbol{\sigma}}_t = \mathbf{1}$. Its share equation in logs is $\ln\widehat{\sigma}_{pt} = \beta_P \ln\widehat{\kappa}_{pt} - \ln\sum_k \sigma_{kt}\widehat{\kappa}^{\beta_P}_{kt}$, so substituting $\widehat{\kappa}_{pt} = \widehat{m}_{pt}\sum_q \omega_{pqt}\widehat{m}_{qt}\widehat{\sigma}_{qt}$, a pass

in log shares $x_p = \ln \widehat{\sigma}_{pt}$ is

$$x_p \longmapsto \beta_P \ln\Big(\sum_q a_{pq} e^{x_q}\Big) + c, \qquad a_{pq} = \widehat{m}_{pt}\, \omega_{pqt}\, \widehat{m}_{qt}, \qquad c = -\ln \sum_k \sigma_{kt} \widehat{\kappa}_{kt}^{\beta_P}.$$

The weights $a_{pq} > 0$ are fixed, and c, the normalization, is the same for every parish.

Theorem E.9 (Rate of convergence)**.** *Let $a_{pq} > 0$, let $T(\boldsymbol{x})_p = \beta_P \ln \sum_q a_{pq} e^{x_q} + c_p$ for $\boldsymbol{x} \in \mathbb{R}^N$ and constants $c_1, \dots, c_N$, with $\beta_P \geq 0$, and let $\operatorname{sp}(\boldsymbol{z}) = \max_p z_p - \min_p z_p$ be the span seminorm of $\boldsymbol{z} \in \mathbb{R}^N$. Then*

$$\operatorname{sp}(T(\boldsymbol{x}) - T(\boldsymbol{y})) \leq \beta_P \operatorname{sp}(\boldsymbol{x} - \boldsymbol{y}).$$

Proof. Let $\boldsymbol{v} = \boldsymbol{x} - \boldsymbol{y}$, $\overline{v} = \max_q v_q$, and $\underline{v} = \min_q v_q$. Since $e^{x_q} = e^{y_q} e^{v_q}$ and $e^{\underline{v}} \leq e^{v_q} \leq e^{\overline{v}}$,

$$\underline{v} + \ln \sum_q a_{pq} e^{y_q} \;\leq\; \ln \sum_q a_{pq} e^{x_q} \;\leq\; \overline{v} + \ln \sum_q a_{pq} e^{y_q}$$

$$\Longrightarrow \qquad T(\boldsymbol{x})_p - T(\boldsymbol{y})_p = \beta_P \Big(\ln \sum_q a_{pq} e^{x_q} - \ln \sum_q a_{pq} e^{y_q}\Big) \in [\beta_P \underline{v}, \beta_P \overline{v}]$$

$$\Longrightarrow \qquad \operatorname{sp}\big(T(\boldsymbol{x}) - T(\boldsymbol{y})\big) \leq \beta_P(\overline{v} - \underline{v}) = \beta_P \operatorname{sp}(\boldsymbol{x} - \boldsymbol{y}). \square$$

Theorem E.10 (The aggregate multiplier)**.** *Take the hat system of Theorem E.8 with $\beta_P < 1$, and let $\overline{L} \to \infty$, so that $\pi_t \to 0$. Let $M_t = \big(\sum_k \sigma_{kt} \widehat{\kappa}_{kt}^{\beta_P}\big)^{1/\beta_P}$ be the access change averaged over London with the observed shares as weights. Then*

$$\ln \widehat{V}_t = \eta \ln(\widehat{S}_t M_t) - \gamma \ln \widehat{S}_t,$$

so the aggregate block in changes reads $\ln \widehat{S}_t = \beta_S \ln \widehat{\overline{K}}_t$ with $\widehat{\overline{K}}_t = \widehat{S}_t M_t$, and

$$\ln \widehat{S}_t = \frac{\beta_S}{1 - \beta_S} \ln M_t,$$

with a positive multiplier.

