Flow of Ideas: Economic Societies and the Rise of Useful Knowledge *

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Abstract

Economic societies emerged during the late eighteenth-century. We argue that these institutions reduced the costs of accessing useful knowledge by adopting, producing, and diffusing new knowledge. Combining location information for the universe of 3,300 members across active economic societies in Germany with those of patent holders and World's Fair exhibitors, we show that regions with more members were more innovative in the late nineteenth century. This long-lasting effect of societies arguably arose through agglomeration economies and localized knowledge spillovers. We provide evidence to support this claim that suggests an immediate increase in manufacturing, an earlier establishment of vocational schools, and a higher density of highly skilled mechanical workers by mid-nineteenth century in regions with more members. We also show that regions with members from the same society had higher similarity in patenting, suggesting that social networks facilitated spatial knowledge diffusion and shaped the geography of innovation.

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"Their Intention is not to amuse the Publick with nice and laboured Speculations; or to enrich the learned World with new and curious Observations: But, in the plainest Manner, to direct the Industry of common Artists; and to bring practical and useful Knowledge from the Retirements of Libraries and Closets into the publick View: In short, to be universally beneficial in their only End: and whether they attain it, by making new Discoveries, or publishing those already made; by increasing the present Fund of Knowledge, or by conveying it into more Hands, is to them perfectly indifferent."

– The Dublin Society (1736)

1 Introduction

Technological progress is central to economic growth. Prior to modern growth, technological advances resulted from tinkering rather than directed research and were not informed by scientific methods. During the Industrial Revolution, inventors increasingly relied on the methods and ideas brought about by the Enlightenment and the Scientific Revolution.[1] The shift towards using scientific methods, e.g., measurement, replication, and experimentation, arguably changed the way engineers and mechanics of the time improved technologies and invented new ones. Access to such useful knowledge became crucial to push the technological frontier. To what extent access to new knowledge affected technological change during the Industrial Revolution is ultimately an empirical question that is hard to answer in the absence of systematic data.[2]

In this paper, we focus on economic societies, institutions committed to improving the local economy by adopting, producing, and diffusing useful knowledge, and investigate their role for innovation during the Industrial Revolution. Economic societies emerged during the eighteenth century all across Europe. They collected, systematized, and promoted the diffusion of useful knowledge among their members, thereby arguably facilitating innovation and sustained technological progress.[3] To do so, societies held regular meetings with debates and public lectures, held contests with prizes awarding innovations, published periodicals with articles discussing recent advances in useful knowledge, and maintained substantial libraries providing members with access to recent scientific books. Several economic societies also established educational institutions instrumental to the training of mechanically-skilled individuals. In addition, economic societies contributed to an increasing flow of ideas because their members formed a social network in which barriers to communication were low. In line with Mokyr (2005), we thus argue that economic societies reduced

[1]For details on the scientific knowledge of engineers and entrepreneurs during the Industrial Revolution and their (lack of) formal education, see, e.g., Allen (2009); Jacob (2014); Meisenzahl and Mokyr (2012); Mokyr (2009); Ó Gráda (2016)

[2]Thus far, the literature has presented econometric evidence on innovative activities undertaken by individuals with formal training in occupations with useful knowledge (see, e.g., Mokyr, Sarid and van der Beek, forthcoming; Maloney and Caicedo, forthcoming) or the growth effects of individuals that had access to a specific body of useful knowledge, such as Diderot's Encyclopédie (see, e.g., Squicciarini and Voigtländer, 2015).

[3]For historian's perspectives on economic societies, see Stapelbroek and Marjanen (2012), Lowood (1989), or Howes (2020).

the costs of accessing new useful knowledge and thereby contributed to the technological progress central to the Industrial Revolution.

This paper presents evidence on the impact of economic societies on innovative activity in Germany.[4] Despite their late adoption, Germany provides an ideal setting to study the impact of economic societies for two reasons. First, in contrast to other countries such as Britain and France, where the spatial location of societies concentrated on commercially active capital cities, the process was highly decentralized in Germany. Here, economic societies were created across polities of different size and with a considerable spatial distribution of membership. Secondly, most economic societies were established within a short time period in response to the Seven Years' War (1756–63). Facing significant deprivation and population losses, local rulers issued decrees for their establishment to facilitate economic activity. The highly decentralized formation process, in combination with the absence of comparable institutions prior to the end of the Seven Years' War facilitates our econometric approach to identify the local impact of societies.

To quantify the contribution of economic societies to technological progress during the Industrial Revolution, we use hand-collected information from membership registers across the universe of active economic societies established between 1764 and 1800 in Germany. We geo-referenced the location of more than 3,300 individual members organized in 15 societies, which reflects variation in access to useful knowledge across space. To combine this information with geo-referenced measures of innovation, we aggregate our data to grid cells of 0.1×0.1 degrees (ca. 15×15 kilometers) encompassing Germany in its borders of 1871. To estimate the long-term impact of societies at the local level, we measure innovation in two ways, either by the number of patents granted in Germany in the period 1877–1914 or by the number of German exhibitors at the 1873 Vienna World's Fair.

We find that doubling the local density of society members is associated with a 19% increase in the density of valuable patents granted in Germany during the Industrial Revolution. The same increase in member density raises the local density of exhibitors at the 1873 Vienna World's Fair by 12%.

We address the concern that society members are not randomly distributed across space by exploiting exogenous variation in distance to the nearest society seat, the location where all society activities took place. Because the costs of participating in society activities, such as debates and official meetings, arguably increase in distance to the society seat, membership density is found to be lower in grid cells further away from the operational center. Identification assumes that distance to the nearest society seat would be (conditionally) excludable from a regression of innovation on society members.[5] We provide both historical and indirect econometric evidence in support of the exclusion restriction. In accordance with the historical literature (see, e.g., Bödeker, 2012), we argue that societies seats did not systematically select into commercial or educational centers

[4] For simplicity, we refer to the territory of interest in this paper as Germany, despite the fact that it changed its name and borders several times during the eighteenth and nineteenth century. In the quantitative analysis, we will focus on the German Empire at its borders of 1871.

[5] When interpreting the emergence of societies as a shock to useful knowledge that occurred after 1763, one would also need to assume that regions followed common trends, independent of their distance to the nearest society seat, in the absence of societies.

in Germany. Furthermore, we present evidence that, independent of their distance to the nearest society seat, regions were on similar trends with respect to the attraction and presence of upper-tail human capital prior to the emergence of societies. For this purpose, we exploit information from biographies of about 6,500 notable individuals listed in the *Deutsche Biographie* (BADW, 2021) in an event-study setup and show that our instrumental variable is unrelated to pre-existing trends in the attraction and presence of such individuals. When using distance to the nearest society seat as an instrumental variable, OLS findings are confirmed.

We undertake several exercises to investigate the channels linking the emergence of economic societies during the last third of the eighteenth century with innovation during the Industrial Revolution. We start by providing evidence for the immediate effects of societies on economic activity. Using a list of all manufactories established in Saxony from the late 16th to early 19th century, we find significantly more of these proto-industrial establishments in regions with more members after 1764. This increase is largely borne by manufactories in textile production, a special focus of the Saxon society that offered several prize competitions for improvements in textile materials and production processes. We argue that the resulting increase in local economic activity may have led to agglomeration economies in manufacturing.

Next, we inspect whether economic societies contributed to the foundation of vocational schools and affected the local stock of skilled mechanics in the first half of the nineteenth century. Consistent with the historical narrative on the activities of economic societies, we argue that many economic societies established vocational schools that provided the necessary training to generate highly-skilled mechanics who played a crucial role in supporting the implementation of new technologies. Vocational schools thereby created agglomeration economies and facilitated the local persistence of technological progress. To test these potential channels, we collected data on the founding years of vocational schools across Germany. Estimates from standard duration models (i.e. Cox proportional hazard models) show that the presence of society members in a region accelerated the adoption of vocational schools. Furthermore, using a sample of Prussian cities for which we have detailed information on the occupational structure in 1849, we show that regions with a higher density of society members also have a higher density of highly-skilled mechanics, but not of other artisans.

Finally, we test the hypothesis that societies facilitated the diffusion of ideas by lowering the costs of accessing useful knowledge. We argue that, because they share a common set of specific technical knowledge, grid-cell pairs with members from the same society should display a similarity in the type of technology used and invented. To test this hypothesis, we inspect technological similarity in patents between grid-cell pairs ($n \approx 365,000$) based on an index proposed by Jaffe (1986) and refined by Bloom, Schankerman and Van Reenen (2013). When estimating a gravity-type specification with origin and destination fixed effects, we find that, conditional on geographic distance, grid-cell pairs with members from the *same* society display a significantly higher technological similarity of their patented innovations. Such similarities are not found in grid-cell pairs with members from *different* societies that arguably did not share the same specific useful knowledge. Our estimates suggest that a connection within the social network of a society had an impact on technological similarity equivalent in magnitude to a railroad connection.

Our paper contributes to the debate on the determinants of technical change during the Industrial Revolution. The most prominent contributions emphasize changes in the demand for new technologies driven by the incentives of inventors to mechanize and reduce labor costs (Allen, 2009) or changes in the supply of new technologies driven by the availability of scientific knowledge following the Enlightenment (Mokyr, 2009, 2016).[6] We contribute to this debate by highlighting the importance of economic societies in providing access to useful knowledge and diffusing it.

The inventors of the Industrial Revolution have largely been described as lacking formal education (Allen, 2009; Jacob, 2014; Mokyr, 2009) so that education was deemed irrelevant for the inventions of the Industrial Revolution in England.[7] More recent scholarship adopts a broader definition of human capital. A new emphasis has been given to the upper tail of the skill distribution that constitutes 3–5% of the labor force (Meisenzahl and Mokyr, 2012). Within this upper tail, the highly-skilled mechanics, so-called 'tweakers', seem to have been essential for technological change during the British Industrial Revolution. A study by Mokyr, Sarid and van der Beek (forthcoming) suggests that English millwrights and their engineering skills were particularly advantageous for technology adoption. Kelly, Mokyr and Ó Gráda (forthcoming) show that mechanical skills were conducive to the industrialization of British textiles and metallurgy.

Related studies provide evidence for the role of craftsmen skills in Prussian innovation (Cinnirella and Streb, 2017), the importance of engineers for U.S. patenting (Maloney and Caicedo, forthcoming), or study the emergence of engineers in England (Hanlon, 2020). Focusing on higher education, Dittmar and Meisenzahl (2020*b*) suggest that the probability that inventors were educated or employed at German universities increases after 1800.[8] Proxying the entire upper-tail of the human capital distribution with the subscriber density of Diderot's famous *Encyclopédie*, Squicciarini and Voigtländer (2015) show that French knowledge elites are positively associated with city growth.

While the literature emphasizes the effect of training for the formation of upper-tail human capital, we add that social interactions constitute an additional source for the formation of upper-tail human capital conducive to innovation during the Industrial Revolution.[9] Thus far, knowledge

[6] A related literature debates whether technical change during the early Industrial Revolution was skill-biased or unskill-biased. Recent evidence supports the view that new technologies stimulated the formation of working skills in England (Feldman and Van der Beek, 2016; Zeev, Mokyr and Van Der Beek, 2017; De Pleijt, Nuvolari and Weisdorf, 2020) and advanced literacy and school enrollment in France (Franck and Galor, forthcoming).

[7] This resonates with earlier work by Mitch (1993), Allen (2003), and Mokyr (1992) arguing that formal education was irrelevant for the Industrial Revolution in England in general. Nevertheless, Becker, Hornung and Woessmann (2011) provide evidence that basic schooling was important for the catch-up of the technological followers such as Prussia.

[8] Other studies that focus on the upper-tail of the human capital distribution informed by higher education includes the literature on land-grant universities in the U.S. (see, e.g. Kantor and Whalley, 2019; Andrews, forthcoming). Focusing on European universities, De la Croix et al. (2020) inspect the functioning of the academic market analyzing migration patterns of students 1000-1800 and Dittmar and Meisenzahl (2020*a*) study the effect of political changes induced by the Protestant Reformation on the accumulation of upper-tail human capital.

[9] Note that we will not be able to disentangle whether economic societies contribute to innovation because they facilitate human capital formation via training or social learning, or because they facilitate social capital formation.

elites have predominantly been viewed as isolated individuals that combine and expand existing knowledge. It is however conceivable that the social network of knowledge elites contributes to their human capital formation. This is in line with Akcigit et al. (2018) who model and empirically confirm that the interaction of researchers leads to knowledge diffusion that contributes to individual human capital formation and productivity, thereby feeding into innovation-based growth. In combination with models of localized knowledge spillovers and agglomeration economies (see, e.g. Krugman, 1991; Glaeser et al., 1992; Ellison and Glaeser, 1997; Audretsch and Feldman, 2004), such a framework could explain the persistent effect of economic societies on innovation in Germany.

We thus connect to the literature emphasizing the importance of social networks for invention and technological diffusion.[10] For example, Andrews (2019) shows the consequences of limited social interactions for innovation when bars closed during the prohibition era, whereas Burlig and Stephens (2019) show that mergers between social networks increased the rate of agricultural technology adoption among farmers in the U.S.[11] We also contribute to a literature acknowledging that access to knowledge is costly and that the reduction of barriers to knowledge flows increases technological diffusion and adoption. For example, Iaria, Schwarz and Waldinger (2018) inspect the collapse of international science as an event that increased the cost of accessing knowledge. Abramitzky and Sin (2014) analyze how the collapse of Communism's in Eastern Europe affected the international flow of ideas via translations. Other studies rely on the idea that migration changes the supply of human capital and facilitates knowledge diffusion and innovation by lowering barriers to personal interaction (see, e.g. Hunt and Gauthier-Loiselle, 2010; Bloom, Van Reenen and Williams, 2019). A number of studies in this field rely on historical migration shocks such as the inflow of German Jewish scientists into the U.S. in the 1930s (Moser, Voena and Waldinger, 2014), the inflow of Huguenots into Prussia (Hornung, 2014), the inflow of Danish migrants to the U.S. (Boberg-Fazlic and Sharp, 2019), or the Age of Mass Migration to the U.S. (Sequeira, Nunn and Qian, 2020).

The remainder of this paper is organized as follows. In Section 2, we provide the historical background on economic societies, their activities, mission, and members. Section 3 describes our main dataset. Section 4 presents our main results with respect to long-run innovation outcomes, including a discussion of identification issues. Section 5 presents results on the immediate impact focusing on the Saxon society. Section 6 provides evidence for potential channels through which economic societies affected innovation in the long-run. Section 7 presents evidence for knowledge flows between society members, before Section 8 concludes.

[10]Another related literature emphasizes the importance of physical infrastructure networks for innovation and technological diffusion. The role of transport infrastructure for the diffusion of ideas and culture have recently been analyzed by Andersson, Berger and Prawitz (2020) and Melander (2020) for Sweden, by Tsiachtsiras (2020) for France, and by Flückiger et al. (forthcoming) for ancient Rome.

[11]This also relates to a literature on social learning and diffusion of agricultural technologies in development economics (see, e.g. Foster and Rosenzweig, 1995; Conley and Udry, 2010; Bandiera and Rasul, 2006).

2 Historical background on the economic societies

The late Enlightenment spawned a plethora of associations, clubs, and salons. This way of formalizing relationships between individuals with a common interest first caught on to elite circles but eventually became a bourgeois phenomenon. Many of the resulting institutions, most notably secret societies such as *Freemasons* and *Illuminati* were very exclusive, catered only to elites, and aimed at advancing the interests of their members. Others, while interested in promoting knowledge creation were not interested in useful knowledge and its application. Hence, economic societies differed from all other Enlightenment institutions in their activities, which aimed at the improvement for the common good and the application of useful knowledge, and in their membership, which was based on openness and equality. We discuss these two major distinctions in greater detail in Sections 2.2 and 2.3. Although we largely focus on German economic societies, the information presented below will often generalize to societies in other countries.

2.1 Emergence and diffusion in Europe and Germany

Economic societies first emerged in early eighteenth-century Great Britain and Ireland, specifically in Edinburgh (1723), Dublin (1731), and London (1754).[12] These were voluntary organizations with the aim to improve the economy for the common good, initially confined to agriculture but soon extended to industry, commerce, and society at large (see Stapelbroek and Marjanen, 2012). They promoted the sharing of new production techniques, new materials, and new agricultural practices and aimed at expanding the existing knowledge using systematization and experimentation, thereby reflecting the emerging culture of practical improvement (see Slack, 2014).

The economic society movement spread all across Europe, reaching as far as New York and St. Petersburg.[13] Many societies broadly emulated the societies in Dublin and London that also formed the blueprint for several economic societies in Germany.[14] In their names, several German societies featured the terms *gemeinnützig*, reflecting their service for the common good and *patriotic*, reflecting loyalty and love for their state or region that was typically associated with republican rather than royalist ideals (Engelhardt, 2007).[15] In Appendix A.1, we show that the emergence of economic societies coincides with a drastic shift towards expressing an interest in useful knowledge

[12] The *Society of Improvers in the Knowledge of Agriculture* was founded in 1723 Edinburgh. Although only short-lived until 1745, it gave rise to the *Dublin Society for improving Husbandry, Manufactures and other Useful Arts* established in 1731 as well as the *Society for the Encouragement of Arts, Manufactures and Commerce* in London established in 1751. For the Scottish Society see Bonnyman (2012) and Smout (2012), for the Dublin Society see Livesey (2012), and for the Society of Arts see Howes (2020).

[13] The estimated number of societies in the world range from 233 in Engelhardt (2007) to 562 in Stapelbroek and Marjanen (2012).

[14] Braun (1980, p. 245) describes how shortly after the foundation of the economic society in Leipzig, the society started to correspond with the society in London, asking for its catalogue of prize competitions as well as for its statutes. The economic society in Leipzig further profited from having a correspondent in London who informed the society in Leipzig of the activities of the Society of Arts (Braun, 1980, pp. 245, 251). The society in Celle also drew on the statutes of the Society of Arts for their own statutes (KLGC 1864).

[15] Note that eighteenth-century patriotism reflects pre-national sentiments of identity that span across ethnicities and even nationalities.

and improvement for the common good in the German historical literature, using German book titles within the Google ngram catalogue.

Economic societies in Germany emerged in the aftermath of the Seven Years' War. Economic deprivation and population losses due to the war motivated local rulers to initiate economic societies to revive the local economy (Rübberdt, 1934, p. 51, 57; Braun, 1980, p. 244).[16] Several rulers, among them many prince-electors of the Holy Roman Empire, granted charters and monopolies to societies. After a first wave of society foundations in the late 1760s and early 70s, a second wave of foundations occurred in the late 1780s and early 90s. During the period of French occupation many societies dissolved, were only re-established after 1812, and rarely managed to live up to their earlier acclaim.[17]

In contrast to Britain, where societies were initiated by merchants, artisans, and inventors, the literature describes the process of society foundation in Germany as top-down. Sometimes the impetus for their creation was given by local rulers who commissioned government officials with the organizational issues. In several cases, these officials established society seats in their home towns (see Appendix A.2 an example). In the eighteenth century, the origin of noble state officials rather reflected the old feudal order than location of the new commercial classes. Thus, the historical literature agrees that societies were not created in centers of commerce and education (see Schlögl, 1993, p. 68, Tosch, 2012, p. 310, Bödeker, 2012, p. 183).

2.2 Mission and activities

Whereas universities, academies, and other learned societies were interested in advancing scientific knowledge for its own sake, the activities of economic societies explicitly aimed at generating and applying useful knowledge at the local level. According to Lowood (1989) no "other set of organizations in Germany, even the much touted universities, better exemplified the scientific, economic, and technological interests of active citizens in the Spätaufklärung [*late Enlightenment*]." Economic societies typically had the explicit statutory mission to improve the local economy for the common good. To accomplish this, economic societies aimed to provide their members with access to useful knowledge. For example, the economic society in Hamburg aimed "[...] to apply every useful result of human knowledge, discovery, and invention to practical and civic life" (translation by Lowood, 1989, p. 22).[18] Table A.1 in the Appendix provides an overview of mission statements for all societies in our dataset.

[16]For evidence of how rulers initiated the foundation of economic societies, see Am Ende (1884, p. 6) for Leipzig, Rübberdt (1934, p. 57) for Celle, Popplow (2010, p. 181) for Lautern, and Rübberdt (1934, p. 80) for the Prussian societies in Silesia.

[17]In the 19th century, societies were increasingly replaced by trade associations such as the Prussian *Verein zur Beförderung des Gewerbefleißes in Preußen*. However, some few societies, such as the Patriotische Gesellschaft in Hamburg remain active until today.

[18]Hubrig (1957, p. 49) lists the following achievements of the Hamburg society during the first twenty years of its existence: introduction of the lightning rod in Hamburg (first appearance in Europe), improvement of street lighting (1767–1771), establishment of a drawing school for 12 students (1767), introduction of vocational schooling, supply of improved fire pumps for the fire station (1769), improvement of street paving (1782), and erection of wind mills to drain tidal wetlands.

The core activities of economic societies included promoting new ideas by granting prizes and rewards, and diffusing new ideas through debates, lectures, collections, and journals. Most activities took place in the operational center, the society seat. Here, members met on a regular basis for debates and public lectures, often organized by sections assigned to specific fields (such as history, geography, philosophy, physics, economics, philology). Here, societies also kept large libraries, filled with recent advances in many fields, and permanent collections displaying curious instruments and machines, accessible for all society members. Societies also published journals to which members submitted articles. Often, there was a core set of active members with a long publication record, ranging from translations of foreign scholarly work into German to reports on their own experiments. To extend access to useful knowledge to non-members, some societies published cheaper versions of their journals for the general public.[19] Well-endowed societies frequently held competitions and awarded prizes toward solving specific known problems in various disciplines. For experimentation and application of new methods, some societies operated demonstration factories and farms.

Societies especially emphasized the verification and falsification of new practices through tests and experiments. Several societies sent out instructions for new practices in agriculture and the trades to their members, asking them to try these practices and to report on their success in questionnaires. The economic society in Burghausen even included a rule in their statute that required each member to do either one experiment, one communication entry, or one empirical observation per year (Lowood, 1989, p. 48). Often, questionnaires were combined with prize competitions for solving a question or producing a certain good.[20]

Despite their focus on applied practices, economic societies also provided access to state-of-the-art scientific knowledge. Table A.4 in the Appendix lists all journal subscriptions held by the society in Breslau in 1806, including many international publications, such as the *Philosophical Transactions* of the Royal Society of London, *Nicholson's Journal of Natural Philosophy, Chemistry, etc.*, *the Annales de Chemie*, and the *Annales des arts, manufactures etc.* In 1828, the society in Potsdam held a total of 1072 books, notable for their practical focus on e.g., agriculture, mineralogy, and engineering (KMÖG, 2021).

Importantly, next to the above activities, societies advanced the diffusion of useful knowledge through the establishment and administration of schools, especially for vocational training. Among a list of 502 society projects compiled by Lowood (1989, p. 88), there are 21 schools founded between 1765 and 1810. For example, in 1791, the Leipzig society established a school after finding that "sustaining the flow of new products and inventions proved difficult, though it sharpened the society's awareness of the need for improving the level of education and training among instrument

[19]For example, the society in Potsdam published a monthly non-member journal (*Gemeinnütziges Volksblatt*) that was meant to be displayed in every parish and city (see Schultze, 1964; Tosch, 2010).

[20]For example, in 1792, the economic society in Potsdam awarded 10 Prussian gold coins towards the invention of a plough that could be build by any commoner. Table A.2 in the Appendix provides an overview of the prizes that were offered by the Leipzig society between 1764 and 1790. It illustrates that most prize questions were aimed at concrete practices of the trades and agriculture. Table A.3 in the Appendix lists all "natural and artificial products", including both new raw materials and finished goods, presented to the society from 1764 to 1767.

makers and others in the mechanical trades" (Lowood, 1989, p. 125).[21] As another example, the Hamburg society opened specialized schools that used their vast collection of instruments and working scale models to train artists and artisans.

2.3 Membership and organization

In contrast to other Enlightenment associations, economic societies generally did not impose restrictions on membership and did not aim at exclusivity (Lowood, 1989, p. 24). They were private institutions whose statutes typically granted admission to any individual who applied for it.[22] If formal requirements for membership were established, they requested, e.g., the submission of written scientific work.