Proof. Corollary E.1 holds in both equilibria, with the same $\tilde{\psi}_{kt}$ since the fundamentals are fixed. Its last display is $\overline{\kappa}'_t / \overline{\kappa}_t = M_t$, so $\widehat{\overline{K}}_t = \widehat{S}_t M_t$, and its first display in ratios is

$$\ln \widehat{V}_t = \eta \ln \widehat{\overline{K}}_t - \gamma \ln \widehat{S}_t = \eta \ln(\widehat{S}_t M_t) - \gamma \ln \widehat{S}_t,$$

which is the first display. As $\overline{L} \to \infty$, $\pi_t \to 0$ and the total of Theorem E.8 is

$\ln \widehat{S}_t = \varepsilon_S \ln \widehat{V}_t$, so

$$\begin{aligned} & \ln \widehat{S}_t = \varepsilon_S \eta \ln(\widehat{S}_t M_t) - \varepsilon_S \gamma \ln \widehat{S}_t \\ \Longrightarrow \quad & (1 + \gamma \varepsilon_S) \ln \widehat{S}_t = \varepsilon_S \eta \ln \widehat{\widehat{K}}_t \\ \Longrightarrow \quad & \ln \widehat{S}_t = \beta_S \ln \widehat{\widehat{K}}_t = \beta_S \left(\ln \widehat{S}_t + \ln M_t \right) \\ \Longrightarrow \quad & (1 - \beta_S) \ln \widehat{S}_t = \beta_S \ln M_t \\ \Longrightarrow \quad & \ln \widehat{S}_t = \frac{\beta_S}{1 - \beta_S} \ln M_t . \end{aligned}$$

The division by $1 - \beta_S$ is legitimate and the multiplier positive because $\beta_S \leq \beta_P < 1$. □

E.8. Relocation and Creation

The change in a parish's count from a counterfactual to the observed equilibrium, $S_{pt} - S'_{pt}$, splits, as in the decomposition of Bennet (1920, p. 457), into relocation, the change in its share at the average total, and creation, its average share of the change in the total.

Theorem E.11 (Relocation and creation). *Let* $\overline{S}_t = \frac{1}{2}(S_t + S'_t)$ *and* $\overline{\sigma}_{pt} = \frac{1}{2}(\sigma_{pt} + \sigma'_{pt})$. *Then*

$$S_{pt} - S'_{pt} = \underbrace{\overline{S}_t (\sigma_{pt} - \sigma'_{pt})}_{\text{relocation}} + \underbrace{\overline{\sigma}_{pt} (S_t - S'_t)}_{\text{creation}}, \tag{E.16}$$

the first term summing to zero over p *and the second to* $S_t - S'_t$.

Proof. Expanding the products,

$$\begin{aligned} \overline{S}_t (\sigma_{pt} - \sigma'_{pt}) + \overline{\sigma}_{pt} (S_t - S'_t) &= \tfrac{1}{2}(S_t + S'_t)(\sigma_{pt} - \sigma'_{pt}) + \tfrac{1}{2}(\sigma_{pt} + \sigma'_{pt})(S_t - S'_t) \\ &= \tfrac{1}{2}\big(S_t \sigma_{pt} - S_t \sigma'_{pt} + S'_t \sigma_{pt} - S'_t \sigma'_{pt} \\ &\qquad + \sigma_{pt} S_t - \sigma_{pt} S'_t + \sigma'_{pt} S_t - \sigma'_{pt} S'_t \big) \\ &= \sigma_{pt} S_t - \sigma'_{pt} S'_t = S_{pt} - S'_{pt}, \end{aligned}$$

and

$$\begin{aligned} \sum_p \overline{S}_t (\sigma_{pt} - \sigma'_{pt}) &= \overline{S}_t \, (1 - 1) = 0, \\ \sum_p \overline{\sigma}_{pt} (S_t - S'_t) &= \tfrac{1}{2}(1 + 1)(S_t - S'_t) = S_t - S'_t. \end{aligned}$$

□

E.9. Estimation, Simulation, and the Aggregate Effect

Procedure E.1 uses the 244 mathematical practitioners of Taylor (1954) and the connections among them documented there and in the Six Degrees of Francis Bacon database (Warren et al., 2016). From Procedure E.2 on, S_{pt} counts those 244 completed with the scientific instrument makers found by later research, the 252 of Clifton (1995) and Hay et al. (2025), 93 of whom are already among the practitioners, so 403 applied scientists

in all (Appendix D.3). They make 797 scientist-decades in 1650–1690, each scientist counted in every decade they were active, 458 of them in parishes that had a coffeehouse by then.

Procedure E.1 (Access, (ϕ, δ))**.** By Theorem E.1, in logs,

$$\mathbb{E}[T_{pqt}] = \exp\big(\ln \chi\rho_t + \phi(D_{pt} + D_{qt}) - \delta d_{pq} + \ln S_{pt} + \ln S_{qt}\big), \tag{E.17}$$

which is (5) with $\mu_t = \ln \chi\rho_t$. The parameters of this conditional mean are consistently estimated by Poisson pseudo-maximum likelihood. The documented connections are undated, so in estimation the mean is summed over the decades in which both practitioners are active, in the parishes where each works in that decade, and the likelihood is evaluated on person dyads, which puts the decade terms inside that sum, one free term per decade. Practitioners with two parishes in a decade count in both, as in the outcomes, and pairs within a parish enter at d_{pp}. The sample is the 14,686 pairs of practitioners active in a London parish in a common decade, 423 of them connected, and standard errors come from 200 bootstrap samples that redraw practitioners, so that pairs sharing a practitioner are drawn together.

Procedure E.2 (The share elasticity, β_P)**.** Indirect inference, in three steps.

1. Run the event study on the observed counts. This gives the post-treatment coefficients $\widehat{\boldsymbol{\tau}} = (\widehat{\tau}_0, \widehat{\tau}_1, \ldots, \widehat{\tau}_4)$ and their standard errors $\mathrm{se}(\widehat{\tau}_0), \ldots, \mathrm{se}(\widehat{\tau}_4)$. The pre-treatment coefficients are not matched, as they are checks on the design.
2. For a trial β_P, build the panel the model implies at the observed geography and run step 1 on it:
   (a) *Fundamentals.* The fundamentals are taken as time-invariant, $\tilde{\psi}_{pt} = \tilde{\psi}_p$. For the trial β_P, recover $\tilde{\psi}_p$ from the pre-coffeehouse decades 1600–1640 by Corollary E.2, $\ln \tilde{\psi}_p = \ln \sigma_p^{\mathrm{pre}} - \beta_P \ln \kappa_p^{\mathrm{pre}} + \tilde{c}$ with $\tilde{c} = 0$, where $\sigma_p^{\mathrm{pre}} = \lambda_p / \sum_k \lambda_k$ is the pre-period share, $\lambda_p = \big(\sum_{t \le 1640} S_{pt} + \frac{1}{2}\big)/5$ the count per decade smoothed by one half, which keeps the parishes with nobody recorded before 1650 from being held at a zero share by construction, and κ_p^{pre} the access these shares imply without coffeehouses ($m_{pt} = 1$).[83]
   (b) *Counts.* For each decade $t = 1600, \ldots, 1690$, with the observed indicators D_{pt}, the fixed $\tilde{\psi}_p$, and the trial β_P, solve the share block: with $Q_{pqt} = m_{pt} e^{-\delta d_{pq}} m_{qt} \tilde{\psi}_q$, that is, (E.13) at $C_t = 1$, iterate $\kappa_{pt} \leftarrow \sum_q Q_{pqt} \kappa_{qt}^{\beta_P}$ in logarithms from any start until it stops changing (Theorem E.5). The shares are (E.12), and since solving at $C_t = 1$ only rescales $\boldsymbol{\kappa}_t$ (Theorem E.5), they are
   $$\sigma_{pt}(\beta_P) = \frac{\tilde{\psi}_p \kappa_{pt}^{\beta_P}}{\sum_k \tilde{\psi}_k \kappa_{kt}^{\beta_P}}.$$
   The model's count is $\sigma_{pt}(\beta_P)\, S_t$ with S_t the observed London total.
   (c) *Coefficients.* Let $\boldsymbol{\tau}(\beta_P)$ denote the post-treatment coefficients of step 1 on the panel $\sigma_{pt}(\beta_P) S_t$.