The organization of economic societies was based on egalitarian principles. Due to the fact that societies were influenced by republican ideals, statutes determined that all members had equal rights and could participate equally in decision making (Im Hof, 1990). Remarkable for the eighteenth century, economic societies mixed noble and non-noble members and thereby broke with social traditions. Nevertheless, many societies imposed membership fees, thereby effectively excluding the lower classes from joining. Thus, despite their official claim to be open for everyone, members predominantly came from the upper-middle class, including government officials, physicians, academics, priests, merchants, and craftsmen. Among these, government officials stand out as the largest group across German societies. Figure A.2 in the Appendix shows the distribution of occupations across society members included in our analysis. It is important to note that information on the occupation of members is missing for about half of the sample.

Most societies had three types of members: ordinary, corresponding, and honorary.[23] Ordinary members built the core of the society and were residents at the society seat; corresponding members resided elsewhere and were invited to attend the meetings and submit articles to the society journal.[24] In contrast, honorary membership was often granted by invitation to high-ranking members of the administration or affluent patrons who usually did not participate in the society activities (Schlögl, 1993, p. 75). In other cases, honorary members were well-known scholars that were expected to actively contribute to publishing activities of the society. Hierarchies between different types of members were nevertheless flat and they interacted on equal footing.

[21] Peter Graf von Hohenthal, the co-founder of the Leipzig society, was a known advocate of school reforms. Engelhardt (2007, p. 211) confirms that Danish economic societies "established elementary schools and peasant libraries, they held reading circles and distributed publications aimed at increasing productivity and improving the morals of the peasants."

[22] The economic society of Silesia provides a vivid example for such open access ideals. According to Lowood (1989, p. 25): "Members should not expect their society to become an "imitation of learned academies on a small scale." It is more important that they remain open to every good citizen, especially the "patriot and the businessman," and never close into a circle of scholars who work for personal reputation or livelihood, rather than the welfare of their fellow man." The Saxonian society in Leipzig invited anyone to join: "every farmer of whatever class, even peasants, artisans, craftsmen, foresters, gardeners" (Lowood, 1989, p. 34). Members of the economic society of Schleswig-Holstein at Kiel vowed that "no rank and no title means anything to us" (Lowood, 1989, p. 37).

[23] Societies in free imperial cities (Hamburg, Lübeck, Nürnberg) did not have corresponding members but only residents.

[24] Statutes that stipulated the privileges of these members widely differ across societies.

New members joined societies either because they had social ties to other members or because they learned about the society from newspapers. Societies actively advertised their formation in advance and reported on their activities to acquire as many potential members as possible. Typically, a core set of founding members would try to enlist accomplished people from various fields.[25]

3 Data

A substantial effort was devoted to collect information on the members of economic societies. We further collected data that measure local innovation activity and human capital from various sources that we describe in detail below. All of these data were geo-located and subsequently aggregated to the respective level of observation, typically grid cells of of 0.1×0.1 degrees (ca. 15×15 kilometers) size. Summary statistics are presented in Table B.2 in the Appendix.

3.1 Economic society members

The literature disagrees on the number of societies that existed, not least because many of them were short-lived or did not engage in substantial activities. Reasonable accounts by van Dülmen (1986) and Bödeker (2012) conjecture that about 60 societies with between 4,000–5,000 members existed in the German language area, 35 of which had their society seat located within the borders of the German Empire (see Appendix B.3 for the full list). While a number of societies actively engaged in publishing journals, thereby leaving a testimony of their existence, others were discontinued shortly after their establishment and left few traceable marks.

Combining the list in van Dülmen (1986) with information from Rübberdt (1934) and our own investigation, we identify 15 societies that match our criteria for an active economic society. In particular, we include societies and their members in our dataset if: (i) their seat was located within the borders of the German Empire of 1871, (ii) the society had the explicit aim to engage in the advancement of the local economy according to their statutes, (iii) the society addressed more than one field of the local economy,[26] (iv) the society actively engaged in publishing or funding of projects for more than one year, (iv) the society was established before 1800. We report information on the 15 societies that match our criteria in Table 1.

In contrast to secret societies, economic societies prided themselves with their members and frequently published registers in society journals. For each of these societies, we thoroughly searched their publications for membership lists and included all members from the earliest available membership register in our dataset. As mentioned above, we focus on societies founded before 1800 and, if possible, use registers published before this cut-off point.[27]

[25] Graf (1993) confirms that social ties were crucial in the recruitment of new members for the society in Burghausen.

[26] This criterion aims to exclude societies that exclusively focused on beekeeping or hunting.

[27] In four cases, we were not able to find a register of members before 1800. This may raise worries that the spatial variation of members from such societies deviates from pre-1800 registers. We thus inspected the spatial correlation between early membership lists for societies from which we found several lists. For the society in Breslau

Table 1: Economic societies and their members

City	Incorporation	Register	Total members	Geolocated members
Bad Homburg	1775	1777	135	132
Breslau	1771/72	1806	245	233
Burghausen	1765	1765–1779	231	196
Celle	1764	1764–1771	265	209
Hamburg	1765	1790	424	424
Jauer / Schweidnitz	1772	1821	154	143
Kassel	1765	1773	72	59
Kiel	1786	1787	154	141
Lautern / Mannheim	1769/70	1769–1780	127	97
Leipzig	1764	1764–1789	643	468
Lübeck	1789	1819	238	238
Mohrungen	1791	1796–1800	120	118
Nürnberg	1792	1817	138	135
Potsdam	1791	1791–1815	332	316
Rostock	1798	1827	417	393
Sum			**3695**	**3302**

Notes: The Table lists the 15 economic societies active in Germany before 1800 by their society seat(s). Two societies switched their seat during the period of investigation (Jauer/Schweidnitz and Lautern/Mannheim). Membership registers from Burghausen, Celle, Mannheim/Lautern, Leipzig, and Potsdam cover all members joining over the period specified, whereas registers from all other societies represent a cross-section of membership in the specified year.

We digitized these lists including members' names, social status, occupation, and location. In total, we collected and geo-located the residence of 3,302 patriotic economic society members. Failure to locate a member arises when registers did not list their residence or when the listed residence could not be assigned to a unique location.[28] Figure 1 shows the geographical distribution of members where the size of a circle indicates the number of members from any society in a given location.[29] The map shows that there is substantial heterogeneity in the spatial distribution of individuals interested in advancing the diffusion of useful knowledge during the late 18th century. For the purpose of our analysis, geo-located members are aggregated to the grid-cell level.

3.2 Measures of innovation and human capital

In our cross-sectional analysis, we rely on the following outcome measures to assess the impact of society members on the local production of innovation and prevalence of skills.

the correlation coefficient of membership frequency across cells between registers from 1806 and 1820 is $p \approx 0.62$. Comparing registers of the society in Leipzig from 1764–1789 and 1811, the spatial correlation is $p \approx 0.65$.

[28] In cases when the residence was missing but the name of the member referred to an estate, we used the location of the estate. In cases when multiple estates were listed, we used the main estate of the family.

[29] Figure B.4 in the Appendix shows 15 separate maps, one for each society.

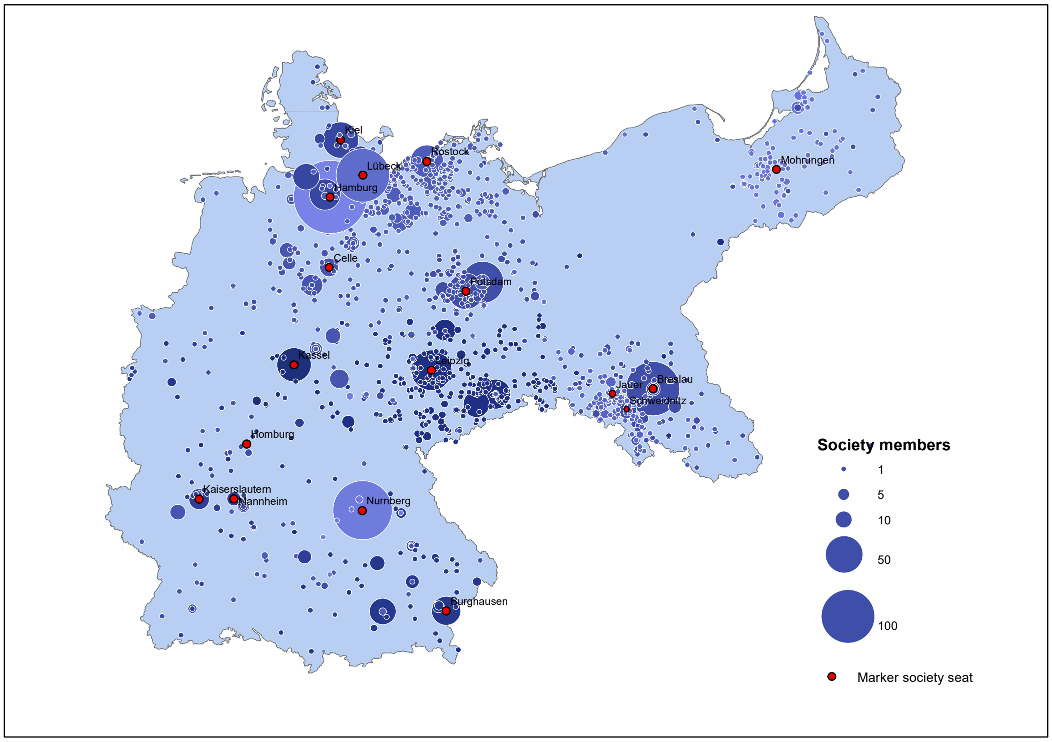


FIGURE 1: Spatial distribution of members in economic societies

Patents We measure the local intensity of innovation by the stock of valuable patents registered in Germany in the period 1877-1914 in a grid cell (see Streb, Baten and Yin, 2006; Cinnirella and Streb, 2017). Valuable patents are those which have been patented for at least 10 consecutive years. In a context of increasing registration fees over time, this is a valid proxy for innovations with a significant economic value. The patent data list the name of inventor, the location, the year of the patent, and the technological class. In Figure 2 we report the spatial distribution of the stock of valuable patents.

Exhibitors Patents, although a good proxy for innovation, might provide a biased picture of local innovation if not all innovations are patented, if patenting varies across technological classes, or if secrecy constitutes a valid alternative to patenting. To overcome such issues, we use data on German exhibitors at the 1873 Vienna World's Fair as an alternative measure for the local intensity of innovation. More than 5,000 in 26,000 individual exhibitors came from the German Empire and presented their novel products at Vienna. Using the exact location as reported in the official catalog of the Vienna World's Fair, we show the spatial distribution of exhibitors in Figure 3. The spatial correlation with the stock of valuable patents is high ($p \approx 0.85$).

Highly-skilled mechanics To capture the upper-tail of the useful knowledge distribution, we rely on Feldman and Van der Beek (2016) and De Pleijt, Nuvolari and Weisdorf (2020) to classify

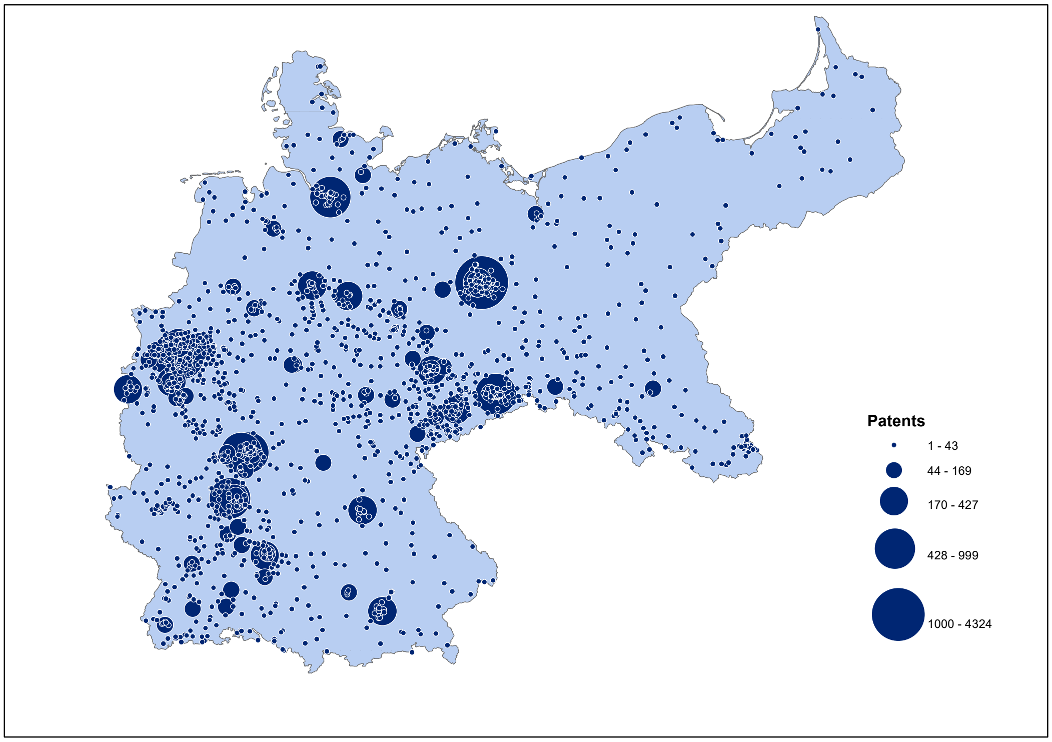


FIGURE 2: Spatial distribution of valuable patents, 1877-1914

occupations into skill groups. The resulting measure of highly-skilled mechanics broadly follows Meisenzahl and Mokyr (2012) who label artisans that operate at the cutting edge of contemporary technology as 'tweakers'. To calculate the local density of highly-skilled mechanics, we rely on the Prussian occupation census of 1849 that reports the number of artisans across approximately 90 occupations at the city level.[30] We categorize other occupations either as other artisans or as factory workers and use these in placebo tests. After geo-locating the cities, the data are aggregated to the grid-cell level. This measure is only available for grid cells in the German Empire that were part of Prussia in 1849.

Vocational schools To capture local investment in vocational schooling, institutions that arguably trained highly-skilled mechanics, we digitized and geo-referenced the universe of vocational schools in the German Empire. Pache (1896–1905) lists all vocational schools including technical colleges (*Fachschulen*) and continuation schools (*Fortbildungsschulen*).[31] These schools provided technical training for children above mandatory schooling age. We focus exclusively on technical

[30]The data include all of the occupations mentioned in Meisenzahl and Mokyr (2012): scientific instrument makers, clockmakers, musical instrument makers, gold- and silversmiths, jewelers, and locksmiths.

[31]Since education was organized at the state level throughout the 19th century, there may be systematic differences between types of vocational schools across states. In the analysis we account for such differences by including polity-fixed effects. Nevertheless, school finance was typically the responsibility of municipalities. In several cases, however, vocational schools were funded by private associations.

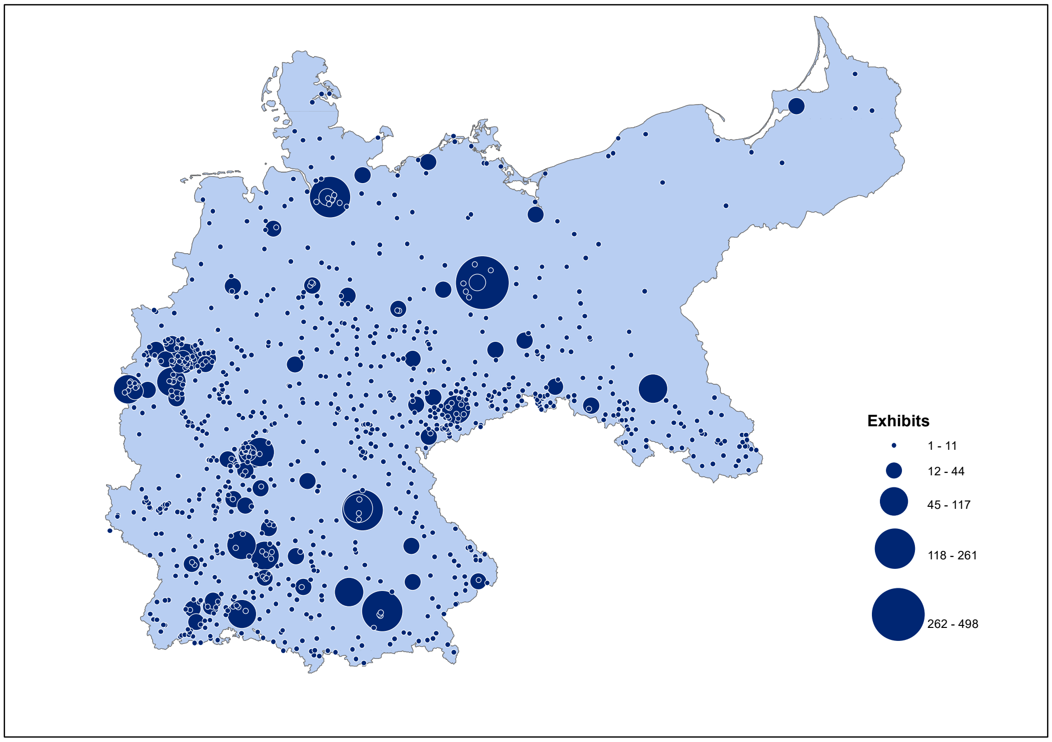


FIGURE 3: Spatial distribution of exhibitors at the Vienna World Exposition, 1873

colleges, including those for crafts, commerce, mining, and agriculture because they provided applied training for students with some prior work experience, usually from the age of 16. Besides the location of the vocational schools, we collected information on their year of establishment.[32] This information is available for 912 out of 1,466 technical colleges.[33]

3.3 Control variables

Geography To account for spatial heterogeneity in geographical endowments that may simultaneously affect incentives for innovation and human capital formation but also the propensity to join a society, our baseline specification includes controls for temperature, precipitation, altitude, soil suitability for cereal crops, and distance to navigable rivers.

Population In the absence of data for population density at the grid-cell level, we capture this dimension through two measures for urban population: the aggregate population of all cities with more than 5,000 inhabitants in 1750 in a grid cell from Bairoch (1988); a count of all cities with

[32]We supplement the original dating by Pache (1896–1905) using information from Glasser (1893), Keyser (1939–1974), and Lexis (1904). In the case the sources reported different years of establishment, we used the earliest year.

[33]We did not find a systematic pattern of omission of the establishment year. For example, missing information occurs in all states of the German Empire.

city status in a grid cell from Keyser (1939–1974). When focusing on grid cells that were part of Prussia in 1849, we include the aggregate population of cities in 1816 and a count of these cities in a grid cell.[34]

Polity-fixed effects To capture institutional, cultural, and other time-invariant unobserved heterogeneity across the German lands, our preferred specifications will condition on polity-fixed effects. To generate polity dummies, we rely on the political borders of the Holy Roman Empire as of 1789.[35] We follow Dittmar and Meisenzahl (2020*a*) and group polities that cover less than five grid cells into a single fixed effect, thereby avoiding issues of multicollinearity. This approach results in a total of 65 polity dummies.[36]

4 Empirical analysis

4.1 Access to useful knowledge and innovation

Our main hypothesis is that societies reduced the cost of accessing useful knowledge, thereby facilitating innovation and technological change. Empirically, we test this hypothesis by inspecting whether a higher density of society members is associated with more innovative activity. Below, we introduce our econometric model, discuss potential endogeneity concerns and threats to identification, introduce an instrumental variable approach to address these issues, and present our main results. As a benchmark, we estimate the following model through OLS:

$$\mathrm{Y}_{ip} = \beta \, \mathrm{Members}_{ip} + X'_{ip}\gamma + \delta_p + \varepsilon_{ip} \tag{1}$$

where the dependent variable Y_{ip} reflects various measures of innovation and human capital, such as the number of valuable patents granted to patent holders in grid cell i ($n \approx 2700$) in polity p ($n = 65$), the number of exhibitors at the 1873 Vienna World's Fair from a given grid cell, or the number of highly-skilled mechanics from cities in a grid cell. The variable $Members_{ip}$ counts members of any economic society residing in grid cell i and polity p. The vector X_{ip} includes geographic controls and controls for urban population size. δ_p indicates polity-fixed effects. Standard errors are clustered at the polity level.

Because Y_{ip} and $Members_{ip}$ are count variables with a skewed distribution and a substantial number of observations that are zeros, we transform them using the inverse hyperbolic sine (arcsinh). This transformation is superior to the logarithmic transformation because it is defined at zero

[34]To appreciate the quality of the city size data reported in Bairoch (1988), we estimate the spatial correlation with city sizes reported in the Prussian census. The correlation coefficient is $p \approx 0.97$.

[35]We rely on a political map by Wolff (1877) that was recently geo-referenced by Huning and Wahl (2020) and made available to us by the authors. Since the map depicts the Holy Roman Empire with its borders as of 1789, it does not include regions in Eastern Prussia and Alsace-Lorraine. We assigned grid cells within these regions to the political entity to which they belonged.

[36]The main results are robust to adding fixed effects for polities that cover less than five grid cells.

but still allows the estimated coefficients to be interpreted as elasticity.[37] Our results are robust to using the natural logarithm or estimating Poisson regression and negative binomial regressions instead (see Table D.1 and D.2 in the Appendix).

4.2 Mitigating endogeneity

The location of society members is not randomly assigned. Membership and willingness to acquire useful knowledge may be related to local economic activity and potential for innovation. Furthermore, the network of members may capture pre-existing ties between individuals with common interests in a particular field or technology. As a consequence, regions with a higher member density could have been more innovative even in the absence of a society.

There is no systematic and centralized process that determines the distribution of members across Germany because each society had its own idiosyncratic history and way to acquire members. Nevertheless, we argue that membership density can be partly explained by the cost of participating in society activities. Attending meetings and lectures, and using the library and collections at the society seat are important benefits of membership that come at the cost of traveling. To acquire useful knowledge, members thus had to travel to the society seat and local member density is expected to decline in distance to the society seat.

Following this logic, we use the geographic distance between the centroid of each grid cell and the nearest society seat as an instrumental variable for the number of society members in a grid cell. In what follows, we inspect the validity of this instrument in two ways. First, we inspect potential violations of the exclusion restriction by showing that distance to the nearest society seat is unrelated to pre-existing trends in human capital. Second, we inspect the potential drivers of location choices for society seats and execute tests using distances to randomly distributed placebo society seats.

4.2.1 Inspecting the exclusion restriction

A crucial concern regarding the validity of our instrument is that distance to the nearest society seat might be correlated with the pre-existing density of upper-tail human capital. To address this concern, we use panel regressions that allow us to inspect differential trends in the presence of upper-tail human capital prior to the emergence of societies between cells of varying distance to society seats. To approximate the local density of upper-tail human capital, we draw on data from the *Deutsche Biographie*, an online compendium of notable individuals in German history published by the (BADW).[38] Individuals included in the *Deutsche Biographie* were not only selected due to their historical fame, but also due to the importance of their intellectual, cultural, or technical contributions (see Hockerts, 2008). This proxy for historical upper-tail human capital was pioneered

[37] For a discussion of the advantages and drawbacks of using the inverse hyperbolic sine transformation, see Bellemare and Wichman (2020).

[38] The online version of the *Deutsche Biographie* contains about 48,000 entries of notable individuals originally published in the *Allgemeine Deutsche Biographie* between 1875 and 1912 and in the *Neue Deutsche Biographie* published since 1952.

by Dittmar and Meisenzahl (2020*a*) and provides a sample of historically notable people within the German speaking lands that is representative across space, religion, and fields of activity.