3. Estimate

$$\widehat{\beta_P} = \arg \min_{\beta_P \in [0, 0.999]} \sum_{\ell=0}^{4} \left(\frac{\widehat{\tau}_\ell - \tau_\ell(\beta_P)}{\mathrm{se}(\widehat{\tau}_\ell)} \right)^2, \tag{E.18}$$

by running step 2 once per trial value of β_P. Figure E1 shows the estimated coefficients and the model's at the estimate. The weighting is diagonal so that the estimate fits the five coefficients themselves rather than the contrasts between them that the inverse covariance weights.

β_S is not identified within London. By Theorem E.3 it enters the model only through the total S_t, and S_t enters the share block only through c_t, which is common to all parishes, so no within-London contrast depends on it. It is bounded, $0 < \beta_S \leq \beta_P$. Yet, it can be calibrated to the aggregate margin, in two designs, each resting on one of the following lemmas.

Lemma E.9 (The aggregate margin). *Let $\theta = \beta_S/(1-\beta_S)$, so that $\ln \widehat{S}_t = \theta \ln M_t$ by Theorem E.10.*

(a) A uniform shock. *If $\widehat{\kappa}_{kt} = e^{2\phi}$ for every parish k, then $\ln \widehat{S}_t = 2\phi\theta$.*

(b) The bracket. *With $u_k = \ln \widehat{\kappa}_{kt}$, $\sum_k \sigma_{kt} u_k \leq \ln M_t \leq \max_k u_k$.*

Proof. (a) Since $\sum_k \sigma_{kt} = 1$,

$$M_t = \left(\sum_k \sigma_{kt} e^{2\phi\beta_P} \right)^{1/\beta_P} = e^{2\phi} \quad \Longrightarrow \quad \ln \widehat{S}_t = \theta \ln e^{2\phi} = 2\phi\theta.$$

(b) Write $\ln M_t = \frac{1}{\beta_P} \ln \sum_k \sigma_{kt} e^{\beta_P u_k}$. Since the weights σ_{kt} sum to one,

$$e^{\beta_P \sum_k \sigma_{kt} u_k} \leq \sum_k \sigma_{kt} e^{\beta_P u_k} \leq e^{\beta_P \max_k u_k} \sum_k \sigma_{kt} = e^{\beta_P \max_k u_k},$$

where the lower-end inequality follows from Jensen's inequality for the convex function e^z and the upper-end one from $e^{\beta_P u_k} \leq e^{\beta_P \max_q u_q}$ for every k. Taking logarithms and dividing by $\beta_P > 0$ gives the bracket. □

Lemma E.10 (The aggregate margin against a control). *Let S'_t be the total with the coffeehouses of decade t removed, so that $\widehat{S}_t = S'_t/S_t$, and let $a_t = -\ln M_t$ be the access lost. Let S_{Rt} be a control series that moves with the same fundamentals up to a linear trend, $\ln S'_t - \ln S_{Rt} = \mu_0 + \mu_1 t + e_t$, with t counted in decades. Then, with $\Delta x_t = x_t - x_{t-1}$,*

$$\Delta \ln \frac{S_t}{S_{Rt}} = \theta \, \Delta a_t + \mu_1 + \Delta e_t,$$

and $0 \leq a_t \leq -\sum_k \sigma_{kt} \ln \widehat{\kappa}_{kt}$ when no parish gains access, $\widehat{\kappa}_{kt} \leq 1$ for every k.

[83] The weight of one half matters for β_P, which is 0.390, 0.485, 0.560, and 0.670 at weights 0, 1/4, 1/2, and 1, but hardly for the aggregate effect of Procedure E.4, 242 to 246 of the 797 scientist-decades at $\beta_S = 0.39$, with 173 to 189 of them in the parishes that had a coffeehouse by the decade. At weight 0, β_P also falls below the instrument makers' $\beta_S = 0.43$ of Procedure E.3, which $\varepsilon_S \leq \varepsilon_P$ rules out.

Proof. By Lemma E.9, $\ln S'_t - \ln S_t = \theta \ln M_t = -\theta a_t$, so

$$\ln S_t - \ln S_{Rt} = \ln S'_t + \theta a_t - \ln S_{Rt} = \mu_0 + \mu_1 t + \theta a_t + e_t,$$
$$\Delta \ln \frac{S_t}{S_{Rt}} = \theta\, \Delta a_t + \mu_1 (t - (t-1)) + \Delta e_t = \theta\, \Delta a_t + \mu_1 + \Delta e_t.$$

For the bounds, with $u_k = \ln \widehat{\kappa}_{kt}$ as in Lemma E.9(b), every $u_k \le 0$ when no parish gains access. Multiplying the bracket of Lemma E.9(b) by -1 reverses its inequalities, and $-\max_k u_k \ge 0$ because every $u_k \le 0$, so

$$0 \le -\max_k u_k \le a_t \le -\sum_k \sigma_{kt} u_k. \qquad \square$$

Procedure E.3 (The aggregate margin, β_S)**.** Both designs read the aggregate response off the European panel of Section 6, 200 cities of 10,000 or more inhabitants in 1600 over 1600–1690, 37 of them with a coffeehouse before 1700, the outcome the count of applied mathematics titles printed in the city (the Universal Short Title Catalogue) or of scientific instrument makers active there (Webster and Webster, 2007).

1. *Cities.* A city whose applied scientists do not move to other cities is the economy of Theorem E.10. Its first coffeehouse, read as reaching the whole city, is $\widehat{m}_{kt} = e^{\widehat{\phi}}$ in every parish, so by Theorem E.8 $\widehat{\kappa}_{kt} = e^{2\widehat{\phi}}$ for every k and the shares do not move, and by Lemma E.9(a) it raises the city's log count by $2\widehat{\phi}\theta$. We estimate this rise in Section 6 as $\ln(1 + b/\text{base})$, with b the mean post-entry effect over event times 0 to 3 and base the treated cities' mean count in the decade before entry, so $\theta = \ln(1 + b/\text{base})/(2\widehat{\phi})$ and $\beta_S = \theta/(1+\theta)$. Titles give $\beta_S = 0.35$ (s.e. 0.12) and instrument makers $\beta_S = 0.43$ (0.15), with parametric-bootstrap standard errors over b and $\widehat{\phi}$.[84]
2. *London against the other European cities.* Removing London's coffeehouses in decade t is $\widehat{m}_{pt} = e^{-\widehat{\phi} D_{pt}}$. The share system of Theorem E.8 then gives $\widehat{\kappa}_{pt}$, which is below one in every parish and decade, and a_t follows at the observed counts and shares, $(\widehat{\phi}, \widehat{\delta})$, and β_P. With the sum over the other 199 cities as the control S_{Rt}, Lemma E.10 makes θ the coefficient of Δa_t in the least-squares regression of $\Delta \ln(S_{Lt}/S_{Rt})$, with S_{Lt} London's count in the panel, on Δa_t and a constant over 1600–1690, nine differences. Titles: $\theta = 0.43$ (s.e. 1.37), $\beta_S = 0.30$. Instrument makers: $\theta = 0.23$ (0.67), $\beta_S = 0.18$. In a parametric bootstrap over θ, β_S has upper ends of 0.76 and 0.61 and no lower end, since $\theta = -1$, where $\theta/(1+\theta)$ is unbounded, lies within two standard errors of both estimates.

The remaining parameters are not estimated. γ and ε_P are not identified, since the data speak to β_P alone (Corollary E.2). Both can be set from the quantitative urban literature, which measures them in other places and centuries: modern Berlin and

[84] The standard error is half the distance between the 16th and 84th percentiles of 20,000 draws of b and $\widehat{\phi}$ from normal distributions at their estimates and standard errors, which matches the standard deviation when the draws are normal. The standard deviation itself is not informative here: $\beta_S = \theta/(1+\theta)$ is unbounded as θ approaches -1, and the few draws that come close dominate it. The draws also have heavier tails than a normal distribution, with 2.5th and 97.5th percentiles of 0.06 and 0.67 for titles and -0.20 and 0.75 for instrument makers.