To understand whether regions in closer proximity to a society seat attracted higher numbers of notable individuals already prior to the emergence of societies, we follow Dittmar and Meisenzahl (2020*a*) and construct a measure of attraction of upper-tail human capital from information on the place of birth and death included in the *Deutsche Biographie*.[39] In particular we estimate the following model:

$$\text{People}_{it} = \zeta_i + \eta_t + \sum_{\tau=1700-04}^{1860-64} \beta_\tau \cdot \text{Distance to Society}_i \times \eta_t + \gamma \cdot \text{Pop}_{it} + \sum_{\tau=1700-04}^{1860-64} \delta_\tau \cdot \text{Z'}_i \times \eta_t + \varepsilon_{it} \quad (2)$$

where People_{it} is the number of notable individuals that died in grid cell i during a 5-year period t (i.e., 1700–04, 1710–14, ... , 1860–64). We only consider individuals that migrated after birth, i.e., who were born in a grid cell $(j \neq i)$.[40] The estimated coefficients β_τ reflect differences in the number of notable individuals that were attracted to grid cells with varying distances to a society seat in a given period t compared to the omitted period (1700–04). $\text{Distance to Society}_i$ is a continuous measure of geographic distance to the nearest society seat. ζ_i and η_t are grid-cell and time-period fixed effects, respectively. Our main specification includes a time-varying measure of urban population size (Pop_{it}) from Pfister (2020).[41] In robustness tests, we include polity-fixed effects Z_i interacted with time-period fixed effects to account for potentially confounding institutional change at the polity level. The main explanatory variable and the dependent variables are transformed using the inverse hyperbolic sine (arcsinh).

Figure 4 plots the coefficients of interest β_τ, estimated from equation 2 using an event study design. The graph depicts changes in the relationship between our instrument—distance to the nearest society seat—and upper-tail human capital over time. Relative to the omitted period, regions closer to a society seat did not differ from other regions with respect to their attraction of notable individuals prior to the emergence of economic societies. This means that locations which later had a higher density of society members did not attract a larger number of notable individuals before 1760. This finding is robust to the inclusion of various control variables (see Appendix C.1).[42]

Instead, we observe a substantial increase in the migration of notable individuals to regions closer to a society seat from about 1800. Because our dependent variable reflects the year of death,

[39] This approach is superior to using the information on the place of impact from the *Deutsche Biographie* which is missing for a large number of individuals. See Appendix C.1 for more details.

[40] Appendix C.2 shows that we obtain similar results when not constraining the sample to migrants, i.e. considering the location of death for all notable individuals.

[41] We use urban population data from Pfister (2020) instead of Bairoch (1988) due to its higher frequency.

[42] In Appendix C.1, we show that there are no discernible pre-trends when we extend the time window to 1665–1864. Results are also robust to using the place of death of all notable individuals and restricting the analysis to grid cells containing cities whose population size is recorded in Pfister (2020) during the period 1700–1864. We obtain qualitatively similar results when using the location of birth as a proxy for the production of upper-tail human capital (not shown). However, we believe that birth years are not informative for our purposes because it is impossible to establish exactly *when* individuals can be considered as 'treated' by a society.

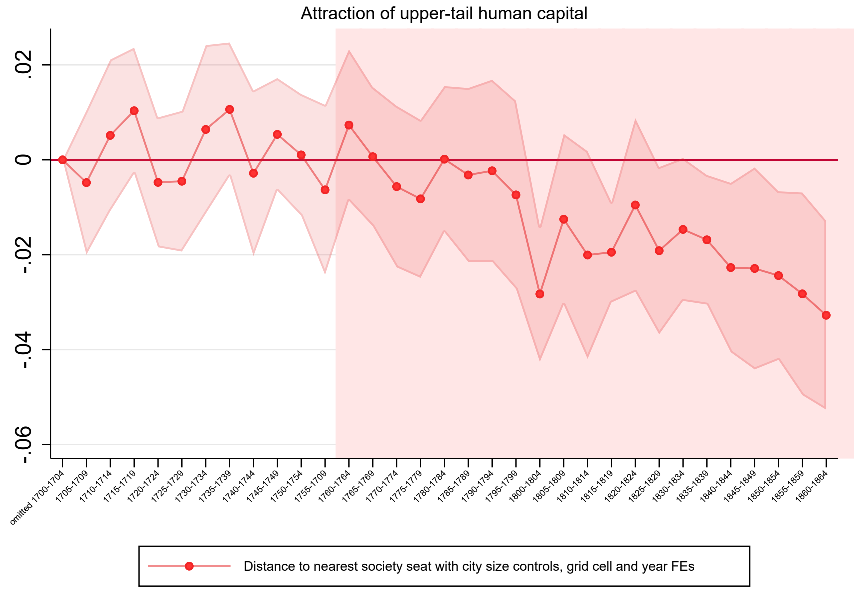


FIGURE 4: Attraction of notable individuals and distance to society seat

The Figure plots β_τ coefficients estimated from equation 2 with 95% confidence intervals. The omitted period is 1700–1704. Dependent variable, main explanatory variable, and city size controls are transformed using the inverse hyperbolic sine (arcsinh). Standard errors are clustered at the grid-cell level.

it is conceivable that individuals migrated to these locations earlier. It seems reasonable to assume that majority of migration spells of individuals who died in the period 1800–04 occurred between 1764 and 1800, within the 35 years before death. Thus, we cautiously interpret the pattern of our results to be consistent with the notion that, if anything, notable individuals were attracted to locations closer to a society seat only after these became active and not before. In sum, this evidence mollifies concerns regarding a violation of the exclusion restriction and supports our instrumental variable approach.

4.2.2 The location of society seats

A remaining concern may be that the society seats themselves were not chosen at random and that the instrument picks up variation in distance to non-arbitrarily chosen places. As argued in Section 2 and Appendix A.2, the choice of society seats reflected individual idiosyncratic decisions rather than a systematic pattern. In Table C.3 in the Appendix, we explore the determinants of society seat location more formally. Using a linear probability model, we regress an indicator that assumes the value one if a grid cell was the location of a society seat on our set of geographical and population controls as well as polity fixed effects and a set of long-run controls described in Section 4.4. These long-run controls measure commercial and educational activity prior the emergence of societies and are included here to test whether society seats were created in cities that were important commercial and educational centers.

We find that neither of these variables significantly raises the probability of being selected as a seat. The only variables that predict seat locations are altitude, temperature, and city size in 1750. Hence, in our preferred specifications, we include these variables as control variables.[43] On top of these controls, we show that our main results are robust to including distance to the 17 largest cities, distance to universities, or distance to other enlightened societies (see Section 4.4).

Next to inspecting the determinants of society seats, in Appendix C.5, we present evidence that our main results cannot be replicated using distance to nearest *placebo* society seat, where locations of placebo society seats are derived from 10,000 random draws of 17 grid cells.[44] We conduct this randomization exercise to understand whether placebo distances generally generate reduced form results that resemble the one on distance to nearest actual society seat.

We use distance to the nearest of 17 randomly drawn grid cells to estimate 10,000 β-coefficients for the reduced form effect on innovation, conditional on our baseline set of controls. Figure C.6 in the Appendix shows the distribution of estimated coefficients using patents and exhibitors as outcomes. As expected, coefficients are normally distributed and center around zero. The estimated coefficients on the distance to nearest actual society seat fall within the highest percentile of estimated coefficients from placebo distances for both, patents and exhibitors. In a second approach, we reduce the sample of grid cells from which we randomly draw placebo seats to cells that include a city with at least 5,000 inhabitants, i.e., to only 191 grid cells. The distribution of coefficients is presented in Figure C.7 in the Appendix. Again, the estimated coefficients are normally distributed and center around zero, whereas the distance to nearest actual society seat stands out in magnitude and falls into the highest percentile for exhibitors and second highest percentile for patents.

We interpret this finding to indicate that there is indeed something about the distance to grid cells with society seats that facilitates innovation and cannot be replicated with combinations of distances to randomly drawn locations, even when these are drawn from a selected sample of cells with large cities. Furthermore, we may interpret the mean effect of the displayed random draws as indicative of potential biases from a confounding distance effect. Using the largest mean value, i.e., the one for distance to nearest placebo society seat in the sample of large cities using patents as dependent variable, displayed in Table C.5 in the Appendix, we conclude that the potential bias amounts to 14% of the estimated reduced-form coefficient on distance to actual society seats (-0.022/-0.154).

[43] Table C.2 in the Appendix shows a list of the 40 largest cities in Germany in 1750 according to Bairoch (1988). Among these largest cities 8 have a society seat whereas 13 have a university. Only four cities have both a university by 1760 and a society seat. We also augment the list with the 9 society seats that were created in minor cities with less than 10,000 inhabitants, among them 4 that are too small to have been recorded by Bairoch (1988).

[44] We exclude grid cells with actual society seats from the draws.

4.3 Society members and innovative activity

In this section, we present our main results regarding the long-run impact of economic societies on innovative activity. Table 2 present OLS estimates from equation (1) across the circa 2,700 grid cells in the German Empire. Panel A shows results using valuable patents as dependent variable, whereas Panel B shows results using exhibitors at the Vienna World's Fair as dependent variable.

Table 2: Society members and innovative activity

Panel A						
Dep. var.:	Patents (1877-1914)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Geography	Urbanization	Polity FE	Society FE	Prussia	IV
Society members	0.573***	0.236***	0.286***	0.150**	0.377***	0.439***
	(0.102)	(0.061)	(0.041)	(0.074)	(0.080)	(0.164)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	No	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	No	No	Yes	Yes	Yes	Yes
Society dummies	No	No	No	Yes	No	No
Observations	2698	2698	2698	2698	718	2698
R-squared	0.17	0.43	0.51	0.52	0.54	
Kleibergen Paap F-statistic						79.38

Panel B						
Dep. var.:	Exhibits (1873)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Geography	Urbanization	Polity FE	Society FE	Prussia	IV
Society members	0.390***	0.167***	0.182***	0.135*	0.165***	0.238***
	(0.062)	(0.040)	(0.043)	(0.067)	(0.043)	(0.086)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	No	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	No	No	Yes	Yes	Yes	Yes
Society dummies	No	No	No	Yes	No	No
Observations	2698	2698	2698	2698	718	2698
R-squared	0.17	0.41	0.44	0.46	0.46	
Kleibergen Paap F-statistic						79.38

Notes: The table shows results from estimating equation 1. The unit of observation is a grid cell. Dependent variables, main explanatory variable, and city size are transformed using the inverse hyperbolic sine (arcsinh). Column 1 controls for geographical endowments (average temperature, average precipitation, altitude, soil suitability, distance to navigable river); Column 2 adds population controls (Bairoch city pop 1750, No. Keyser cities, Berlin dummy); Column 3 adds polity-fixed effects; Column 4 adds society dummies; Column 5 estimates in a sample of Prussian grid cells; Column 6 estimates the specification in Column 3 using distance to society seat as an instrument variable. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

When conditioning only on the set of geographic controls in column 1 of Panel A, we find a large and significant positive relationship between the local density of society members and patenting activity. In column 2, we additionally condition on urban population size and thereby account for the fact that social activity but also innovation may be driven by pre-existing agglomeration effects. Indeed, the estimated coefficient for society members is smaller in size, consistent with the notion that society members are located in more urban environments. However, the positive relationship remains statistically significant and economically relevant.

In our preferred specification in column 3, we add 65 polity-fixed effects, reflecting the political borders of the Holy Roman Empire as of 1789. By including such fixed effects, we account for time-invariant unobserved heterogeneity, e.g., the institutional and cultural framework under which societies and their members acted. The resulting coefficient in column 3, when interpreted at the mean (mean: 1.2 members, sd: 10.7), indicates that an increase in member density by 100% is associated with an increase in the number of valuable patents by 19% (mean: 9.6 patents, sd: 111.5).[45]

We add 15 society fixed effects in column 4. Each dummy takes the value of one if a cell is inhabited by a member of a given society and zero otherwise.[46] By using only variation within cells populated by members of the same society, we aim to account for heterogeneity in the characteristics of societies, such as their activities, their way of acquiring members, or the timing of publication of membership registers. Since some societies might have been more active than others in promoting knowledge diffusion, we consider the estimated coefficient with society fixed effects to represent a conservative estimate. Indeed, the coefficient presented in column 4 is somewhat smaller and less precisely estimated than in column 3.

In column 5, we focus on a sample of grid cells containing at least one Prussian city in 1816 ($n = 718$). In this sample, we can add a more precise control for urban population size from the Prussian census of 1816. The estimated coefficient remains highly significant and large.

In column 6, we report results from estimating the second stage of a 2SLS approach, using distance to the nearest society seat as instrumental variable for the number of society members, as proposed in Section 4.2. The first stage estimates, presented in Appendix Table C.6 yield that our instrument is relevant and powerful with a first-stage F-statistic of 79. The IV coefficient is larger than the corresponding OLS estimate in column 3. However, a Hausman test cannot reject the equality of the least squares estimate and the 2SLS estimate. At face value, the IV estimate suggests that doubling the number of society members in a cell is associated with an increase of valuable patents by 33%.

Many inventions, even the most successful ones, were not patented. To address this concern, the literature (see, e.g., Moser, 2005, 2012) has relied on other proxies, such as exhibitors at world's fairs, to measure spatial variation in innovation. In panel B of Table 2, we replicate the results from panel A using the local number of German exhibitors at the 1873 Vienna World's Fair as dependent variable. Again, we find a robust positive relationship between member density and innovation across specifications. The coefficient is smaller once measures for urban population size are included in column 2 but remains stable when adding polity and society fixed effects (columns 3 and 4). We obtain similar results when using the sample of Prussian grid cells with more comprehensive information on city size (column 5). Finally, in column 6 we again present 2SLS results using distance to the nearest society seat as instrumental variable. The coefficient is comparable in size to the coefficient in column 3 and suggests that doubling the member density at the mean is associated with approximately 19% more exhibitors.

[45]For the correct way to calculate the elasticity when both variables are arcsinh transformed see Bellemare and Wichman (2020).

[46]Note that there are members from more than one society in 118 of 2698 grid cells. In such cases multiple dummies assume the value one for the same cell.

4.4 Robustness checks

Alternative controls Table D.3 addresses possible concerns regarding the way our main control variables are designed. Due to absence of precise data on population density at the grid-cell level, we resort to presenting a number of results from second best alternatives. Columns 2–5 show that results are robust to replacing our baseline population control derived from urban population size reported in Bairoch (1988) with urban population size reported in Pfister (2020), or with measures of overall population size, urban population size, and urbanization rates derived from the HYDE dataset by Klein Goldewijk et al. (2017). In column 6, we replace the polity-fixed effects based on 1789 administrative borders with polity-fixed effects based on 1820 borders. In this way, we might be able to better capture differences in institutions governing innovation and patenting (see, e.g., Donges and Selgert, 2020). We find that our results are robust to changing the definition of our control variables.

Long-run controls Table D.4 presents estimates which aim to exclude that pre-existing differences in development confound our results. In particular, we add indicators for Hanseatic League membership, Bishop seat in 1500, printing press in 1500, Free and Imperial city status, market charter by 1760, primary school before 1760, as well as the number of notable constructions in 1760, and a measure of market access in 1750. The coefficient on member density remains positive and significant even when we include all variables simultaneously.

Human capital controls Table D.5 presents estimates conditioning on the pre-existing stock of notable individuals for different periods. While we show that there is no evidence of pre-existing differential *trends* in the attraction of upper-tail human capital to regions closer to society seats in Section 4.2.1, this does not constitute evidence for the absence of pre-existing differences in *levels* of upper-tail human capital density in the cross section. The estimated coefficients on society member density remain largely unaffected by the inclusion of such controls, independent of the respective period during which the stock of notable individuals accumulated.

Distance controls In Table D.6, we show that our instrument does not capture other potentially confounding distances. In particular, we add several distance measures to our baseline IV specification, including distance to (*i*) the nearest university operating in 1760 (column 2), (*ii*) the 17 largest cities in 1750,[47] (*iii*) literary society seats, and (*iv*) reading society seats. Several of these distances are positively related to successive innovative activity. However, the negligible changes in the coefficient of interest indicate that the economic society effect is largely orthogonal to other distances. Similar results are found when we drop grid cells that are located in closer proximity to universities as presented in Table D.7.

[47] The number 17 mimics the number of society seats.

Sample splits We further corroborate our results by introducing various sample restrictions in Table D.8. We drop grid cells that contain a society seat (column 2), we estimate within a sample of grid cells with at least one city according to the Bairoch (1988) definition (column 3), we exclude such grid cells (column 4), and we split the sample between grid cells east and west of the river Elbe (columns 5 and 6). None of these sample variations changes the results qualitatively.

Grid-cell size In Table D.9, we show that our results are robust to increasing the size of grid cells from ca. 15×15 km to ca. 45×45 km. Using larger cells allows to capture local spillovers, especially because of more accurate matches between cities and their catchment area. However, assignment to polities is less accurate. Estimated elasticities are slightly larger than when using smaller cells.

Spatial correlation Cross-sectional studies of persistence have recently been put under scrutiny due to spatial correlation issues (see, e.g., Voth, 2021). To account for arbitrary spatial correlation, we adjust our standard errors using the correction introduced by Conley (1999). Table D.10 shows that our results on valuable patents and exhibitors are robust to distance cut-offs of 50 km, 100 km, and 200 km. In addition, Section D.1 in the Appendix performs a robustness check testing whether simulated spatial noise predicts innovation. When regressing spatial noise on our patents outcome, we find that none of the *t-statistics* for the spatial noise variable are more significant than the *t-statistics* for the coefficient of society members.

Instrument validity In Table D.11, we present further evidence to corroborate the validity of our instrument. Here, we split the sample between grid cells with a positive member density and grid cells with zero members to estimate separate reduced-form effects of distance to society seat on innovative activity. Columns 1 and 2 show that the instrumental variable only affects innovation in the presence of society members. In the absence of the proposed channel, i.e. differences in the propensity to join a society, distance to a society seat has no discernible impact on innovation. This add further support to our instrumental variable approach.

In sum, our analysis confirms that there is a robust positive effect of society membership on innovative activity during the Industrial Revolution. The extensive set of robustness checks lends credibility to the main results and the validity of the instrumental variable approach.

5 Immediate effects for the local economy

Our main results show that economic societies had a long-term impact on innovation. However, since one of their main goals was to improve the local economy, this section inspects whether societies had an immediate impact. Specifically, we analyze the case of the Saxon economic society seated in Leipzig.[48] As presented in Appendix Tables A.2 and A.3, their prize competitions and

[48]The decision to focus on Saxony is predominantly driven by data availability. However, as one of the earliest regions in the German lands to industrialize, Saxony is clearly of special interest.

inspected products indicate substantial activity directed at improving the local manufacturing sector, especially in textile production. Of the 23 competitions, 11 targeted improvements in textiles, whereas six targeted improvements in agriculture. We thus expect new enterprises in manufacturing to emerge in response to the improved access to new knowledge about materials and production techniques provided by the society.

Using a geo-referenced list on the timing of manufactory creation in Saxony from Forberger (1958), we test whether regions with more society members saw an increase in manufactory foundations after the emergence of the Saxon society. The list of manufactories includes 253 firms and covers a period between the sixteenth century and 1845 (for details, see Appendix E). By focusing on manufactories, we capture a highly progressive sector during the phase of "proto-industrialization" in Germany (Ogilvie, 1996).

The list can be interpreted as panel data that we use to estimate the following difference-in-difference model:

$$\text{Manufactories}_{it} = \alpha_i + \delta_t + \beta\,\text{Members}_i \times \text{Post society foundation}_t + X'_{it}\,\gamma + \varepsilon_{ip} \qquad (3)$$

where $Manufactories_{it}$ is the number of manufactories created in a county (Amt) i during a period t. Time periods are defined as years before and after the foundation of the society in Leipzig in 1764, restricted to 1700–1800. Thus, there are 95 counties and 2 time periods. During this period 193 firms were created, 133 of which in textiles. As in the main specifications, the explanatory variable of interest, $Members_i$, counts the number of society members residing in a county. Conditional on county- and time-fixed effects α_i and δ_t, the coefficient β captures differential changes in manufactory creation between counties with varying numbers of members after the emergence of the society. The vector X'_{it} includes controls for the census population in 1755 and 1792 to capture (potentially endogenous) population growth following the foundation of the society. It further includes our measure of the local attraction of upper-tail human capital derived from the migration of notable individuals mentioned in the *Deutsche Biographie*. All continuous variables are transformed using the inverse hyperbolic sine (arcsinh).

In Table 3, we present the results from the difference-in-differences model in equation 3. Our baseline specification in column 1 only conditions on county-fixed effects capturing unobserved time-invariant heterogeneity, whereas column 2 adds controls for population size and the immigration of notable individuals. Both columns consistently show that counties with more members saw an increase in manufactory establishment after the Saxon society formed. The coefficient in column 2 indicates that doubling the society members in a county is associated with a 20% increase in manufactory foundations, when interpreted at the mean (mean: 0.98 members, sd: 3.185).[49]

In columns 3 and 4, we distinguish between manufactories associated with textile production and manufactories in all other sectors. In line with the notion that the Saxon society especially focused

[49] Appendix E shows that results are robust to using the entire list spanning the sixteenth century until 1845 and to excluding manufactories for which only the year of first mention instead of the foundation year is known.

Table 3: Society members and manufactory establishment

	Number of new manufactories			
	(1)	(2)	(3)	(4)
	All	All	Textiles	Other
Society members × Post 1764	0.159***	0.148**	0.172***	0.115
	(0.0571)	(0.0617)	(0.0484)	(0.0731)
Census population 1755/1792		-0.0290	-0.0340	-0.0823
		(0.186)	(0.166)	(0.105)
Attraction of upper-tail human capital, 1700-1800		-0.136	-0.0884	0.00343
		(0.189)	(0.173)	(0.199)
County fixed effect	Yes	Yes	Yes	Yes
Period fixed effect	Yes	Yes	Yes	Yes
Observations	190	190	190	190
R-squared	0.85	0.85	0.86	0.74

Notes: The table shows results from estimating equation 3. The unit of observation is the county × time period (1700–1763, 1764–1800). Dependent variables, main explanatory variable, population and attraction of upper-tail human capital are transformed using the inverse hyperbolic sine (arcsinh). Column 1 estimates the difference-in-difference model with county-fixed effects; column 2 adds control variables; column 3 uses only textile firms for the dependent variable; column 4 uses all non-textile firms. Standard errors clustered at the county level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

in improving the local textile economy, as indicated by their large number of prize competitions in this sector, we find that the overall effect is borne by increases in textile manufactories.

We interpret these results as evidence for the immediate impact of societies. It seems that the local economy indeed benefited from improved access to useful knowledge already during the pre-industrialization period. Potentially, the local increase in manufacturing may have led to agglomeration effects. This could partly explain the observed higher levels of innovation in the long-run.

6 Channels of transmission in the long-run

How can we better understand the link between society membership in the late eighteenth century and innovation in the late nineteenth century? As laid out in Section 2, economic societies facilitated human capital formation and created information networks. These aspects likely continued to influence the local economy even when societies ceased to exist by creating localized knowledge spillovers and agglomeration economies, resulting in persistently higher innovation. We provide evidence on the immediate improvement of the local economy in this section, for the formation of human capital Section 6, and regarding the long-run effect of information networks in Section 7.

6.1 Societies and the provision of vocational schooling

Economic societies were particularly interested in advancing technical training and they actively contributed to the opening of vocational schools. We provide evidence consistent with this historical narrative, showing that regions with more society members adopted vocational schools earlier. We argue that, by establishing vocational schools, societies created the prerequisites for the training of highly-skilled mechanics, a group of individuals that played a key role in triggering innovation and technical change in the early phase of the industrialization process (Meisenzahl and Mokyr, 2012; Mokyr, Sarid and van der Beek, forthcoming). Therefore, we argue that the provision of vocational schooling constitutes one potential channel of transmission linking society members with innovative activity during the Second Industrial Revolution.

To test whether economic societies fostered the *early* adoption of vocational schooling, we estimate duration models of the time to establish the first vocational school. Using the terminology of duration analysis, in this case a "failure event" is the opening of the first vocational school in a grid cell.[50] The time at risk for opening a vocational school (of any type) in a grid cell begins in 1764, with the emergence of the first societies. Grid cells that did not have a vocational school by 1899 are treated as censored spells with 1900 as censoring date.

In Figure 5 we show Kaplan–Meier survival estimates for two groups: grid cells with at least one society member and grid cells without any society member. In comparison to grid cells without any member, grid cells with members experience a considerable increase in the adoption rate starting in the 1820s, with an even higher difference in growth rates after the 1860s. In other words, the probability of not having a vocational school ("surviving") in a given grid cell is systematically higher in cells without any society member from 1820 onward.