London give the premises share $\gamma = 0.225$ and the commuting dispersion $\varepsilon_P = 5$ (Ahlfeldt et al., 2015; Heblich et al., 2020), so that $\eta = \beta_P(1 + \gamma\varepsilon_P)/\varepsilon_P = 0.238$ by (E.4), and postwar American occupational choice gives ε_S between 1.5 and 2.7, with 2 the base case (Burstein et al., 2019; Galle et al., 2023; Hsieh et al., 2019; Lagakos and Waugh, 2013). The implied $\beta_S = \beta(2) = 0.33$, and 0.27 to 0.40 over that range, is a check on the values calibrated in Procedure E.3, 0.18 to 0.43, not a measurement of β_S.

Procedure E.4 (The aggregate effect)**.** With (ϕ, δ), β_P, and β_S in hand, the no-coffeehouse counterfactual is computed decade by decade for 1650–1690, in ratios and from the observed decade alone, with the fundamentals held fixed (Theorem E.8). For one decade:

1. *Baseline.* From the observed counts and geography, the shares $\sigma_{pt} = S_{pt}/S_t$, the access shares ω_{pqt} of Definition E.6, and the treatment ratios $\widehat{m}_{pt} = e^{\phi(D'_{pt} - D_{pt})}$, here $\widehat{m}_{pt} = e^{-\phi D_{pt}}$ since every coffeehouse is removed ($D'_{pt} = 0$). Parishes with $S_{pt} = 0$ stay at zero.
2. *Shares.* Solve the share system of Theorem E.8 for $\widehat{\sigma}_{pt}$ and $\widehat{\kappa}_{pt}$ by iterating it from $\widehat{\boldsymbol{\sigma}}_t = \mathbf{1}$ until nothing changes. By Theorem E.9 each pass contracts the error by β_P, and the solution is the unique one of Theorem E.5 applied to the kernel $\widehat{m}_{pt}\omega_{pqt}\widehat{m}_{qt}$.
3. *Total.* $\ln \widehat{S}_t = \frac{\beta_S}{1-\beta_S} \ln M_t$ by Theorem E.10.
4. *Counts.* The counterfactual count is the observed count times its ratio, $S'_{pt} = \widehat{S}_{pt} S_{pt}$ with $\widehat{S}_{pt} = \widehat{\sigma}_{pt}\widehat{S}_t$ (Theorem E.8), and the decade's aggregate effect is $\sum_p (S_{pt} - S'_{pt})$. Theorem E.11 splits each parish's change into relocation and creation.

Procedure E.1 gives $\phi = 0.554$ (s.e. 0.20) and $\delta = 0.277$ (0.12), Procedure E.2 $\beta_P = 0.560$, and Procedure E.4 turns each value of β_S from Procedure E.3 into the aggregate effect of Table E1, with $\beta_S = 0$ and the bound $\beta_S = \beta_P$ alongside. We prefer the city estimates for their statistical power: they compare 37 treated cities with 163 never treated, whereas London against the other cities is one series of nine differences, which leaves β_S without a lower end. Their average, $\beta_S = 0.39$, is the preferred value. At it the parishes that had a coffeehouse by the decade lose 182 of the 243 scientist-decades and the others a net 61, and coffeehouses account for 46 percent of the rise in the number of applied scientists from the 1640s to the 1690s (40 to 52 at the two city estimates).