To model the adoption of vocational schools, we estimate a standard Cox proportional hazards model (Cox, 1972) specified as follows:

$$\lambda_{ip}(t) = \lambda_0(t)\ \exp(\beta\,\text{Members}_{ip} + X'_{ip} + \gamma\,\delta_p) \tag{4}$$

The term $\lambda_0(t)$ is the unknown baseline hazard function where t is time measured in years. The term $exp(\cdot)$ represents the covariate-specific relative risk. $Members_{ip}$ is either an indicator variable that assumes the value one if we recorded at least one member of a given society in a grid cell i within polity p or a variable that counts the number of members of economic societies in a grid cell. The vector X includes geographic and urbanization controls. δ_p reflects polity-fixed effects. Standard errors are clustered at the polity level.[51]

[50] As discussed in Section 3, information on the year of establishment is missing for approximately 40 percent of schools. Furthermore, we observe only schools that were still open by 1899, thus ignoring schools that opened and closed before 1899.

[51] The Cox proportional hazard model assumes that the hazard ratio is constant over time. To test the proportionality assumption, i.e., whether the log hazard ratio function is constant over time, we inspect the Schoenfeld residuals for our preferred specification which conditions on polity-fixed effects (Column 3). The lack of a systematic pattern over time indicates that the proportionality assumption cannot be rejected.

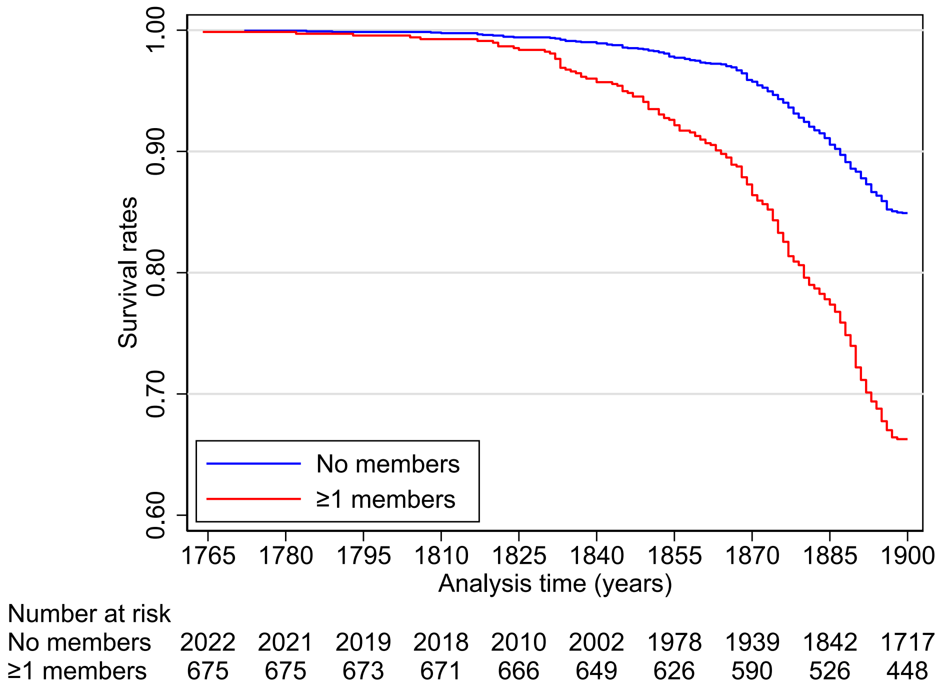


FIGURE 5: Kaplan–Meier survival estimates by membership status

Kaplan-Meier survivor functions from a Cox proportional hazards analysis for grid cells with no members and grid cells with at least one member in an economic society. The table below the graph lists the number of grid cells "at risk" of adopting their first vocational school in a given year.

TABLE 4: Society members and the adoption of vocational schooling

Dep. var.:	Year vocational school established					
	(1)	(2)	(3)	(4)	(5)	(6)
	Geography	Urbanization	Polity FE	Society FE	Intensive Margin	Both
$\geq$ 1 Society members	2.803***	1.650***	1.675***	1.467**		1.283
	(0.310)	(0.175)	(0.144)	(0.227)		(0.230)
Society members					1.405***	1.347***
					(0.141)	(0.155)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	No	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	No	No	Yes	Yes	Yes	Yes
Society dummies	No	No	No	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698

Notes: The table shows results from estimating Cox proportional hazards models via equation 4 conditional on time invariant control variables. Hazard ratios reported. *Year vocational school established* is the earliest year of foundation of a vocational school in a grid cell after 1764, before 1900. $\geq$ 1 *society members* is a dummy variable equal to one if records show at least one member of any society in a grid cell. *Society members* is a continuous variable, transformed using the inverse hyperbolic sine (arcsinh), counting all society members in a grid cell. Column 1 controls for geographical endowments (average temperature, average precipitation, altitude, soil suitability, distance to navigable river); Column 2 adds population controls (Bairoch city pop 1750, No. Keyser cities, Berlin dummy); Column 3 adds polity-fixed effects; Column 4 adds society dummies. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

In Table 4 we present the results from the Cox proportional hazard model. The reported coefficients are hazard ratios, i.e., a coefficient larger than one indicates that a variable increases the hazard rate of establishing a vocational school. Across columns, we expand the model by controlling for geographic factors (column 1), urban population (column 2), polity-fixed effects (column 3), and society fixed effects (column 4). The coefficient associated with the dummy variable for having at least one society member is larger than one and highly significant across all specifications. This indicates that grid cells with one or more society members adopt vocational schools earlier compared to grid cells without any society member.

In column 5 we inspect the intensive margin, using the number of members in a grid cell as variable of interest. We find that a higher number of society members is also associated with the earlier adoption of a vocational schools. Finally, in column 6 we include both margins simultaneously and find that, while the coefficient on the extensive margin remains well over one, only the intensive margin is significantly associated with the earlier adoption of vocational schools.

6.2 Societies and skilled mechanics

After having adopted comparatively earlier vocational schools for technical training, regions with more society members may have gained a head-start in training workers which turned out to be crucial for subsequent industrialization and innovation. Thus, we expect regions with a larger number of society members to have a higher density of highly-skilled mechanics, potentially trained in vocational schools. To test this hypothesis, we use the earliest available full-scale occupational census undertaken in Prussia in 1849 to approximate the local distribution of skills. This comes at the cost of reducing the sample to the 718 grid cells that were part of Prussia in 1849.

Table 5: Society members and highly-skilled mechanics

	OLS			IV		
Dep Var.:	(1) Highly-skilled mechanics	(2) Other artisans	(3) Factory workers	(4) Highly-skilled mechanics	(5) Other craftsmen	(6) Factory workers
Society members	0.070***	0.048***	0.045	0.078**	0.024	-0.216
	(0.015)	(0.014)	(0.056)	(0.030)	(0.034)	(0.151)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	718	718	718	718	718	718
R-squared	0.86	0.86	0.66			
Kleibergen Paap F-statistic				41.6	41.6	41.6

Notes: The table shows results from estimating equation 1 via OLS (columns 1–3) and 2SLS, using distance to society seat as an instrumental variable (columns 4–6). The unit of observation is a grid cell, limited to a sample of Prussian grid cells. Dependent variables, main explanatory variable, city size, and instrumental variable are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Prussian city pop 1816, number of Prussian cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 5 presents OLS estimates of Equation 1 using the number of highly-skilled mechanics as the dependent variable (column 1).[52] In falsification tests (columns 2–3), we use dependent variables that group the remaining occupations into other artisans and factory workers. In columns 4-6 we report the corresponding second stage estimates using distance to the nearest society seat as instrumental variable. For consistency, all dependent variables are subject to the inverse hyperbolic sine transformation.

The estimates in Column 1 show a strong positive relationship between society members and the number of highly-skilled mechanics. Column 2 shows that there is also a positive and significant correlation with other artisans. The relationship with factory workers (Column 3), a broad measure of industrialization, is insignificant although the point estimate is similar to the estimate in Column 2.

When estimating the same three specifications exploiting arguably exogenous variation in distance to the nearest society seat, only the relationship between society members and highly-skilled mechanics remains significant (Column 4). The relationship between members and other artisans (Column 5) turns insignificant and the relationship between members and factory workers (Column 6) remains insignificant and has a negative sign. The instrumental variable results are therefore consistent with our claim that economic societies either attracted or contributed to the training of highly-skilled mechanics who became key in the industrial revolution and in pushing technological innovation.

6.3 Societies, vocational schooling, skilled mechanics, and innovation

In this section, we show that societies boosted innovation in locations with an earlier provision of vocational schooling and a higher supply of highly-skilled mechanics. For this purpose, in Table 6 we present results interacting the number of society members with an indicator for the presence of a vocational school by 1849 (column 1–3) and results when interacting the number of society members with the number of highly-skilled mechanics (columns 4–5). Columns 1–3 show a baseline effect indicating that grid cells with more society members generally have more skilled mechanics in 1849, more exhibits in 1873, and more patents in 1877–1914. The interaction term shows that these effects are at least twice as large in grid cells with a vocational school.[53] Columns 4–5 show that skilled mechanics are positively correlated with both measures of innovation and that this effect significantly increases in magnitude with the presence of more society members.[54]

[52] We follow Feldman and Van der Beek (2016) and De Pleijt, Nuvolari and Weisdorf (2020) in their definition of highly-skilled mechanical occupations. These are: cabinet makers, carpenters and ship builders, instrument makers, wrights, plumbers, printers, copper engravers, craftsmen in lithographic institutions, bell founders, tin moulders, coppersmiths, locksmiths, blacksmiths, coopers, and turners. Within the categories listed above we include both masters and assistants, as well as self-employed craftsmen.

[53] Note that the baseline coefficient on vocational schools in column 1 reflects cases where there is a school but no society member, which is true for exactly one grid cell in this Prussian sample.

[54] Note that the baseline coefficient on society members in columns 4 and 5 reflects cases where the number of skilled mechanics is zero, which is true for exactly one grid cell in the Prussian sample. Therefore the negative coefficient for society members should not be directly interpreted.

Table 6: Society members, vocational schools, and highly-skilled mechanics

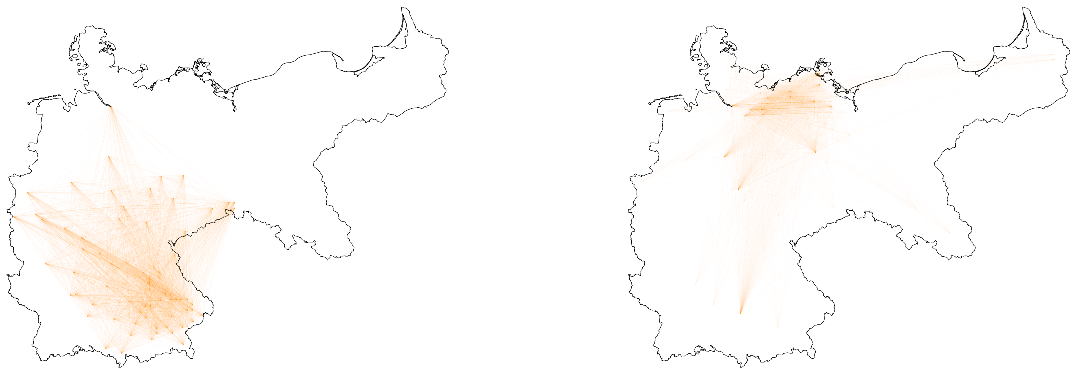
Dep. Var.:	Highly-skilled mechanics (1849)	Exhibits (1873)	Patents (1877–1914)	Exhibits (1873)	Patents (1877–1914)
	(1)	(2)	(3)	(4)	(5)
Society members	0.061***	0.143***	0.239***	-0.718***	-0.480
	(0.017)	(0.035)	(0.045)	(0.221)	(0.294)
Voc. school 1849=1	-0.308	0.403**	0.431		
	(0.190)	(0.162)	(0.262)		
Voc. school 1849=1 × Society members	0.190***	0.191**	0.241***		
	(0.068)	(0.092)	(0.083)		
Skilled mechanics 1849				0.231**	0.613***
				(0.110)	(0.164)
Society members × Skilled mechanics 1849				0.144***	0.135**
				(0.040)	(0.055)
Geographical controls	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	718	2698	2698	718	718
R-Squared	0.86	0.44	0.50	0.45	0.54

Notes: The table shows results from estimating equation 1 via OLS, interacting the number of society members with an indicator variable that reflects the presences of at least one vocational school by 1849 (columns 1–3) or with the number of highly-skilled mechanics (columns 4–5). The unit of observation is a grid cell, limited to a sample of Prussian grid cells in columns 1, 4, and 5. Dependent variables, main explanatory variable, and city size are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy (columns 2–3) or Prussian city pop 1816, No. Prussian cities, Berlin dummy (columns 1, 4, 5). Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

We interpret these findings to support the idea that societies affected innovation in the long-run, inter alia, through the establishment of vocational schools and the training of comparatively more highly-skilled mechanics. The results indicate that vocational schools trained more highly-skilled mechanics in places with society members. This may have contributed to innovation because highly-skilled mechanics are more innovative themselves or because this determined the location of more innovative industries (see Mokyr, Sarid and van der Beek, forthcoming). Furthermore, the results indicate that in places with more society members, highly skilled mechanics were more innovative than in other places, leading us to speculate that there was a location-specific endowment of useful knowledge that facilitated continuous innovation.

7 Diffusion of useful knowledge

In the last part of our analysis, we argue that members of economic societies formed a social network that facilitated the diffusion of useful knowledge with important consequences for the long-run location of innovation. In particular, based on the notion that members of a given society residing in different locations are endowed with the same type of useful knowledge, we expect that they innovate, invest, and specialize in similar technologies. As a consequence, the network of society members established in the late eighteenth century may have long lasting consequences for the economic geography of innovation in the late nineteenth century because of directed technological change.



(a) Society in Burghausen (b) Society in Rostock

FIGURE 6: Illustration of society networks across locations with common membership

Spatial networks of members in the economic societies of Burghausen and Rostock. Each member of a given society is connected with a line to every other member.

Empirically, we test whether common membership in a given society across cell-pairs increases similarity in the technological classes of innovation during the Second Industrial Revolution. Figure 6 illustrates two examples of networks created by common membership in the societies in Burghausen and Rostock.[55] We test our hypothesis by estimating the following gravity-type equation:

$$T_{ij} = \alpha_i + \alpha_j + \beta\, M_{ij} + \delta\, D_{ij} + \lambda\, P_{ij} + \mathbf{X}'_{ij}\theta + \varepsilon_{ij} \tag{5}$$

where T_{ij} is the level of technological similarity between grid cells i and j based on Jaffe (1986). The logic behind this index is that each cell is a series of vectors in a multidimensional technology space defined by the technological classes which are 86 in our case. The index measures the degree of overlap across technological classes between cell pairs and is defined between zero and one. If two grid cells have patents in the exact same technological class, the index will be one; if two grid cells have no overlap in the technological classes of their patents, the index will be zero. Grid cell i and grid cell j fixed effects are captured by α_i and α_j. The inclusion of these fixed effects captures local heterogeneity in geography, economic activity, and cultural attitudes in both cells. The variable of interest M_{ij} is an indicator which takes the value one if grid-cell pair i, j has at least one member from the same society in both cells i and j.[56]

Consistent with the standard assumption in gravity-type models, we expect geographically more proximate areas to be more technologically integrated. Thus, we condition on geographic

[55] Figure F.1 in the Appendix provides figures for the networks of all individual societies.

[56] Note that a grid-cell pair can have common members in several societies.

distance D_{ij} between grid cells i and j to capture effects arising from geographic proximity. P_{ij} is an indicator that takes the value one if grid-cell pair i, j belongs to the same polity in 1789. This is expected to capture border effects and a home bias in similarity. Finally, in an extended versions of the model, we add the vector X_{ij} that includes factors that are likely to facilitate the flow of information between cells due to better connectivity via transport infrastructure such as joint access to roads, railroads, and navigable rivers. Standard errors are two-way clustered at grid cells i and j level.

The unit of observation in this regression framework is a grid-cell pair i, j. Our sample consists of approximately 365,000 grid-cell pairs with positive patenting activity in both cells, since similarity between i and j can only be calculated with positive patenting activity in both cells. Furthermore, each grid-cell pair is included only once because we do not assume any direction of information flows.

Descriptive statistics of the grid-cell pairs used in this analysis are reported in Table F.1 in the Appendix. The mean value of the Jaffe index for technological similarity is 0.06. The relatively low value is due to the large number of zeros ($\approx 73\%$), that is, the number of grid-cell pairs with no technological similarity. The share of grid-cell pairs with members from the same society is 3%. We also report descriptive statistics for membership in different societies, an indicator that will be used in a falsification test: 12% of grid-cell pairs have members belonging to different societies.

Estimates of equation (5) are reported in Table 7. The results in Column 1 show that grid-cell pairs with members from the same society have significantly higher technological similarity, i.e., they tend to patent in similar technological classes towards the end of the nineteenth century. The size of the coefficient is substantial: having members from the same society increases the technological similarity of a grid-cell pair by 1.5 points which is an increase of 35% at the mean. As expected, larger geographic distance is associated with lower technological similarity, whereas belonging to the same polity tends to increase similarity, although the coefficient is insignificant.

In column 2, we drop pairs in which at least one cell is the seat of a society. In this way, we test whether the diffusion of technological knowledge worked exclusively through the main hub constituted by the seat of the society. The coefficient for the variable of interest in Column 2 is of similar size and highly significant indicating that society seats are not the main drivers of our results.

In columns 3 and 4, we perform a falsification test estimating the impact of membership in *different* societies on technological similarity. If a given society network only provides access to a specific set of technological knowledge, we expect to find a zero effect when inspecting grid-cell pairs with members belonging to different societies. Indeed, this is what we find: the coefficient for members from different societies in column 3 is small and not significantly different from zero. This result is confirmed when dropping cells with societies seats (column 4). The coefficient for same polity affiliation increases in size and significance compared to columns 1 and 2 suggesting joint membership in the same society absorbs some of the home bias effect. In columns 5 and 6 we run a 'horse-race' between joint membership in the same versus in different societies. Both coefficients

Table 7: Shared knowledge and technological similarity

Dep. var.: Technological similarity	Same society		Different society		Horse race
	(1)	(2)	(3)	(4)	(5)
		W/o society seat		W/o society seat	W/o society seat
Members from same society	0.015***	0.013***			0.013***
	(0.003)	(0.003)			(0.003)
Members from different society			0.002	0.000	0.001
			(0.002)	(0.002)	(0.002)
Geographic distance	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Same polity	0.003	0.003	0.005**	0.004**	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Grid-cell i and j fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	365938	354901	365938	354901	354901
R-squared	0.13	0.13	0.13	0.13	0.13

Notes: The table shows results from estimating equation 5 via OLS. The unit of observation is a grid-cell pair, limited to a sample of cells with positive patenting activity. *Technological similarity* is an index based on Jaffe (1986) capturing the level of technological similarity in patents across grid-cell pairs. *Members from same society* is an indicator that takes the value one if both cells in a pair are home to at least one member of the same economic society. *Members from different society* is an indicator that takes the value one if both cells in a pair are home to members from different economic societies. Geographic distance is reported per 100 kilometers. *Same polity* is equal to one if a grid-cell pair belongs to the same polity as in 1789. Standard errors, two-way clustered at grid cells i and j, in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 8: Shared knowledge and technological similarity – Robustness check

Dep. var.: Technological similarity	(1)	(2)	(3)	(4)	(5)
Members from same society	0.015***	0.014***	0.015***	0.015***	0.014***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Both access to road	0.007**				0.006*
	(0.003)				(0.003)
Both access to railroad		0.011***			0.011***
		(0.004)			(0.004)
Both access to river			0.005**		0.005**
			(0.002)		(0.002)
Both urban				0.002	0.001
				(0.002)	(0.002)
Geographic distance	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Same polity	0.003	0.003	0.003	0.003	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Grid-cell i and j fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	365938	365938	365938	365938	365938
R-squared	0.13	0.13	0.13	0.13	0.13

Notes: The table shows results from estimating equation 5 via OLS. The unit of observation is a grid-cell pair, limited to a sample of cells with positive patenting activity. *Technological similarity* is an index based on Jaffe (1986) capturing the level of technological similarity in patents across grid-cell pairs. *Members from same society* is an indicator that takes the value one if both cells in a pair are home to at least one member of the same economic society. *Members from different society* is an indicator that takes the value one if both cells in a pair are home to members from different economic societies. Geographic distance is reported per 100 kilometers. Access to road refers to 1848; access to railroad to 1875; access to river to 1874. *Same polity* is equal to one if a grid-cell pair belongs to the same polity as in 1789. Standard errors, two-way clustered at grid cells i and j, in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

remain largely unchanged from the previous specifications, confirming that they are conditionally unrelated.

In Table 8 we estimate specifications testing the robustness of our findings to ensure that the networks of society members do not overlap with physical networks and other means of communication. During the nineteenth century, new means of transportation such as railroads became important vectors of knowledge diffusion (see, e.g., Melander, 2020) and could therefore affect the technological similarity within a cell pair. Nevertheless, since railroads and roads (to the extent that they have been constructed after the establishment of societies) are likely endogenous to existing social networks, controlling for them potentially captures mechanisms rather than confounders. We add dummy variables indicating whether both cells i and j had access to a paved road in 1848 (column 1), to a railroad in 1875 (column 2), and to a navigable river in 1874 (column 3).[57] We also include a dummy variable accounting for the fact that both cells are urban, i.e., have at least one town with city rights according to Keyser (1939–1974) (column 4).

Our results indicate that all three means of communication significantly increase the technological similarity of a grid-cell pair. The coefficient for having members of the same society remains unchanged. It also remains unchanged when all control variables are added at the same time in column 5. While the index of technological similarity is not straightforward to interpret, these results allow us to assess some magnitudes. By comparing the estimated coefficients, we can conclude that the effect of common society membership is roughly similar in size to common access to railroads. This result suggests that, in the eighteenth century, social networks were as important as physical networks for the diffusion of useful information. Furthermore, these results imply that by substantially lowering the costs of accessing useful knowledge during the Enlightenment, economic societies had lasting consequences for the direction of technical change and thereby shaped the economic geography of innovation in Imperial Germany.

8 Conclusion

In this paper, we provide evidence for the important role that economic societies played for innovation and technical change during Germany's Industrial Revolution. At the end of the eighteenth century, the newly established economic societies substantially lowered the cost of accessing new useful knowledge. Using unique data from membership registers of all active German economic societies, we document that regions which had a higher density of members during the late eighteenth century display higher levels of innovative activity during the Second Industrial Revolution. Our results suggest that doubling member density is associated with a 19% increase in patents granted between 1877-1914 and a 11% higher number of exhibitors at the 1873 Vienna World's Fair. To rule out that membership density reflects underlying trends in economic development, we adopt an instrumental variable strategy that exploits plausibly exogenous variation in the distance to the nearest society seat. We present extensive evidence that regions closer to these seats did not experience different trends in upper-tail human capital attraction prior to the emergence of societies using a difference-in-differences approach.

Focusing on the Saxon society, another difference-in-differences approach yields increases in the establishment of new manufactories in regions with more members after the society emerged. This effect is driven by textiles, a sector for which the society offered a large number prize competitions to improve the local economy. We argue that societies had a long-lasting effect on innovation due

[57] Note that these variables measure if cells i and j have both access to the infrastructure but do not necessarily imply that these cell are directly linked by the given mean of communication.

to agglomeration economies, e.g., due to larger local manufacturing sectors and due to localized knowledge spillovers. Indeed, our analysis shows that regions with members from economic societies adopted vocational schooling earlier and accommodate higher numbers of highly-skilled mechanics but not other artisans or factory workers.

Finally, we also shed some light on the impact of networks of economic societies members on the direction of technical change. We hypothesize that members of a given society had access to a specific set of technological information that was shared more intensively within the society's network. We provide evidence for this conjecture by showing that areas which have members from the same society innovate in similar technological classes, even 100 years later. This finding suggests that (*i*) the societies' networks were important channels of knowledge transmission that transcended geographic barriers; (*ii*) social networks may have long-lasting consequences and may generate path dependence in technological advancements. Our results indicate that reducing barriers to knowledge diffusion is beneficial for innovation and that social networks can affect the direction of technological change.