E.10. Figures

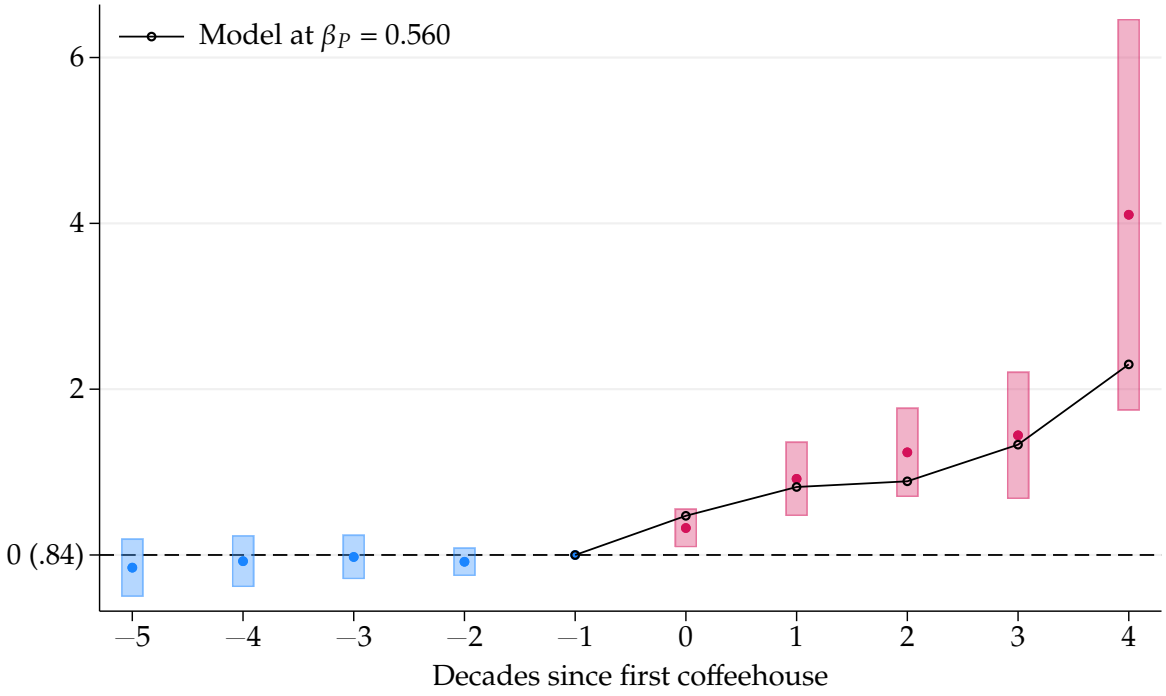


Figure E1. The event study and the model at the estimated β_P

Notes: Dots with bars: the coefficients $\widehat{\tau}_\ell$ of the event study on the observed counts of the combined roster, step 1 of Procedure E.2, with 95 percent intervals, the decade before entry normalized to zero, drawn as in Figure 4 (blue before entry, red after, the treated parishes' mean count in the decade before entry beside the zero tick). Line with hollow markers: the post-treatment coefficients $\boldsymbol{\tau}(\widehat{\beta_P})$ of the same event study on the panel the model implies, step 2, at the estimate $\widehat{\beta_P} = 0.560$ of (E.18). Only the post-treatment coefficients are matched. [Return to pages 36, OA-103]

E.11. Tables

Table E1—The aggregate effect of removing every coffeehouse, 1650–1690

		Aggregate effect		Gain of the treated parishes	
	β_S	Count	Percent	Relocation, %	Creation, %
No aggregate response	0.00	0	0	100	0
London against Europe, titles	0.30	172	22	31	69
London against Europe, makers	0.18	96	12	46	54
Cities, titles	0.35	212	27	26	74
Cities, makers	0.43	276	35	21	79
Average of the two city estimates	0.39	243	31	23	77
Upper bound, $\beta_S = \beta_P$	0.56	405	51	14	86

Notes: Procedure E.4, the five decades summed, on the combined roster of applied scientists. Count in scientist-decades, percent of the 797 observed. The last two columns take the gain of the parishes that had a coffeehouse by the decade, $S_{pt} - S'_{pt}$ summed over those parishes and the five decades, and split it into the relocation and creation terms of Theorem E.11, summed the same way, each in percent of the gain. Relocation is the part that the counterfactual places in other London parishes, and creation the part it places outside science. β_S from Procedure E.3: titles are the applied mathematics titles printed in a city and makers its scientific instrument makers. Light shading marks the two city estimates and dark shading their average, the preferred value. [Return to pages 37, OA-105]

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