References

Abramitzky, Ran, and Isabelle Sin. 2014. "Book Translations As Idea Flows: The Effects of the Collapse of Communism on the Diffusion of Knowledge." *Journal of the European Economic Association* 12 (6): 1453–1520.

Akcigit, Ufuk, Santiago Caicedo, Ernest Miguelez, Stefanie Stantcheva, and Valerio Sterzi. 2018. "Dancing with the Stars: Innovation through Interactions." NBER Working Paper 24466.

Allen, Robert C. 2003. "Progress and Poverty in Early Modern Europe." *Economic History Review* 56 (3): 403–443.

Allen, Robert C. 2009. *The British Industrial Revolution in Global Perspective.* Cambridge: Cambridge University Press.

Am Ende, Ch. G. Ernst. 1884. *Die Oekonomische Gesellschaft im Königreich Sachsen in ihrer geschichtlichen Entwicklung seit 120 Jahren.* Dresden: G. Schönfeld's Verlagsbuchhandlung.

Andersson, David, Thor Berger, and Erik Prawitz. 2020. "Making a Market: Infrastructure, Integration, and the Rise of Innovation." Research Institute of Industrial Economics Working Paper 1319.

Andrews, Michael. 2019. "Bar Talk: Informal Social Interactions, Alcohol Prohibition, and Invention." NBER mimeo.

Andrews, Michael. forthcoming. "How Do Institutions of Higher Education Affect Local Invention? Evidence from the Establishment of Us Colleges." *American Economic Journal: Economic Policy* forthcoming.

Audretsch, David B., and Maryann P. Feldman. 2004. "Chapter 61–Knowledge Spillovers and the Geography of Innovation." In *Cities and Geography*, Vol. 4 of *Handbook of Regional and Urban Economics*, edited by J. Vernon Henderson and Jacques-Francois Thisse, 2713–2739. Elsevier.

(BADW) - Bayerische Akademie der Wissenschaften. 2021. "Deutsche Biographie." *www.deutsche-biographie.de.*

Bairoch, Paul. 1988. *Cities and Economic Development: From the Dawn of History to the Present.* Chicago, IL: University of Chicago Press.

Bandiera, Oriana, and Imran Rasul. 2006. "Social Networks and Technology Adoption in Northern Mozambique." *Economic Journal* 116 (514): 869–902.

Becker, Sascha O., Erik Hornung, and Ludger Woessmann. 2011. "Education and Catch-Up in the Industrial Revolution." *American Economic Journal: Macroeconomics* 3 (3): 92–126.

Bellemare, Marc F., and Casey J. Wichman. 2020. "Elasticities and the Inverse Hyperbolic Sine Transformation." *Oxford Bulletin of Economics and Statistics* 82 (1): 50–61.

Bloom, Nicholas, John Van Reenen, and Heidi Williams. 2019. "A Toolkit of Policies to Promote Innovation." *Journal of Economic Perspectives* 33 (3): 163–84.

Bloom, Nicholas, Mark Schankerman, and John Van Reenen. 2013. "Identifying Technology Spillovers and Product Market Rivalry." *Econometrica* 81 (4): 1347–1393.

Boberg-Fazlic, Nina, and Paul Sharp. 2019. "Immigrant Communities and Knowledge Spillovers: Danish-Americans and the Development of the Dairy Industry in the United States." CEPR Discussion Paper 13757.

Bödeker, Hans Erich. 2012. "Economic Societies in Germany, 1760–1820: Organisation, Social Structures and Fields of Activities." In *The Rise of Economic Societies in the Eighteenth Century: Patriotic Reform in Europe and North America*, edited by Koen Stapelbroek and Jani Marjanen, 182–211. Springer.

Bonnyman, Brian. 2012. "Agrarian Patriotism in the Landed Interest: The Scottish 'Society of Improvers in the Knowledge of Agriculture', 1723-1746." In *The Rise of Economic Societies in the Eighteenth Century: Patriotic Reform in Europe and North America*, edited by Koen Stapelbroek and Jani Marjanen. Houndmills, Basingstoke, Hampshire: Palgrave Macmillan UK.

Braun, Hans-Joachim. 1980. "Die Sozietäten in Leipzig und Karlsruhe als Vermittler englishcer ökonomisch-technischer Innovation." In *Deutsche patriotische und gemeinnützige Gesellschaften*, edited by Rudolf Vierhaus, 241–254. München: Kraus international Publications.

Burlig, Fiona, and Andrew Stephens. 2019. "Reap What Your Friends Sow: Social Networks and Technology Adoption." University of Chicago mimeo.

Cantoni, Davide. 2020. "Princes and Townspeople: A Collection of Historical Statistics on German Territories and Cities. 5: Construction Activity."

Cinnirella, Francesco, and Jochen Streb. 2017. "The Role of Human Capital and Innovation in Economic Development: Evidence from Post-malthusian Prussia." *Journal of Economic Growth* 22 (2): 193–227.

Conley, Timothy G. 1999. "GMM Estimation with Cross Sectional Dependence." *Journal of Econometrics* 92 (1): 1–45.

Conley, Timothy G., and Christopher R. Udry. 2010. "Learning about a New Technology: Pineapple in Ghana." *American Economic Review* 100 (1): 35–69.

Cox, David R. 1972. "Regression Models and Life-tables." *Journal of the Royal Statistical Society: Series B (Methodological)* 34 (2): 187–202.

De la Croix, David, Frédéric Docquier, Alice Fabre, and Robert Stelter. 2020. "The Academic Market and the Rise of Universities in Medieval and Early Modern Europe (1000-1800)." CEPR Discussion Paper 14509, CEPR Discussion Paper No. DP14509.

De Pleijt, Alexandra, Alessandro Nuvolari, and Jacob Weisdorf. 2020. "Human Capital Formation during the First Industrial Revolution: Evidence from the Use of Steam Engines." *Journal of the European Economic Association* 18 (2): 829–889.

Dittmar, Jeremiah E, and Ralf R Meisenzahl. 2020*a*. "Public Goods Institutions, Human Capital, and Growth: Evidence from German History." *Review of Economic Studies* 87 (2): 959–996.

Dittmar, Jeremiah E., and Ralf R. Meisenzahl. 2020*b*. "The Research University, Invention, and Industry: Evidence from German History." London School of Economics mimeo.

Donges, Alexander, and Felix Selgert. 2020. "The Consequences of Radical Patent-Regime Change." University of Mannheim mimeo.

Ellison, Glenn, and Edward L. Glaeser. 1997. "Geographic Concentration in Us Manufacturing Industries: A Dartboard Approach." *Journal of Political Economy* 105 (5): 889–927.

Engelhardt, Juliane. 2007. "Patriotism, Nationalism and Modernity: The Patriotic Societies in the Danish Conglomerate State, 1769–1814." *Nations and Nationalism* 13 (2): 205–223.

Feldman, Naomi E., and Karine Van der Beek. 2016. "Skill Choice and Skill Complementarity in Eighteenth Century England." *Explorations in Economic History* 59: 94–113.

Fischer, Christian Friedrich Emanuel, ed. 1822. *Verhandlungen und Arbeiten der ökonomisch-patriotischen Societät der Fürstenthümer Schweidnitz und Jauer im Jahre 1821.* Breslau: Wilhelm Gottlieb Korn.

Flückiger, Matthias, Erik Hornung, Mario Larch, Markus Ludwig, and Allard Mees. forthcoming. "Roman Transport Network Connectivity and Economic Integration." *Review of Economic Studies* forthcoming.

Forberger, Rudolf. 1958. *Die Manufaktur in Sachsen - Vom Ende des 16. bis Anfang des 19. Jahrhunderts.* Berlin: Akademie Verlag.

Foster, Andrew D., and Mark R. Rosenzweig. 1995. "Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture." *Journal of Political Economy* 103 (6): 1176–1209.

Franck, Raphaël, and Oded Galor. forthcoming. "Technology-skill Complementarity in Early Phases of Industrialization." *Economic Journal* forthcoming.

Gerber, Michael Rüdiger. 1988. *Die Schlesische Gesellschaft für Vaterländische Cultur (1803-1945).* Vol. IX of *Beihefte zum Jahrbuch der Schlesischen Friedrich-Wilhelms-Universität zu Breslau.* Thorbecke Jan Verlag.

Gesellschaft des Ackerbaus und der Künste. 1790. "Statuta der in der Residenzstadt Cassel auf gnädigstes Gutfinden und Erlaubnis zusammengetretenen Gesellschaft des Landbaus (1765) und Statuten der hiesigen Gesellschaft des Ackerbaus und der Künste." In *Sammlung kurhessischer Landes-Ordnungen und Ausschreiben nebst dahin gehörigen Erläuterungsund anderen Rescripten, Resolutionen, Abschieden, gemeinen Bescheiden und dergleichen, Sechster Theil*, edited by Christoph Ludwig Kleinschmidt, 736–737. Cassel: Johann Nicolas Seibel.

Gesellschaft zur Beförderung der Naturkunde und Industrie Schlesiens. 1806. *Verhandlungen der Gesellschaft zur Beförderung der Naturkunde und Industrie Schlesiens.* Breslau: Graß und Barth.

Gesellschaft zur Beförderung vaterländischer Industrie. 1831. *Skizze einer Geschichte der Gesellschaft zur Beförderung vaterländischer Industrie - als Manuscript für die Mitglieder.* Nürnberg: Cerpersche Officin.

Glaeser, Edward L, Hedi D Kallal, Jose A Scheinkman, and Andrei Shleifer. 1992. "Growth in Cities." *Journal of Political Economy* 100 (6): 1126–1152.

Glasser, Franz. 1893. *Das commercielle Bildungsnvesen in Österreich-Ungarn auf Grundlage des elementaren und mittleren Unterrichtes und der kaufmännischen Lehranstalten des deutschen Reiches.* Wien und Leipzig: A. Hölder.

Graf, Sieglinde. 1993. *Aufklärung in der Provinz – Die sittlich-ökonomische Gesellschaft von Ötting-Burghausen 1765-1802.* Göttingen: Vandenhoeck & Ruprecht.

Hanlon, W. Walker. 2020. "The Rise of the Engineer: Inventing the Professional Inventor During the Industrial Revolution." NYU Stern School of Business mimeo.

Hockerts, Hans Günter. 2008. "Vom nationalen Denkmal zum biographischen Portal. Die Geschichte von ADB und NDB 1858-2008." In *... für deutsche Geschichts- und Quellenforschung". 150 Jahre Historische Kommission bei der Bayerischen Akademie der Wissenschaften*, edited by Lothar Gall, 229–269. München: Oldenbourg.

Hornung, Erik. 2014. "Immigration and the Diffusion of Technology: The Huguenot Diaspora in Prussia." *American Economic Review* 104 (1): 84–122.

Howes, Anton. 2020. *Arts and Minds: How the Royal Society of Arts Changed a Nation.* Princeton: Princeton University Press.

Hubrig, Hans. 1957. *Die patriotischen Gesellschaften des 18. Jahrhunderts.* Berlin: Verlag Julius Beltz.

Huning, Thilo R., and Fabian Wahl. 2020. "You Reap What You Know: Appropriability and the Origin of European States." University of Hohenheim mimeo.

Hunt, Jennifer, and Marjolaine Gauthier-Loiselle. 2010. "How Much Does Immigration Boost Innovation?" *American Economic Journal: Macroeconomics* 2 (2): 31–56.

Iaria, Alessandro, Carlo Schwarz, and Fabian Waldinger. 2018. "Frontier Knowledge and Scientific Production: Evidence from the Collapse of International Science." *Quarterly Journal of Economics* 133 (2): 927–991.

IEG. 2010. "IEG-Maps: Server for Digital Historical Maps." Leibniz Institute of European History, Mainz, Germany. http://www.ieg-maps.uni-mainz.de/.

Im Hof, Ulrich. 1990. "German Associations and Politics in the Second Half of the Eighteenth Century." 207–218. Oxford: Oxford University Press.

Jacob, Margaret C. 2014. *The First Knowledge Economy: Human Capital and the European Economy, 1750–1850.* Cambridge University Press.

Jaffe, Adam. 1986. "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value." *American Economic Review* 76 (5): 984–1001.

Kantor, Shawn, and Alexander Whalley. 2019. "Research Proximity and Productivity: Long-term Evidence from Agriculture." *Journal of Political Economy* 127 (2): 819–854.

Kelly, Morgan, Joel Mokyr, and Cormac Ó Gráda. forthcoming. "The Mechanics of the Industrial Revolution." *Journal of Political Economy.*

Keyser, Erich. 1939–1974. *Deutsches Städtebuch-Handbuch städtischer Geschichte.* Vol. 1–5. Stuttgart: Kohlhammer.

Klein Goldewijk, Kees, Arthur Beusen, Jonathan Doelman, and Elke Stehfest. 2017. "Anthropogenic Land Use Estimates for the Holocene–HYDE 3.2." *Earth System Science Data* 9 (2): 927–953.

(KLGC) - Königliche Landwirthschafts-Gesellschaft zu Celle. 1864. *Festschrift zur Säcularfeier der Königlichen Landwirthschafts-Gesellschaft zu Celle am 4. Juni 1864: 1. Festschrift Zur Säcularfeier Der Königlichen Landwirthschafts-Gesellschaft Zu Celle Am 4. Juni 1864.* Hannover: Klindworth's Verlag.

(KMÖG) - Königlich märkische ökonomische Gesellschaft. 1828. *Verzeichnis der Bibliothek der königlichen märkischen ökonomischen Gesellschaft in Potsdam.* Gedruckt im Auftrag der Bibliothek.

Königliche Landwirthschafts-Gesellschaft zu Celle. 1864. *Festschrift zur Säcularfeier der Königlichen Landwirthschafts-Gesellschaft zu Celle am 4. Juni 1864.* Hannover: Klindworth's Verlag.

Krugman, Paul. 1991. "Increasing Returns and Economic Geography." *Journal of Political Economy* 99 (3): 483–499.

Krünitz, J.G., F.J. Floerke, H.G. Flörke, and J.W.D. Korth. 1807. *Oeconomische Encyclopädie oder Allgemeines System der Land-, Haus- und Staats-Wirthschaft: in alphabetischer Ordnung.* Joachim Pauli.

La Société patriotique de Hesse-Hombourg. 1777. *Programme de la Société patriotique de Hesse-Hombourg.* Homburg: de l'Imprimerie de la Société-Patriotiquer.

Lexis, Wilhelm Hector Richard Albrecht. 1904. *Das Unterrichtswesen im Deutschen Reich.* Vol. 4 – Das technische Unterrichtswesen. Berlin: A. Asher & Co.

Livesey, James. 2012. "A Kingdom of Cosmopolitan Improvers: The Dubilin Society, 1731-1798." In *The Rise of Economic Societies in the Eighteenth Century: Patriotic Reform in Europe and North America*, edited by Koen Stapelbroek and Jani Marjanen. Houndmills, Basingstoke, Hampshire: Palgrave Macmillan UK.

Lowood, Henry E. 1989. *Patriotism, Profit, and the Promotion of Science in the German Enlightenment: The Economic and Scientific Societies, 1760–1815.* New York & London: Gardland Publishing, Inc.

Maloney, William F., and Felipe Valencia Caicedo. forthcoming. "Engineering Growth: Innovative Capacity and Development in the Americas." *Economic Journal* forthcoming.

Meisenzahl, Ralf R., and Joel Mokyr. 2012. "The Rate and Direction of Invention in the British Industrial Revolution: Incentives and Institutions." In *The Rate and Direction of Inventive Activity Revisited*, edited by Josh Lerner and Scott Stern, 443–479. University of Chicago Press.

Melander, Eric. 2020. "Individual Mobility and Social Mobilisation: Evidence from Swedish Grassroots Movements." University of Namur mimeo.

Mitch, David. 1993. "The Role of Human Capital in the First Industrial Revolution." 267–307. Boulder, Colo.: Westview Press.

Mokyr, Joel. 1992. *The Lever of Riches: Technological Creativity and Economic Progress.* Oxford: Oxford University Press.

Mokyr, Joel. 2005. "The Intellectual Origins of Modern Economic Growth." *Journal of Economic History* 65 (2): 285–351.

Mokyr, Joel. 2009. *The Enlightened Economy: An Economic History of Britain 1700–1850.* Yale University Press.

Mokyr, Joel. 2016. *A Culture of Growth: The Origins of the Modern Economy.* Princeton University Press.

Mokyr, Joel, Assaf Sarid, and Karine van der Beek. forthcoming. "The Wheels of Change: Technology Adoption, Millwrights, and Persistence in Britain's Industrialization." *Economic Journal* forthcoming.

Moser, Petra. 2005. "How Do Patent Laws Influence Innovation? Evidence from Nineteenth-century World's Fairs." *American Economic Review* 95 (4): 1214–1236.

Moser, Petra. 2012. "Innovation without Patents: Evidence from World's Fairs." *The Journal of Law and Economics* 55 (1): 43–74.

Moser, Petra, Alessandra Voena, and Fabian Waldinger. 2014. "German Jewish émigrés and US invention." *American Economic Review* 104 (10): 3222–3255.

Motschmann, Uta, ed. 2015. *Handbuch der Berliner Vereine und Gesellschaften 1786–1815.* Berlin, Boston: De Gruyter Akademie Forschung.

Niemann, August Christian Heinrich, ed. 1787. *Schleswig-Holsteinische Provinzialberichte.* Vol. 1. Altona: Altona: J.D.A. Eckhardt.

Ogilvie, Sheilagh. 1996. "Proto-industrialization in Germany." In *European Proto-Industrialization: An Introductory Handbook*, *European Proto-industrialization*, edited by Sheilagh Ogilvie and Markus Cerman. Cambridge: Cambridge University Press.

Ó Gráda, Cormac. 2016. "Did Science Cause the Industrial Revolution?" *Journal of Economic Literature* 54 (1): 224–39.

Ostpreußisch-Mohrungsche physikalisch-ökonomische Gesellschaft. 1792. *Acta der Königlich-bestätigten Ostpreußisch-Mohrungschen physikalisch-ökonomischen mit dem Preußisch ökonomischen Lese-Institut zu Königsberg verbundenen Gesellschaft, zur Nachricht der Mitglieder (1792).* Königsberg: Hartung, königl. preuß Hofbuchdrucker.

Pache, Oskar. 1896–1905. *Handbuch des Deutschen Fortbildungsschulwesens.* Vol. 1–7. Wittenberg: R. Herrose's Verlag.

Pfister, Ulrich. 2020. "Urban population in Germany, 1500–1850." University of Münster, Center for Quantitative Economics Working Paper 90.

Physikalisch-ökonomische und Bienengesellschaft zu Lautern. 1771. *Bemerkungen der physikalisch-ökonomischen und Bienengesellschaft zu Lautern, vom Jahr 1769.* Lautern: C.F. Schwan kuhrfürstl. Hofbuchhändler.

Popplow, Marcus, ed. 2010. *Landschaften agrarisch-ökonomischen Wissens: Strategien innovativer Ressourcennutzung in Zeitschriften und Sozietäten des 18. Jahrhunderts.* Münster: Waxmann Verlag GmbH.

Rübberdt, Rudolf. 1934. *Die ökonomischen Sozietäten: ein Beitrag zur Wirtschaftsgeschichte des XVIII. Jahrhunderts.* Vereinigten Friedrichs-Universität Halle-Wittenberg.

Schlesische Gesellschaft für Vaterländische Cultur . 1822. *Constitution der schlesischen Gesellschaft für vaterländische Cultur.* Vol. 4. Breslau: Wilhelm Gottlieb Korn.

Schlögl, Rudolf. 1993. "Die patriotisch-gemeinnützigen Gesellschaften: Organisation, Sozialstruktur, Tätigkeitsfelder." In *Aufklärungsgesellschaften*, *Schriftenreihe der Internationalen Forschungsstelle Demokratische Bewegung in Mitteleuropa 1770-1850*, edited by Helmut Reinalter, 61–82. Frankfurt am Main: Peter Lang.

Schultze, Johannes. 1964. *Forschungen Zur Brandenburgischen und Preussischen Geschichte: Ausgewählte Aufsätze.* Walter de Gruyter.

Sequeira, Sandra, Nathan Nunn, and Nancy Qian. 2020. "Immigrants and the Making of America." *The Review of Economic Studies* 87 (1): 382–419.

Slack, Paul. 2014. *The invention of improvement: information and material progress in seventeenth-century England.* Oxford: Oxford University Press.

Smout, Thomas Christopher. 2012. "A New Look at the Scottish Improvers." *The Scottish Historical Review* 91 (231): 125–149.

Squicciarini, Mara P., and Nico Voigtländer. 2015. "Human Capital and Industrialization: Evidence from the Age of Enlightenment." *Quarterly Journal of Economics* 130 (4): 1825–1883.

Stapelbroek, Koen, and Jani Marjanen. 2012. *The Rise of Economic Societies in the Eighteenth Century: Patriotic Reform in Europe and North America.* Palgrave Macmillan.

Streb, Jochen, Jörg Baten, and Shuxi Yin. 2006. "Technological and Geographical Knowledge Spillover in the German Empire 1877–1918." *Economic History Review* 59 (2): 347–373.

Tosch, Frank. 2010. "Der Aufklärertypus Friedrich Eberhard von Rochow (1734-1805) und die Märkische ökonomische Gesellschaft zu Potsdam." 155–173. Waxmann Verlag.

Tosch, Frank. 2012. "Programm, Praxis und Personen der Märkischen Gesellschaft zu Potsdam um 1800." In *Die Entdeckung von Volk, Erziehung und Ökonomie im europäischen Netzwerk der Aufklärung (= Presse und Geschichte—Neue Beiträge, 58;= Philanthropismus und populäre Aufklärung. Studien und Dokumente, 1)*, edited by Hanno Schmitt, Holger Böning, Werner Greiling and Reihnart Sieger, 305–332. Bremen: edition lumière.

Tsiachtsiras, Georgios. 2020. "Transportation Networks and the Rise of the Knowledge Economy in 19th Century France." University of Barcelona mimeo.

van Dülmen, Richard. 1986. *Die Gesellschaft der Aufklärer: Zur bürgerlichen Emanzipation und aufklärerischen Kultur in Deutschland.* Frankfurt am Main: S. Fischer Verlag.

Verein zur Beförderung des Gewerbefleißes in Preußen. 1822. *Verhandlungen des Vereins zur Beförderung des Gewerbefleißes in Preußen. Verhandlungen des Vereins zur Beförderung des Gewerbfleißes in Preußen.* Berlin: Duncker und Humblot.

Voth, Joachim. 2021. "The Handbook of Historical Economics." edited by Alberto Bisin and Giovanni Federico, Chapter Persistence: Myth and Mystery. Elsevier.

Weppelmann, Norbert. 1980. "Die Gesellschaft zur Beförderung gemeinnütziger Tätigkeit in Lübeck im 18. und 19. Jahrhundert als zentrum bürgerlicher Eigenitiative." In *Deutsche patriotische und gemeinnützige Gesellschaften*, *Wolfenbütteler Forschungen*, edited by Rudolf Vierhaus, 143–160. München: Kraus International Publications.

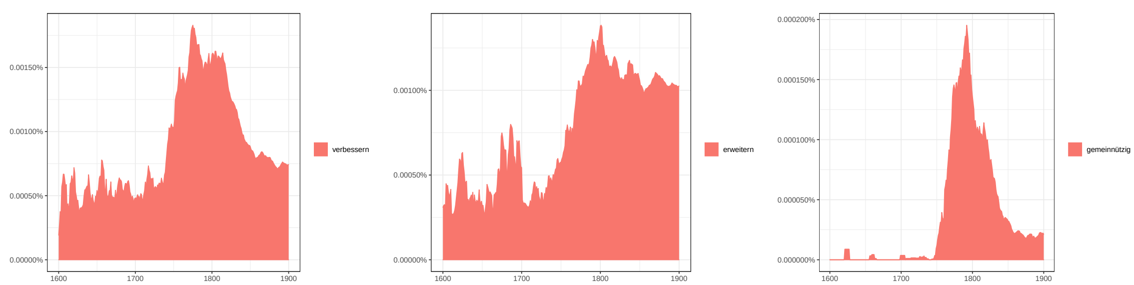
Wolff, Carl. 1877. *Carl Wolff's historischer Atlas.* Berlin: Reimer Verlag.

Zeev, Nadav Ben, Joel Mokyr, and Karine Van Der Beek. 2017. "Flexible Supply of Apprenticeship in the British Industrial Revolution." *Journal of Economic History* 77 (1): 208–250.

Appendix A Historical background

A.1 The rise of useful knowledge in Germany

The rise of useful knowledge coincides with the emergence of economic societies in the aftermath of the Seven Years' War (1756–1763). To provide evidence for the timing of this change in attitudes towards the appreciation of useful knowledge, we use text-analysis to quantify the use of words associated with this culture (Slack, 2014; Howes, 2017). Slack (2014) highlights that 'improvement' emerged as a new term in the English language during the seventeenth century and associates it with the influence of Francis Bacon. Improvement became synonymous with the Baconian program of advancing the economic state of humankind through increased empirical knowledge (Slack, 2014, p. 4). According to Slack (2014, p. 6), the German words 'verbessern' and 'erweitern' are the closest German contemporary equivalents of 'improvement' that capture the essence of the English term. We extend the analysis with the term 'gemeinnützig' that translates into 'serving the common good' and reflects that economic societies primarily aimed to improve for the common good.



(a) "verbessern' (b) "erweitern" (c) "gemeinnützig"

FIGURE A.1: Ngram frequency for German terms associated with the rise of useful knowledge

Notes: Figures present the frequency of the words specified in sub-captions in books included in the German version of the Google ngram catalogue for the period 1600–1900.

To quantify the intensity of using words that arguably best reflect the rise in useful knowledge in the German literature, we track the frequency of 'verbessern', 'erweitern', and 'gemeinnützig' in all German books within the Google ngram catalogue, following the approach by Michel et al. (2011). Panels (a) and (b) in Figure A.1 suggest that 'verbessern' and 'erweitern' both experienced a much higher frequency of use from the 1760s. Similarly, Panel (c) suggests that 'gemeinnützig' was rarely used prior to the 1760s and subsequently enjoyed a substantial popularity until the middle of the nineteenth century. We interpret this as evidence for a shift towards a culture of Industrial Enlightenment in the spirit of Mokyr (2009) in Germany that coincides with the arrival of economic societies.

A.2 State officials and the choice of society seat locations

This Appendix provides anecdotal evidence to support the claim that societies chose their society seats for idiosyncratic reasons, such that our instrumental variable distance to nearest society seat does not systematically measure proximity to places that were pre-destined to become important hubs of innovation. Especially during the first wave of society foundations in the late 1760s and early 1770s, local rulers entrusted local state officials and bureaucrats with establishing economic societies. In many cases, they picked their home towns. Because of their primarily noble origins, home towns of state officials reflected the old feudal order rather than a location of commercial interest. The following example from Hanover documents how the choice of a society seat may have looked in many cases.

The Hanoverian society in Celle was founded at the initiative of newly crowned George III, king of Great Britain and Ireland and ruler of the Electorate of Hanover (i.e., the Duchy of Brunswick-Lüneburg) in the German lands. The decision to establish an economic society was motivated by the economic effects of the Seven Year's War in the Hanoverian lands (Rübberdt, 1934, p. 57). The task of founding the society was entrusted to King George III's minister of state for the Electorate of Hanover in London, Freiherr Burchard Christian von Behr, a local nobleman from the principality of Lüneburg in Hannover (KLGC 1864). Next, a circle of state-bureaucrats from the local nobility under the guidance of von Behr chose the old residence town of the principality of Lüneburg, the city of Celle, as the new seat for the economic society (KLGC 1864). The decision appears to be idiosyncratically linked to von Behrs origin from the principality of Lüneburg and his connections within the local nobility. More natural choices for the society seat could have been the capital of the Electorate of Hanover was Hanover (15,736 inhabitants in 1764), the second largest city, Lüneburg (8,612 inhabitants), or Göttingen (6,099 inhabitants), the location of the university and the Royal Academy of Sciences, whereas Celle was only the third largest city (7,514 inhabitants).

A.3 Statutory missions of Economic Societies

TABLE A.1: Statutory mission of societies

Society	Statements of aims (original) & sources	Statements of aims (translation)
Bad Homburg	"La Société Patriotique composée de Savants, de Littérateurs , d'Artistes de bons Citoyens de toutes les contrées de l'Europe, pour travailler de concert l'encouragement des Sciences, des Arts & des Moeurs , sera divisée en autant de Comités ou Départements, que les le local l'éxigeront. Chaque Capitale de Province, Où la Société aura plusicurs membres, formera un grand Comité qui' correspondra directement pour lui & pour les autres Comités de la Province avec celui de Hesse-Hombourg." (La Société patriotique de Hesse-Hombourg, 1777, p. 6)	"The Patriotic Society composed of artists, writers, good artists, citizens from all parts of Europe working together for the encouragement of the sciences, arts & more, will be divided into as many committees or departments, as will be demanded locally. Each capital of a province, where the Society will have several members, will form a committee which will correspond directly with them and with the other committees of the province and with the one of Hesse-Homburg
Breslau	"Beförderung der Geistes- und Gewerbscultur" "Es werden sich solche [Sectionen] (...) entweder für irgend ein, enger oder weiter zu begränzendes wissenschaftliches Gebiet, z.B. Geschichte, Mathematik, Naturkunde u.s.w., oder für irgend einen wichtigen Zweig der Industrie, z.B. die Oeconomie, das Fabrikwesen u.s.w. oder für einen bestimmten Zweig der öffentlichen Wohlfahrt, z.B. die Schulverfassung, die Art und Weise, der Armuth vorzubeugen oder sie auf die beste Art zu unterstützen u.s.w. bilden können" (Schlesische Gesellschaft für Vaterländische Cultur , 1822)	"Encouragement of the Intellectual and Trade Culture", "[sections] such as, a narrowly or wider defined scientific area, e.g. history, mathematics, natural philosophy, etc., or an important sector of industry, e.g. the economy, the factories, or a special branch of public welfare, e.g. the constitution of schools, or ways to prevent poverty or to help them in the best way etc., can be founded"
	"Eine Verbindung mit vorzüglichen Künstlern, Fabrikanten und Manufakturisten, die (. . .) theils bey anzustellenden Versuchen und Prüfungen neuer (. . .) Entdeckungen zu Rathe gezogen werden können, theils im Stande sind, taugliche Maschinen, Instrumente und Geräthschaften zu verfertigen" (Gesellschaft zur Beförderung der Naturkunde und Industrie Schlesiens, 1806, p. xv)	"A connection with excellent artists, fabricants, and manufacturers, who (. . .) can be consulted partly on new experiments and on examinations of new (. . .) inventions and partly are able to construct new machines, instruments, and devices"
Burghausen	"(. . .) soll nach gnädigstem Befehle ihre Abhandlungen bloß auf landwirthschaftliche Gegenstände richten; und andurch trachten solche Vorschläge, Beweise und pracktische Unternehmungen auszuführen, wodurch das Wohlseyn der Bürger, und Unterthanen gemein-nutzlich befördert werden möge. (...) Ist der Gesellschaft jedennoch nicht verwehret durch sittliche, sonderlich aus den bürgerlichen, societätsmäßigen Pflichten abflüßende Beweggründe den Burger, und Unterthan anzufrischen" (Gesetze der Churbaierischen landwirthschaftlichen Gesellschaft zu Altenoettingen, as cited in Graf, 1993, p. 264)	"(. . .) according to the most gracious order [the society] shall only make agricultural objects the topic of its publications; and shall thereby try to bring such suggestions, proofs and practical projects into practice as can encourage the welfare of its citizens and subjects. (. . .) However, the society is not forbidden to refresh the citizen and subject through moral motives, especially as they follow from the civic societal duties."
Celle	"Verbesserung der Landwirthschaft, der Forsten, der Manufacturen, der Künste und des Handels" "Die Gesellschaft giebet sich mit keinen blos speculativen Theorien und mit keinen weit aussehenden und noch nicht vortheilhaft befundenen Projecten ab", "Der engere Ausschus setzet jährlich einen Preis auf eine vorgelegte Aufgabe" (Statuten der Gesellschaft 1764-1788, as cited in Königliche Landwirthschafts-Gesellschaft zu Celle, 1864, pp. 24-39)	"Improvement of Agriculture, forests, manufacture, the arts, and trade", "The society does not engage in only speculative theories and with broad looking projects, not yet judged to be useful", "The smaller committee awards a yearly premium for a task to presented"

Hamburg	“an alle wahre Patrioten Hamburg gerichtete Ermahnung zur Aufrichtung einer ähnlichen Patriotischen Gesellschaft, zur Aufnahme der Handlung, der Künste, der Manufakturen und des Ackerbaues, wie die zu London und Paris ist” (Title of an anonymous publication calling for the foundation of the “Patriotische Verein” in 1765, as cited in Rübberdt, 1934, p. 65)	“An appeal to all true patriots of Hamburg, for a foundation of a similar patriotic society for the trades, arts, manufactures, and agriculture, as exist in London and Paris”
Jauer / Schweidnitz [A.1]	“Betriebsamkeit ihrer [Schlesiens] Einwohner — der Verbesserung des Ackerbaus — Vermehrung des Viehstandes”, “Erzeugnisse vortheilhaft zu verarbeiten und abzusetzen” (Fischer, 1822)	“Industriousness of its [Silesia] inhabitants — the improvement of acgriculture — increase of livestock”, “to produce and sell commodities in advantageous ways”
Kassel	“Die Gesellschaft beschäftiget sich mit allen denenjenigen Untersuchungen, welche die Verbesserung des Land-Baues und was damit Verbindung stehet (...), befördern können” (Statuta 1765, S. 298) “Die Absicht der Gesellschaft ist, alle dem Staat nützliche Künste aufzumuntern und insbesondere diejenige zur Vollkommenheit zu bringen, welche dem Volke einträgliche Verrichtungen schaffen und Handel und Wandel in einen blühenden Stand setzen”, konkret “Feldbau”, “Manufacturen” und “Handel und Wandel” (Statuta 1773, as cited in Gesellschaft des Ackerbaus und der Künste, 1790, p. 736)	“The society looks at all investigations that can improve the agriculture and everything related to it”, “The aim of the society is to encourage all arts useful to the state and especially to bring that to perfection that can create profitable work for the people and bring the trades into a blooming state”, specifically “agriculture”,“manufactures”, and “the trades”
Kiel	“Wirksamkeit zur Bevörderung der Landeskunde und des bürgerlichen Wohlstandes als den Zweck unserer Vereinigung festgesetzt”, “vollständige Topographie der Herzogthümer [Schleswig-Holstein]”, “manche Landeserzeugnisse gewis zwekmässiger genüzt und vortheilhafter verädelt werden” (Niemann, 1787, pp. x–xii)	“Effectiveness of improvement of natural history and of civil wealth are set as the aim of this society”, “complete topography of the duchies [of Schleswig-Holstein]”, “some local products can surely be used more sensibly and be refined more advantageously”
Lautern / Mannheim	“Jedoch gedenkt die Gesellschaft nicht, unter diesem ehrwürdigen Vorwande geringe oder seichte Schriften drucken zu lassen; nein, sie wird sich immer bestreben, blos sehr nützliche und durch Erfahrung erprobte Sachen dem gemeinen Wesen vorzulegen. ”, “Verbesserungen der Landwirthschaft” (Physikalisch-ökonomische und Bienengesellschaft zu Lautern, 1771, pp. 4 ff.)	“The society, however, does not aim to print lower or shallow works; no, it will always try to only present useful topics proved through experience”, “improvement of agriculture”
Leipzig	“Die Errichtung einer Gesellschaft (...), welche den Nahrungsstand überhaupt, als Land- und Stadtwirthschaft, Manufacturen und Handlungen im weitesten Umfange, zum Gegenstande ihrer Beschäftigung macht” (As cited in Am Ende, 1884, p. 6)	“The foundation of a society, which takes as its purpose agriculture in general and the rural and urban economy, manufactures, and trades in its widest scope”
Lübeck	“1. Daß die Gesellschaft innerhalb ihres Kreises den gemeinnützig-tätigen Sinn ihrer Mitglieder durch belehrende wissenschaftliche Unterhaltung fördern sollte. 2. Daß die gemeinnützige Gesellschaft außerhalb ihres Kreises a) Maßnahmen, die die Erhaltung der Existenz des Menschen sichern, in Gang setzen sollte. b) Unternehmungen, die der Vermittlung gemeinnütziger Erkenntnisse in allen Volksklassen dienen, zu unterstützen hatte; c) Einrichtungen, die der Entwicklung mechanischer Fertigkeiten zum Nutzen der Gewerbetreibenden dienen könnten, zu fördern hatte.” (Statutes, as cited by Weppelmann, 1980, p. 151)	“1. That the society shall encourage the welfare promoting sense of its members through educational scientific discourse. 2. That the welfare promoting society outside the circle of its members a) shall start actions that ensure the preservation of the existence of the people b) shall support projects that serve the transfer of welfare promoting insights into all classes c) shall promote facilities that could serve the development of mechanical skills for the use of the trades”

[A.1] This society can be traced back to the “Patriotische Gesellschaft in Schlesien” from 1781 (Gerber, 1988) and seems to have been reconstituted as the “ökonomisch-patriotische Societät der Fürstenthümer Schweidnitz und Jauer” around 1800 - the statutes refer to the introduction to its aims from Fischer (1822).

Mohrungen	"Die Aufklärung und Vervollkummnung der verschiedenen Zweige des Nahrungs-Standes, sollen der Zweck ihrer Arbeisen seyn" - Aufteilung in Klassen: "Chemische", "Physikalische", "Medicinische", "Mathematische", "Cameralistische" - alle auf praktische Anwendbarkeit hin definiert" (Ostpreußisch-Mohrungsche physikalisch-ökonomische Gesellschaft, 1792, pp. 30–56)	"The aim of these works shall be the enlightenment and perfection of all areas of the agricultural class" Seperation into sections: "Chemical", "Physical", "Medicinal", "Mathematical", "Cameralistic" - all to be used for practibal purposes
Nürnberg	"einen Verein zu gründen, durch welchen der gesunkene Gewerbsfleiß ermuntert, Bürgerglück und Bürgerwohlstand befördert, schädliche und tief eingewurzelte Mißbräuche vertilgt, für die Bildung armer Kinder gesorgt, und leidenden Gewerbsgliedern Trost und Hülfe verschafft werden soll" (Gesellschaft zur Beförderung vaterländischer Industrie, 1831, p. 3)	"to found a society, through which the fallen industriousness shall be encouraged, happiness and wealth of citizens be promoted, harmful and deeply entrenched malpractices be eradicated, the education of poor children be provided, and suffering members of the trades be provided with solace and help"
Potsdam	"einheimisch-ländlichen und städtischen Nahrungsgeschäfte", "Land- und Stadtgewerbe", "oekonomischer Kenntnisse zu vermehren", "Bildung des Menschen" (Annalen der Märkischen Oekonomischen Gesellschaft zu Potsdam 1792, as cited in Motschmann, 2015)	"local rural and urban food trades", "Rural and urban trades", "increasing economic knowledge", "education of man"
Rostock	"Die Verbesserung der Mecklenburgischen Landwirthschaft", "so werden die ordentlichen Mitglieder, allein aus der Mitte der in Mecklenburg mit Landgütern Angesessen genommen" "Wird selbiger [der Sekretär] zur Anschaffung einer zu errichtenden Sammlung von Modellen, Zeichnung [. . .] bestimmt", "Werden Preisaufgaben zu öffentlicher-Beantwortung gestellt" (Krünitz et al., 1807, pp. 30–34)	"The improvement of agriculture in Mecklenburg", "thus, all full members are only selected from the ranks of residents of country estates in Mecklenburg", "The same [the secretary] is appointed to the acquirement of a collection of models, drawings [. . .] to be brought together", "Prize competitions are advertised to be answered by the public"

Verein zur Beförderung des Gewerbfleißes in Preußen	"indem sie ihnen [Fabrikanten und den Künsten] geprüfte Neuerunggen mittheilt; sie wird Erfindungen des Vaterlands, die ihr mitgetheilt werden, und die sie nach vorgängiger Prüfung für nützlich hält, belohnen; sie wird Gegenstände zur öffentlichen Preisbewerbung bringen (...); sie wird Sammlungen von vorzüglichen Produktionen des In- und Auslands, desgleichen von Modellen und Zeichnungen für Maschinen (. . .) veranstalten" (Verein zur Beförderung des Gewerbefleißes in Preußen, 1822, p. 3)	"by informing them [manufacturers and the arts] on proved innovations; it will give awards to inventions of the fatherland communicated to it and that have, after previous examination, been judged as useful; it will put topics to public prize competitions (. . .); it will create collections of the best productions of national or foreign origin, and in the same way of models and drawings of machines."

A.4 Example of prize competitions

Table A.2: List of the topics of all price competitions and special awards published by the economic society in Leipzig between 1764 and 1790

1. On Potash
2. On the perfection of bleaches in Saxony
3. On the improvement of hop growing
4. For the cloth and harness maker and linen weavers
5. On a durable color with turmeric on wool
6. On a vivid and durable flesh tone on cotton
7. On wool sorting
8. On the refinement and increase of wool
9. For the best spinsters in the ore mountains
10. On a "perpétuel" from sheep wool and an improved cotton ("Péruvienne")
11. On a treatise on viticulture
12. On a treatise on the prevention of price increases
13. On a complete treatise on a topic in economics to be self-selected
14. Award to M. Gruhlich for making his spinning wheel with a double reel available to public use
15. On economic descriptions of natural history
16. On a remedy for the killing off plant lice
17. On the production of good linen
18. An investigation of mistletoe
19. Award to the deputy Ranstler, the pastor Rudolphi, and the bailiff Hering (10 Thlr) for the useful works they had sent in
20. On the produced observation of weather conditions
21. On the purchase of a twining machine
22. On answering the question of how to make stable feeding more universal
23. On the planting of fruit trees near Wittenberg

Notes: Taken from Leipziger ökonomische Gesellschaft (1790, pp. 319 ff., pp. 25 f.) and translated by the authors.

A.5 Example of list of of products assessed by the economic society

Table A.3: List of all natural and artificial products presented to the society in Leipzig between 1764 and 1767

1764	1766	1767
1. A swatch died with domestic common madder	1. A sample of China ink produced from domestic soil	1. Different domestic types of marble
2. Various died ribbons from tree bark	2. A sample of red dye produced after a procedure of the privy counsellor von Kessel	2. A sample of white soil from Thuringia for fireproof melting pots
3. An oil sample	3. A sample of asphalt suitable for cement	3. Aluminous black coal, from the same place
4. Local coal, found near Domsen	4. A sample of especially refined textile, including its yarn	4. One adstringent soil, from the same place
5. English oats, Polnish wheats, and perennating flax grown in Belgershayn	5. All kind of paper and cardboard samples	5. Processed domestic cotton, including fustian and stockings produced from it
6. A sample of starch from Menßdorf	6. Samples from an alkaline salt that was produced from different materials from plants and animal products	6. Sample from an inexpensive, eatable and well burning oil
7. Different American seeds	7. A fulling tone, discovered by the senior civil servant, von Schütz at Erdmannsdorf	7. A curious turnip because of the strength of its roots and the amount of its stems
8. 300 different terra sigillata from Saxony, from a stone-inspector Frenzel	8. Different soils from there	8. Alsatian hemp, Turkish wheat and rye, all build on the soil near Dresden
	9. Minerals from the coal pit in Mertensdorf	9. Long Turkish millet, grown near Seyda
	10. Samples of domestic colour ?Bieyweiß?	10. Turnips and rapes of excellent size
		11. Died plants in which the cochineal was found near Dresden
		12. Textile and hemp samples, from Alsatian hemp
		13. Dying samples with domestic Cochenille ? on wool and silk
		14. A sample of yarn from domestic production
		15. A fine ribbon and a few fine stockings, from especially finely spun wool
		16. Samples from three types of leather, with heather alone, half with heather and blaze, and prepared with sawdust
		17. Sample of a blaze prepared with fir needles
		18. A collection of different geological types of seam, found in a seam near Wildenstein
		19. A collection of different fossils in the Herrschaft Baruth
		20. A sample of blue earth from Eckartsberg

Notes: Taken from Leipziger ökonomische Gesellschaft (1790, pp. 322 ff.) and translated by the authors.

A.6 Example of journals held by an economic society

Table A.4: Overview of all journal subscriptions held by the economic society in Breslau in 1806

1. Gilberts Annalen der Physik
2. Voigts Magazin für das Neueste der Naturkunde
3. Neues allgemeines Journal der Chemie
4. Göttlings Taschenbuch für Scheidekünstler
5. Molls Annalen der Berg- und Hüttenkunde
6. Magazin aller neuen Erfindungen
7. Busch Almanach der neuesten Erfindungen und Entdeckungen
8. Journal für Fabrik, Manufactur, Handlung und Mode
9. Annalen des Ackrebaues von Thär
10. Annalen der Schlesischen Landwirthschaft
11. Landwirthschaftliche Zeitung von Schnee
12. Gartenzeitung von Sprengel
13. Reils Archiv der Physiologie
14. Berlinisches Jahrbuch für die Pharmacie
15. Hallische Litteraturzeitung
16. Memoires de l'institut nationale des sciences mathematiques et Physiques
17. Journal de Physique, de Chemie etc. par Delamethrie
18. Bibliotheque Physio-oeconomique
19. Annales de Chemie
20. Journal de Chemie
21. Journal des mines
22. Annales des arts, manufactures etc.
23. The philosophical transactions of the royal Society of London
24. Transactions of the royal Society of Edinburg
25. Nicholson's Journal, of Natural Philosophy, Chemistry etc.
26. The Brittish Museum
27. The Repertory of Arts etc.
28. Annales of Botany
29. The Farmer's Magazine

Notes: Taken from Gesellschaft zur Beförderung der Naturkunde und Industrie Schlesiens (1806, pp. xxxii. f.) and translated by the authors.

A.7 Statistics on Member's Occupations

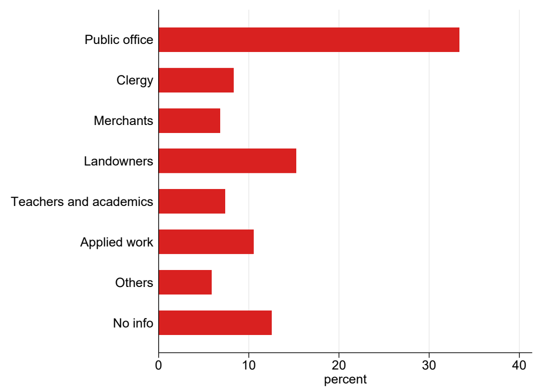


Figure A.2: Distribution of member's occupations for all economic societies

Notes: Information on occupations is taken from the original membership lists and classified according to nine categories. Public office refers to all people employed by the state, especially all kind of "Räte". Clergy includes all clerical positions. Merchants includes all kind of mercantile business independent of size. Landowners are members where the membership lists explicitly refer to their landholdings. Teachers and academics includes both school teachers, private teachers, and professors at university. Applied work refers to physicians, apothecaries, jurists, and applied mechanical constructors. The coding of occupations explicitly allows for people to hold multiple occupations - hence percentages here explicitly refer to the proportion of observed occupations, not to the proportion of members exclusively holding occupation. Information on occupations for members in Hamburg and Läbeck are missing and both societies therefore excluded from the graph.

Appendix B Data description

B.1 Variable definitions

B.1.1 Society members

Society members. The number of members in any economic society established between 1764 and 1800 whose place of residence is located in a given a grid cell. See Section 3 and Table B.3 for a discussion of society selection criteria. The sources for each membership register are listed in Table B.1 below. Registers reflect either the stock of current members at a given date or the stock at a given date (typically the year of establishment) plus members joining the society during subsequent years.

TABLE B.1: Sources of membership registers

Society seat	Source	Type of membership register
Bad Homburg	SPHH (1777, pp. 19–54)	Stock in 1777
Breslau	SGVC (1826–1840)	Stock in 1806
Burghausen	Graf (1993, pp. 266–276)	Stock in 1765 + entry until 1779
Celle	KGCBLL (1772, pp. 730–739)	Stock in 1764 + entry until 1771
Hamburg	Kopitzsch (1980, p. 85)	Stock in 1790
Jauer / Schweidnitz	Fischer (1822, pp. 1–12)	Stock in 1821
Kassel	Runde (1773, introduction, pp. 11–18)	Stock in 1773
Kiel	SPHH (1812, pp. 612–623)	Stock in 1787
Lautern / Mannheim	KPÖG (1771; 1773; 1776; 1779)	Stock in 1769 + entry until 1780
Leipzig	LÖG (1790, pp. 258–300)	Stock in 1764 + entry until 1789
Lübeck:	Heller (1859, p. 16)	Stock in 1819
Mohrungen	KOMPÖ (1796, pp. 11–24)	Stock in 1796 + entry until 1800
Nürnberg	GBVIN (1833)	Stock in 1817
Potsdam	Motschmann (2015, pp. 105–109)	Stock in 1791 + entry until 1815
Rostock	MPV (1827, pp. 710–735)	Stock in 1827

Notes: Table shows primary sources of registers for each society.

B.1.2 Innovation and human capital

Patents 1877-1914. The number of valuable patents issued during the period 1877–1914 with the German Imperial Patent Office by a patent holder located in a given grid cell. If the patent holder is an individual, the location is their place of residence. If the patent holder is a firm, the location is their firm location. Valuable patents are defined as patents that were renewed for at least 10 consecutive years. Data obtained from Streb, Baten and Yin (2006).

Exhibitors 1873. The number of exhibitors at the 1873 Vienna World's Fair, whose place of residence is located in a given a grid cell, according to the official catalog of the Vienna World's Fair. The newly digitized data are obtained from the original catalog of the exhibition, General-Direction der Weltausstellung (1983).

Vocational schools. Year of establishment of the earliest vocational school located in a given grid cell. Only technical colleges (*Fachschulen*) whose year of establishment was available. included. The newly digitized data are obtained from Pache (1896–1905).

Highly-skilled mechanics. The number of highly skilled-mechanics located in cities in a given grid cell. Following Feldman and Van der Beek (2016, Table A1), highly-skilled mechanics are defined as artisans in occupations that require mechanical skills. These are Cabinet Maker, Coach Maker, (House) Carpenter, Joiner, Engineers and wrights, Machine and instrument makers, Plumber, Brazier, Cutler, Goldsmith/Silversmith, Jeweler, Printing and engraving, Working with precious metals, Ship builder, Gun and Lock smiths, Other smiths and founders, Pewterrer, Smith, Carver, Cooper, and Turner in wood. Data obtained from the Prussian artisan census of 1849 (Statistisches Bureau zu Berlin, 1851–1855, vol. 5).

Other artisans. The number of other artisans located in cities in a given grid cell. Other artisans are all artisans in occupations that do not require mechanical skills following Feldman and Van der Beek (2016, Table A1). Data obtained from the Prussian artisan census of 1849 (Statistisches Bureau zu Berlin, 1851–1855, vol. 5).

Factory workers. The number of factory workers located in cities in a given grid cell. Factory workers are all workers in occupations included in the factory census of 1849, obtained from (Statistisches Bureau zu Berlin, 1851–1855, vol. 6a).

B.1.3 Geographical controls

Average temperature. The average temperature in degrees Celsius in a grid cell during the 1960–1990 time horizon, constructed by temporally and spatially aggregating time series information on mean monthly temperature at a geospatial resolution of 30 arc seconds (i.e., grid cells of approximately 1 kilometer squared each), obtained from the WorldClim (version 1) data set (http://www.worldclim.org/version1) of Hijmans et al. (2005).

Average precipitation. The average precipitation in hundreds of millimeters in a grid cell during the 1960–1990 time horizon, constructed by temporally and spatially aggregating time series information on total monthly precipitation at a geospatial resolution of 30 arc seconds (i.e., grid cells of approximately 1 kilometer squared each), obtained from the WorldClim (version 1) data set (http://www.worldclim.org/version1) of Hijmans et al. (2005).

Altitude. The average terrain altitude in m in a grid cell, at a geospatial resolution of 30 arc seconds (i.e., grid cells of approximately 1 kilometer squared each). Obtained from the WorldClim (version 1) data set (http://www.worldclim.org/version1) of Hijmans et al. (2005).

Distance to navigable river. The geographic distance in hundreds of kilometers from a grid cell centroid to the nearest navigable river, constructed using a map of all waterways (*Schiffahrtsstraßen*) in the *Zollverein* (German Customs Union) in 1850 (http://www.ieg-maps.uni-mainz.

de/mapsp/mapw850d.htm), hosted by the "Server for Digital Historical Maps" at the Leibniz Institute of European History at the University of Mainz IEG (2010).

Soil suitability (cereals). The average suitability of the soil in a grid cell for growing cereal crops, constructed by spatially aggregating information on an agro-ecological suitability index (class) for low-input-level rain-fed cereal crops at a geospatial resolution of 30 arc seconds (i.e., grid cells of approximately 1 kilometer squared each), obtained from the Food and Agriculture Organization's (FAO) Global Agro-Ecological Zones (GAEZ) Data Portal version 3.0 (http://gaez.fao.org).

B.1.4 Population controls

Bairoch city pop 1750. The total population of cities with at least 5,000 inhabitants in 1750 located in a given grid cell. Data obtained from Bairoch (1988).

Prussian city pop 1816. The total (non-military) population of cities with city rights in 1816 according to the Prussian census of 1816, located in a given grid cell. Data obtained from Mützell (1823–1825).

Pfister city pop 1763. The total population of cities with at least 5,000 inhabitants in 1763 located in a given grid cell. Missing data is linearly imputed over time, but not extrapolated. Data obtained from Pfister (2020).

Hyde population 1760. The (estimated) total population in 1760 in a given grid cell. Gridded total population data drawn from HYDE version 3.2, which is derived from algorithms to spatially distribute the total population to 5 arc minute pixels. Data obtained from Klein Goldewijk et al. (2017).

Hyde urban population 1760. The (estimated) urban population in 1760 in a given grid cell. Gridded urban population data drawn from HYDE version 3.2, which is derived from algorithms to spatially distribute the urban population to 5 arc minute pixels. Data obtained from Klein Goldewijk et al. (2017).

Hyde urbanization 1760. The urbanization rate (estimated urban population as a fraction of estimated total population) in 1760 in a given grid cell. Gridded population data drawn from HYDE version 3.2, which is derived from algorithms to spatially distribute the population to 5 arc minute pixels. Data obtained from Klein Goldewijk et al. (2017).

No. Keyser cities. The total number of cities with city rights awarded until 1760, located in a given grid cell. Data obtained from Bogucka, Cantoni and Weigand (2020) are based on Keyser (1939–1974). For regions outside the Weimar Republic but part of the German Empire, we add a city count based on information obtained from Matzerath (1990) and KSAB (1903).

No. Prussian cities. The total number of cities with city rights according to the Prussian census of 1816, located in a given grid cell. Data obtained from Mützell (1823–1825).

Berlin dummy. Indicator that assumes the value one if the grid cell contains Berlin, the capital of the German Empire and the location of the Imperial Patent Office.

B.1.5 Polity-fixed effects

Polity-fixed effects 1789. Indicator variables assuming the value one if the centroid of a given grid cell is located within the territory of a state in the Holy Roman Empire in 1789. Polities that contain five centroids or less are grouped into a single indicator. Polity borders obtained from Huning and Wahl (2020), based on a map by Wolff (1877).

Polity-fixed effects 1820. Indicator variables assuming the value one if the centroid of a given grid cell is located within the territory of a state in the German Confederation in 1820. Polities that contain five centroids or less are grouped into a single indicator. Polity borders obtained from HGIS Germany (2019).

B.1.6 Robustness controls

Market access in 1750. The sum of the total population of cities located in grid cells j, weighted by their geographic distance (in kilometers) to grid cell i: $M_i = \sum_{i=1}^{N}(\frac{\text{pop}_j}{\text{dist}_{ij}})$. Where $j \neq \imath$. Population data is obtained from Bairoch (1988) for large cities. We assume a size of 1,000 inhabitants for cities not included in Bairoch (1988).

Hanse member. Indicator that assumes the value one if the grid cell contains a city that was a member of the Hanseatic League. Data obtained from Hammel-Kiesow (2014), further refined with Wikipedia searches.

Bishop in 1500. Indicator that assumes the value one if the grid cell contains a bishop's residence in 1500. Data obtained from Rubin (2014).

Imperial / Free city. Indicator that assumes the value one if the grid cell contains a free or imperial city. Free and imperial cities were independent of local territorial rulers and were represented in the Imperial Diet. Data obtained from Rubin (2014).

Printing press in 1500. Indicator that assumes the value one if the grid cell contains a printing press in 1500. Data obtained from Rubin (2014).

Market by 1760. Indicator that assumes the value one if the grid cell contains at least one city which obtained market privileges by 1760. This includes annual, weekly, and daily markets. Data obtained from Bogucka, Cantoni and Weigand (2020), based on Keyser (1939–1974).

No. constructions until 1750. Total number of significant buildings erected until 1750. This includes clerical, administrative, economic, private, military, and social buildings erected since medieval times. Data obtained from Cantoni (2020), based on Keyser (1939–1974).

School by 1760. Indicator that assumes the value one if the grid cell contains at least one school established before 1760. Data obtained from Keyser (1939–1974).

Upper-tail human capital attraction. The total number of notable individuals as recorded in the *Deutsche Biographie* that died in a given grid cell during a given period and was born in a different grid cell. Data obtained from (BADW)

Distance to nearest society seat The geographic distance (in kilometers) between the centroid of a given grid cell and the closest seat of an economic society. A list of society seats is presented in table 1.

Distance to university in 1760. The geographic distance (in kilometers) between the centroid of a given grid cell and the closest university. The list of universities includes all German universities operating in 1760, according to Naragon (2016), an updated version of Eulenburg (1904).

Distance to 17 largest cities 1750 (w/o society seats). The geographic distance (in kilometers) between the centroid of a given grid cell and the closest of the 17 largest cities in Germany in 1750, according to Bairoch (1988), excluding cities that subsequently became society seats.

Distance to literary society seat. The geographic distance (in kilometers) between the centroid of a given grid cell and the closest seat of a literary society established in the period 1750–1800 according to van Dülmen (pp. 150–152 1986).

Distance to reading society seat. The geographic distance (in kilometers) between the centroid of a given grid cell and the closest seat of a reading society established in the period 1750–1800 according to van Dülmen (1986, pp. 165–171).

B.2 Summary statistics

TABLE B.2: Summary statistics

Variable	Mean	SD	Min	Max	Obs.
Society members	1.152	(10.708)	0	432.000	2698
(arcsinh) Society members	0.367	(0.762)	0	6.762	2698
(arcsinh) Patents 1877-1914	0.717	(1.335)	0	9.217	2698
(arcsinh) Exhibits World Fair 1873	0.439	(0.943)	0	7.244	2698
Vocational schools	0.543	(1.587)	0	31	2698
Altitude	220.976	(233.637)	0	2344	2698
Average temperature	8.097	(1.169)	-1.200	10.420	2698
Average precipitation	0.698	(0.155)	0	1.514	2698
Soil suitability (cereals)	4.137	(1.356)	0	9.000	2698
Distance to navigable river	23.065	(25.822)	0	148.482	2698
(arcsinh) Bairoch city pop 1750	0.665	(2.421)	0	12.346	2698
No. Keyser cities	0.926	(1.066)	0	10	2698
(arcsinh) Pfister city pop 1763	0.589	(2.307)	0	12.217	2698
(arcsinh) Hyde pop 1760	8.926	(2.353)	0	11.907	2698
(arcsinh) Hyde city pop 1760	1.192	(3.128)	0	11.766	2698
Hyde urbanization 1760	0.061	(0.175)	0	1	2550
(arcsinh) Upper-tail human capital attraction 1720-60	0.089	(0.392)	0	4.454	2698
(arcsinh) Upper-tail human capital attraction 1760-65	0.018	(0.152)	0	3.093	2698
(arcsinh) Upper-tail human capital attraction 1760-80	0.077	(0.349)	0	4.304	2698
(arcsinh) Upper-tail human capital attraction 1760-90	0.105	(0.420)	0	4.625	2698
(arcsinh) Upper-tail human capital attraction 1760-00	0.131	(0.482)	0	4.997	2698
(arcsinh) Distance to nearest economic society	4.970	(0.881)	0	6.222	2698
(arcsinh) Distance to 17 largest Bairoch cities in 1750	11.767	(1.226)	0	13.261	2698
(arcsinh) Distance to university in the 1760s	4.571	(1.033)	0	6.124	2698
(arcsinh) Distance to nearest inactive society seat	11.959	(1.197)	0	13.474	2698
(arcsinh) Distance to literary society	4.597	(0.999)	0	6.383	2698
(arcsinh) Distance to reading society	3.680	(1.423)	0	6.096	2698
(arcsinh) Distance to 17 largest Bairoch cities (w/o soc seats)	11.776	(1.233)	0	13.313	2698
Market access in 1750	6.822	(1.995)	2.975	15.527	2698
Hanse member	0.054	(0.226)	0	1	2698
Bishop member	0.012	(0.108)	0	1	2698
Imperial / Free city	0.025	(0.157)	0	1	2698
Printing press in 1500	0.021	(0.145)	0	1	2698
Market by 1760	0.377	(0.485)	0	1	2698
(arcsinh) No. construnctions until 1750	1.247	(1.447)	0	5.642	2698
School by 1760	0.450	(0.498)	0	1	2698
(arcsinh) Highly-skilled mechanics 1849	5.342	(0.943)	0	10.283	734
(arcsinh) Other artisans 1849	6.303	(0.898)	3.402	10.924	734
(arcsinh) Factory workers 1849	4.201	(2.017)	0	10.636	734
(arcsinh) Prussian city pop 1816	8.400	(0.850)	5.684	12.826	721
No. Prussian cities	1.332	(0.676)	1	9.000	734

Notes: Table shows summary statistics for all variables used in cross-sectional estimations.

B.3 List of all Economic Societies

TABLE B.3: Full list of Patriotic Economic Societies

List of societies according to van Dülmen (1986)				Reason for exclusion			
City	Country	Society Name	Year	Not Germany[B.1]	Inactive[B.2]	Small[B.3]	No records[B.4]
Zurich	CHE	Physikalisch-ökonomische Gesellschaft	1757	x			
Bern	CHE	Schweizer Landwirtschaftsgesellschaft	1758	x			
Bern	CHE	ökonomische Gesellschaft (mit Zweiggesellschaften in Emmental, Simmental, Aarau, Nidau, Aigle, Avenches, Lausanne, Nyon, Payerne, Vevey, Yverdon)	1759	x			
Zurich	CHE	ökonomische Kommission der Naturforschenden Gesellschaft (mit Zweiggesellschaft im Kyburgeramt)	1759	x			
Biel	CHE	ökonomische Gesellschaft	1761	x			
Fribourg	CHE	ökonomische Gesellschaft	1761	x			
Solothurn	CHE	ökonomische Gesellschaft	1761	x			
Flensburg	DEU	Königliche Dänische Ackerakademie (Glücksburgische ökonomische Gesellschaft)	1762				x
Weißensee	DEU	Thüringische Landwirtschaftsgesellschaft	1762		incl. in Leipzig from 1764		
Celle	DEU	(Königlich Großbritannische) Braunschweigisch-Lüneburgische Landwirtschaftsgesellschaft (mit Zweigstellen in Uelzen, Hannover, Nienburg, Dannenberg, Stade)	1764				
Graz	AUT	K.K. Gesellschaft des Ackerbaus und der nützlichen Künste in Steyermark	1764	x			
Klagenfurt	AUT	K.K. Ackerbaugesellschaft in Kärnten	1764	x			
Leipzig	DEU	ökonomische Sozietät (mit 6 Kreissozietäten)	1764				
Prag	CZE	Ackerbau- oder ökonomische Gesellschaft im Königreich Böhmen (K.K. Böhmische patriotisch-ökonomische Gesellschaft)	1764	x			
Zurich	CHE	Moralische Gesellschaft	1764	x			
Ansbach	DEU	Fränkische physikalisch-ökonomische Gesellschaft	1765			x	
Görz	ITA	K.K. Ackerbaugesellschaft	1765	x			
Hamburg	DEU	Gesellschaft zur Beförderung der Manufacturen, Künste und nützlichen Gewerbe (Patriotische Gesellschaft)	1765				
Karlsruhe	DEU	Gesellschaft der nützlichen Wissenschaften zur Beförderung des gemeinen Besten (Sozietät zur Verbesserung der Landesökonomie)	1765		x		
Kassel	DEU	Hochfürstlich Hessen-Kasselische Gesellschaft des Ackerbaues und der Künste	1765				
Burghausen	DEU	Churbaierische Gesellschaft der Sittenlehre und Landwirtschaft (in Altötting gegründet)	1765				

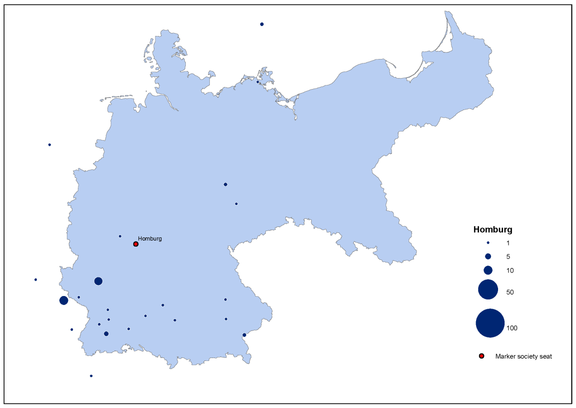
[B.1] Following the borders of the German Empire in 1871
[B.2] According to Rübberdt (1934)
[B.3] Exclusive focus on beekeeping or hunting.
[B.4] According to own research

Bautzen	DEU	Physikalisch-ökonomische Bienengesellschaft in Oberlausitz	1766			x	
Innsbruck	AUT	K.K. patriotische Gesellschaft des Akkerbaues und der Künste für Tirol und Vorarlberg	1766	x			
Linz	AUT	K.K. Ackerbaugesellschaft	1766	x			
Laibach	SVN	K.K. Gesellschaft des Ackerbaus und der nützlichen Künste im Herzogtum Krain	1767	x			
Freiburg (Br.)	DEU	K.K. Vorderösterreichische Ackerbaugesellschaft	1768				x
Gotha	DEU	ökonomische Sozietät	1768		x		
Wien	AUT	K.K. Ackerbaugesellschaft (Niederösterriech) (zu Wien für das Kronland Nieder-österreich)	1768	x			
Hermannstadt	ROU	Siebenbürgische Ackerbaugesellschaft	1769	x			
Kaiserslautern	DEU	Kurpfälzisch physikalisch-ökonomische Gesellschaft	1769/70	moved between Lautern and Mannheim			
Brünn	CZE	K.K. mährisch-schlesische Gesellschaft zur Beförderung des Ackerbauers, der Natur- und Landeskunde	1770	x			
Troppau	CZE	K.K. Ackerbaugesellschaft	1770	x			
Breslau	POL	Patriotische Gesellschaft in Schlesien (9 Kreissozietäten)	1771/72				
Jauer[B.5]	POL	ökonomisch-patriotische Sozietät der Fürstentümer Schweidnitz und Jauer	1772				
Magdeburg	DEU	ökonomische Gesellschaft im Magdeburgischen	1772		x		
Debrecen	HUN	K.K. Ackerbaugesellschaft	1775	x			
Komitat Tolna	HUN	K.K. Ackerbaugesellschaft	1775	x			
ödenburg	HUN	K.K. Ackerbaugesellschaft	1775	x			
Komitat Preßburg	HUN	K.K. Ackerbaugesellschaft	1775	x			
Basel	CHE	Gesellschaft zur Beforderung des Guten und Gemeinnützigen	1777	x			
Chur	CHE	Gesellschaft landwirtschaftlicher Freunde in Bünden	1778	x			
Homburg	DEU	Hochfürstlich Hessen-Homburgische patriotische Gesellschaft zur Beforderung der Kenntnisse und Sitte	1778[B.6]				
Heidelberg	DEU	Kurpfälzisch physikalisch-ökonomische Gesellschaft	1784	moved from Kaiserslautern in 1784			
Altona	DEU	Schleswig-Holsteinische Patriotische Gesellschaft	1786	same as Kiel			
Kiel	DEU	Schleswig-Holsteinische Patriotische Gesellschaft	1786				
Lübeck	DEU	Gesellschaft zur Beforderung gemeinnütziger Tätigkeit	1789				
Seefeld	DEU	Seefeldische Feldbau-Jagdsozietät in Bayern	1789			x	
Hamm	DEU	Westfälisch-ökonomische Gesellschaft in der Grafschaft Mark zur Beförderung der ökonomie der Fabriken und Manufakturen, der Handlung, Gewerbe und Künste	1791		x		
Mohrungen sp. Königsberg	POL	Mohrungsche physikalisch-ökonomische Gesellschaft	1791				
Neuenburg	CHE	Patriotische Nacheiferungsgesellschaft	1791	x			
Potsdam	DEU	Königlich Märkisch-ökonomische Gesellschaft	1791				
Dorpat	EST	Kaiserlich Livländische gemeinnützige und ökonomische Societät	1792	x			

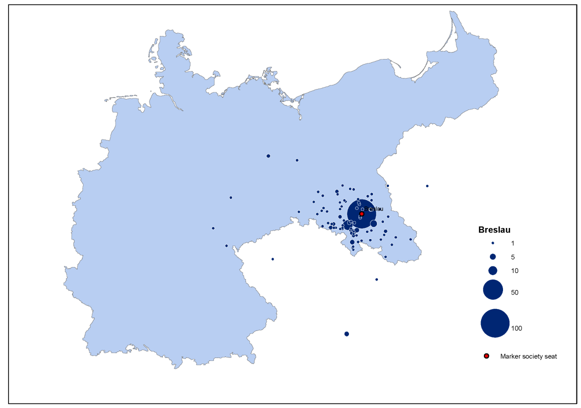
[B.5] According to our investigations, the society had two seats, in Schweidnitz and Jauer.
[B.6] According to our own investigations, the correction year is 1775.

Nürnberg	DEU	Gesellschaft zur Beforderung der vaterländischen Industrie	1792				
Basel	CHE	Okonomische Gesellschaft	1796	x			
Riga	LVA	Liefländische gemeinnützige und ökonomische Societät	1796	x			
Güstrow	DEU	Mecklenburgisch-Patriotische Gesellschaft	1798	moved to Rostock in 1798			
Rostock	DEU	Mecklenburgisch-landwirtschaftliche Gesellschaft	1798	moved from Güstrow in 1798			
Wetzlar	DEU	Gemeinnützige Gesellschaft zu Wetzlar	1799			x	
Straßburg	DEU	ökonomische Gesellschaft	1800				x
Eutin	DEU	Holsteinische ökonomische Gesellschaft	?				x
Gießen	DEU	Patriotische Gesellschaft	?				x
Hannover	DEU	Königliche Landwirtschaftsgesellschaft	?	same as Celle			
Wittenberg	DEU	ökonomische Gesellschaft	?	chapter of Leipzig			
Danzig	POL	Gesellschaft für Künste, Manufakturen und Handlung	?				x

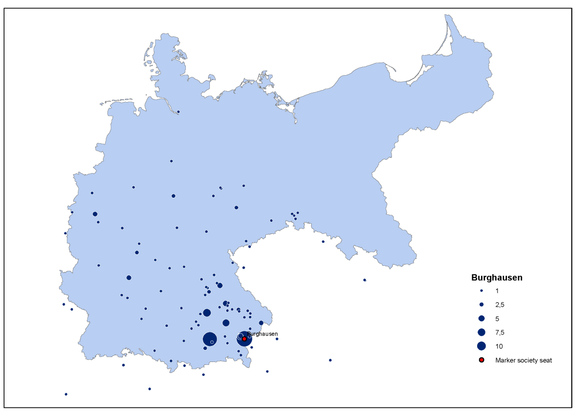
B.4 Spatial distribution of members by society



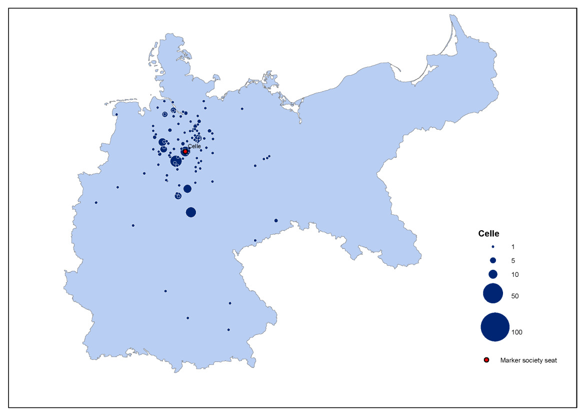
(a) Bad Homburg



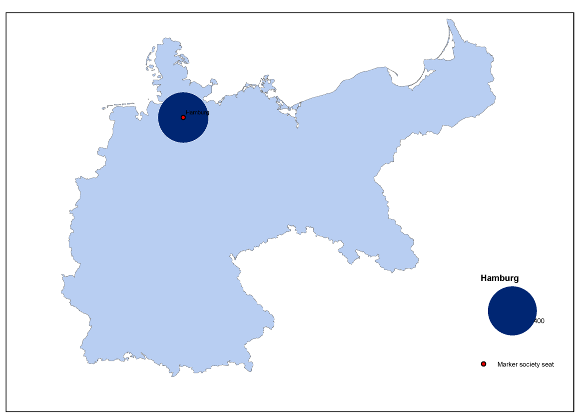
(b) Breslau



(c) Burghausen



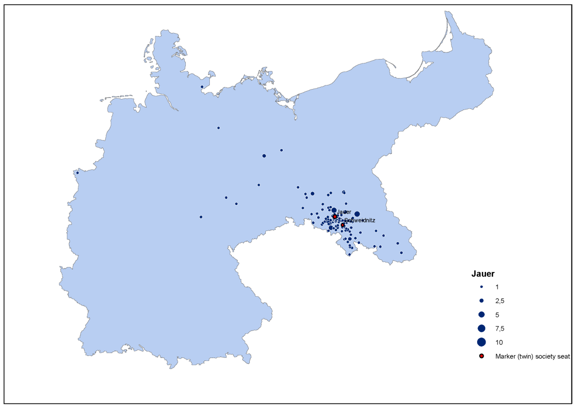
(d) Celle

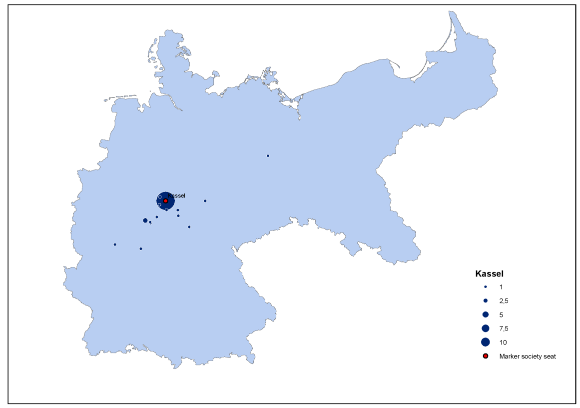


(e) Hamburg

FIGURE B.1: Spatial distribution of members by society.

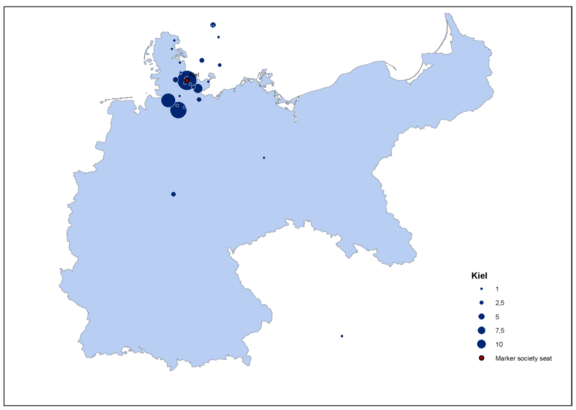
Notes. Location of members in economic societies by society

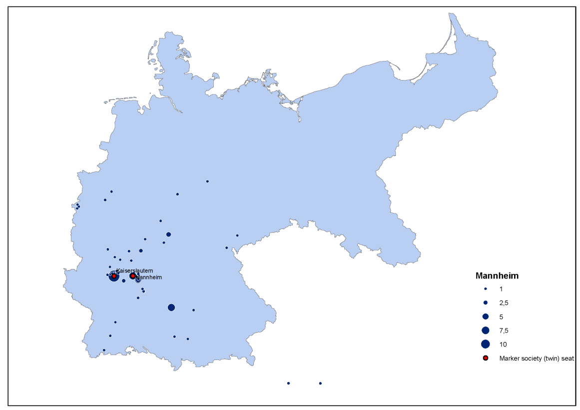




(f) Jauer / Schweidnitz

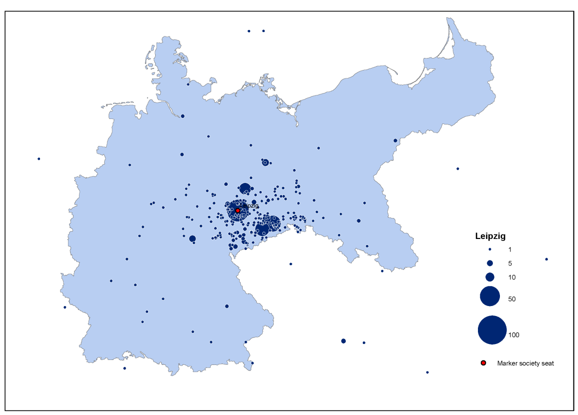
(g) Kassel





(h) Kiel

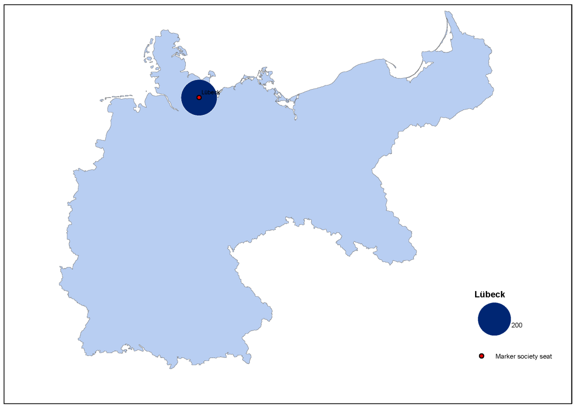
(i) Lautern / Mannheim



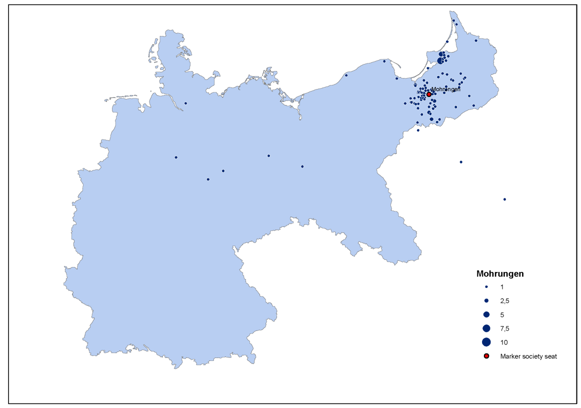
(j) Leipzig

FIGURE B.1: Spatial distribution of members by society (cont.)

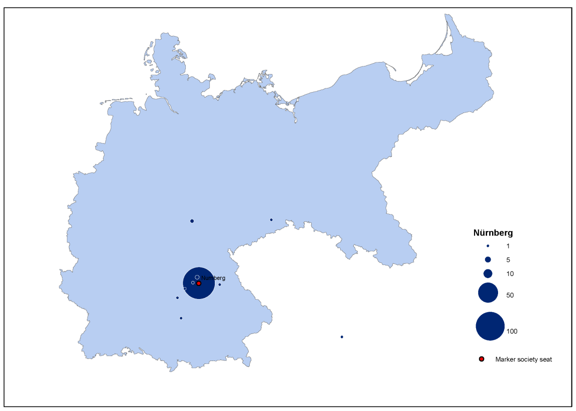
Notes. Location of members in economic societies by society.



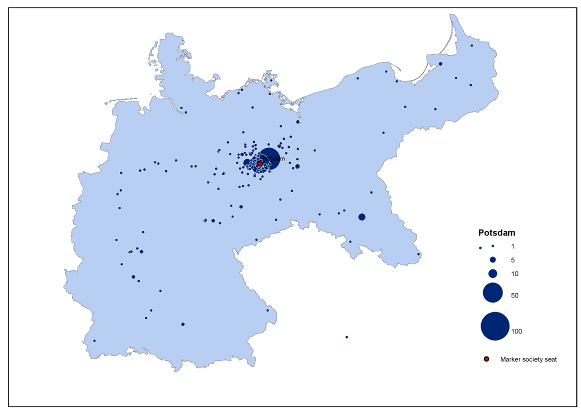
(k) Lübeck



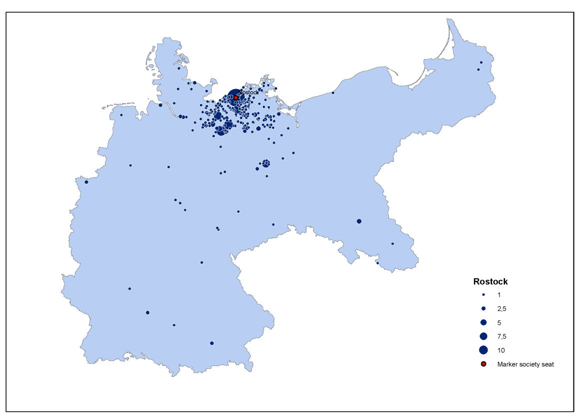
(l) Mohrungen



(m) Nürnberg



(n) Potsdam



(o) Rostock

FIGURE B.1: Spatial distribution of members by society (cont.)

Notes. Location of members in economic societies by society.

Appendix C Mitigating endogeneity

C.1 Distance to society seats and upper-tail human capital: documentation

To approximate the local density of upper-tail human capital, we draw on data from the *Deutsche Biographie*, an online compendium of notable individuals in German history published by the (BADW).[C.1] Individuals included in the *Deutsche Biographie* were not only selected due to their historical fame, but also due to the importance of their intellectual, cultural, or technical contributions (see Hockerts, 2008). This proxy for historical upper-tail human capital was pioneered by Dittmar and Meisenzahl (2020*a*) and provides a sample of historically notable people within the German speaking lands that is representative across space, religion, and fields of activity.[C.2] This builds on a larger literature, in which e.g., Tabellini and Serafinelli (forthcoming) and De la Croix and Licandro (2015) use compilations of historically significant people to approximate the local presence of upper-tail human capital. Dittmar and Meisenzahl (2020*a*) use the local presence of notable individuals listed in the *Deutsche Biographie* as a proxy for historical upper-tail human capital in the German lands before and after the Protestant Reformation. In the same spirit, we use this data as a proxy for the historical location of upper-tail human capital in Germany before and after the establishment of economic societies.

For a large number of individuals, the *Deutsche Biographie* includes information on the places of birth and death as well as the years of birth and death. We use these information to construct our main variable that reflects the presence of upper-tail human capital in a given grid cell i that is not their place of birth. This variable counts the number of notable individuals that died in grid cell i but who were born in another grid cell $j \neq i$. By constructing the variable in this way, we follow Dittmar and Meisenzahl (2020*a*) and approximate whether grid cell i was an attractive destination for individuals with upper-tail human capital. However, the measure contains uncertainty with respect to the timing when notable individuals moved from grid cell j to grid cell i.

In the absence of information on the timing of movement, we have to assume that the move occurred between their year of birth and year of death, without being able to exploit information on the exact date. For the construction of the variable, the presence of a notable individual who was attracted to grid cell i will be counted in the period when their death occurred, while their migration and therefore the potential exposure to an economic society must have happened earlier. Using the year of death is the most conservative approach when examining the exposure to societies prior to their emergence. In our event study design in Figure 2, this introduces a fuzzy overlap between treatment in t_T and the longest lifespan of members $t_{T+\text{lifespan}}$. Within this fuzzy period, migration may have occurred before or after t_T. Any individual whose death occurred prior to 1764, i.e., in period t_{T-1}, has by definition not been exposed to the treatment of economic societies, whereas

[C.1] The online version of the *Deutsche Biographie* contains about 48,000 entries of notable individuals originally published in the *Allgemeine Deutsche Biographie* between 1875 and 1912 and in the *Neue Deutsche Biographie* published since 1952.

[C.2] See Dittmar and Meisenzahl (2020*a*)'s online appendix for a detailed discussion of the compilation and representativeness of the *Deutsche Biographie* as well as Hockerts (2008) and Reinert et al. (2015) for further background on the history of the *Deutsche Biographie*.

any individual whose death occurred after 1764, i.e., in period t_{T+1}, will potentially be exposed to the society treatment for an increasing amount of time. This makes the interpretation of pre-trends straightforward because anyone dying in period t_{T-1} was, by definition, not affected by the treatment in t_T.

The interpretation of post-trends is a little more elaborate. Due to the brevity of potential exposure prior to their demise, it is unlikely that we will find a significant difference in the attraction of notable individuals between regions close and distant from society seats immediately after 1764. However, we expect coefficients to increase over time once regions in closer proximity to a society seat had sufficient time to attract notable individuals. This expectation is reinforced by the fact that some societies were established only in the 1780s and 1790s. Note that, the more time passes since t_T, the harder it becomes to distinguish between individuals that were notable before they were attracted by a society and those that became notable due to the exposure to the activities of a society. Therefore, in robustness test, we use an alternative measure of upper-tail human capital for which we drop the migration restriction. This variable counts total number of notable individuals that died in grid cell i in a given period t and thereby approximates upper-tail human capital that was either produced in i or attracted to migrate into i.

To account for time-varying population size that is not accounted for by grid-cell fixed effects, we condition on city size in our baseline specification. Time-varying city population size data are taken from Pfister (2020) which provides, to the best of our knowledge, the most comprehensive database of German city sizes over time. This source expands the semi-centennial Bairoch (1988) dataset with annual city size observations interpolated from all available information in Keyser (1939–1974) and a rich amount of other sources. We use all 118 cities for which population data is available starting in 1700, the first year included in the panel analysis. Furthermore, in robustness checks, we add dummies for polities of the Holy Roman Empire in 1789 from Huning and Wahl (2020) interacted with time-fixed effects.

Table C.1: Data description

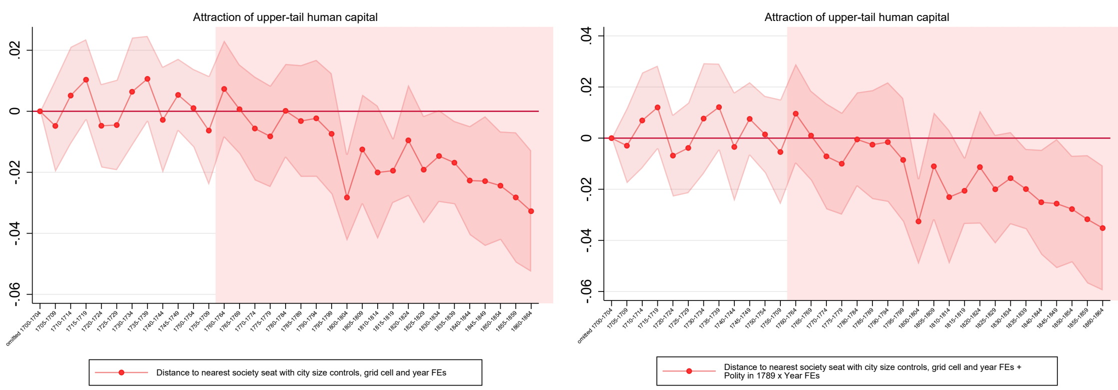
Variable	Mean	SD	Min	Max	Obs.
Upper-tail human capital (*Deutsche Biographie*), places of death	0.074	(0.730)	0.000	52.000	89001
(IHS) Upper-tail human capital (*Deutsche Biographie*), places of death	0.043	(0.253)	0.000	4.644	89001
Attraction of upper-tail human capital, (*Deutsche Biographie*) migrants	0.044	(0.447)	0.000	34.000	89001
(IHS) Attraction of upper-tail human capital, (*Deutsche Biographie*) mig	0.028	(0.196)	0.000	4.220	89001
Pfister city size for cities with info since 1700	703.736	(6248.932)	0.000	532036.063	89001
(IHS) Pfister city size for cities with info since 1700	0.474	(2.114)	0.000	13.878	89001
Dummy for cities mentioned in the Keyser Stadtebuch	0.499	(0.500)	0.000	1.000	89001

Notes: Table shows summary statistics for all main variables within the panel analysis.

Table C.1 reports summary statistics for these variables in a dynamic panel based on 15km × 15km grid cells and 5 year intervals. The panel starts with the period 1700–1704 and ends with the period 1860–1864, the last period for which city size data from Pfister (2020) is available.

C.2 Distance to society seats and upper-tail human capital: robustness checks

This section presents robustness checks for the results presented in Section 4.2.1, estimating the relationship between distance to society seat and the attraction of upper-tail human capital using Equation 2. First, we present results when adding dummies for polities of the Holy Roman Empire in 1789 interacted with time-fixed effects. Secondly, we present results extending the pre-treatment period backwards until 1665. Thirdly, we present results using information on the location of death for all notable individuals as the dependent variable, instead of only those whose location of death deviates from the location of birth. Lastly, we present results in a sample of grid cell that include at least on city with population data from Pfister (2020), to test for potential biases resulting from measurement error in the population size of smaller cities and rural areas.



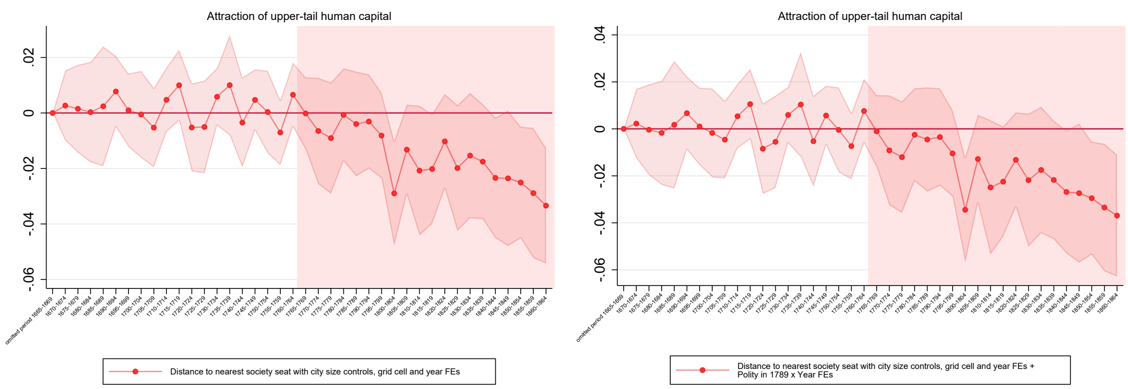
(a) Baseline results from section 4.2.1 (b) Adding polity × year FEs

FIGURE C.1: Distance to society seat and attraction of notable individuals

Notes: Figure plots β_τ coefficients estimated from Equation 2 with 95% confidence intervals. The omitted period is 1700–1704. All continuous variables are transformed using the inverse hyperbolic sine (arcsinh). Standard errors are clustered at the grid-cell level.

As reference point, panel a) of Figure C.1 repeats our baseline results from Figure 2. Panel b) adds fixed effects for polities of the Holy Roman Empire in 1789 × year fixed effects that capture time-variant institutional and territorial variation throughout the period. The results appear very robust to the more demanding specification. Both figures indicate an absence of differences in the pre-treatment trends and a post-treatment trend that becomes significant after 1795–1799. This seems plausible, as we expect the effect of economic societies to grow over time. Furthermore, notable individuals that died in the 1770s and 1780s may have been too old to have been fully affected by the creation of economic societies, having already completed most of their lifetime work and being at an age where they were less likely to migrate.

Secondly, we present results estimating Equation 2 using an extend sample period—1660–1864. This is to make sure that the pre-trends are not sensitive to the selection of the start year of the sample. Using a longer sample comes at the disadvantage of having less information on city size



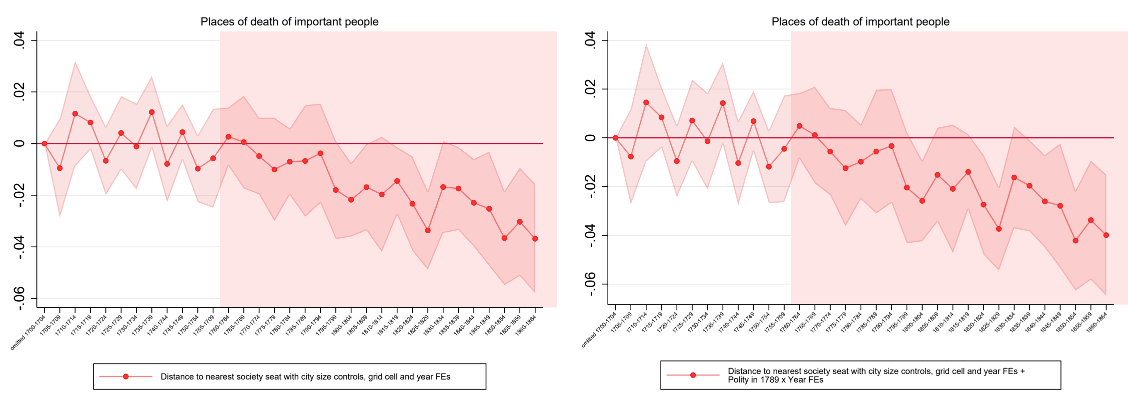
(a) Baseline results for the period 1665–1864

(b) Adding polity × year FEs

FIGURE C.2: Distance to society seat and attraction of notable individuals for the period 1665–1864

Notes: Figure plots β_τ *coefficients estimated from Equation 2 with 95% confidence intervals for the period 1665–1864. The omitted period is 1665–1669. All continuous variables are transformed using the inverse hyperbolic sine (arcsinh). Standard errors are clustered at the grid-cell level.*

controls. For the whole period 1660–1864 we can only draw on 69 cities with complete observations throughout the period, in contrast to 131 cities for 1700–1864. Therefore, we prefer the period 1700–1864 as the baseline specification. However, the results presented in Figure C.2 indicate that the results are not sensitive to extending the period.



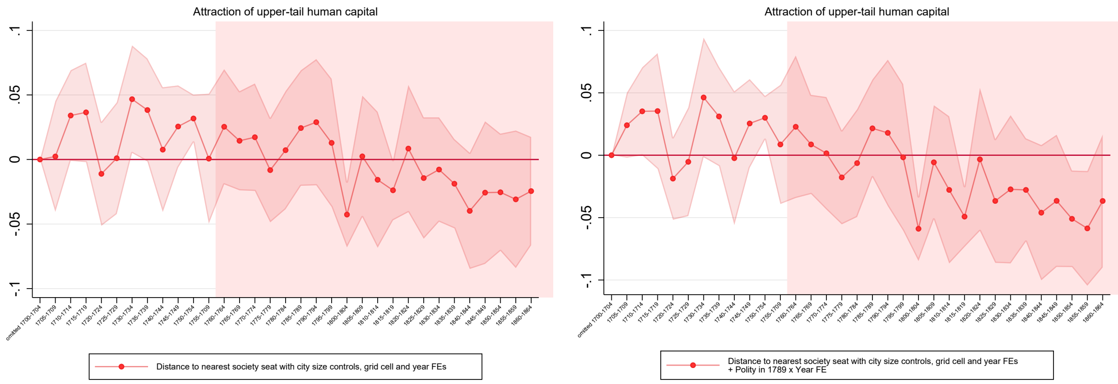
(a) Baseline results using all places of death

(b) Adding polity × year FEs

FIGURE C.3: Distance to society seat and places of death of notable individuals

Notes: Figure plots β_τ *coefficients estimated from Equation 2 with 95% confidence intervals. The omitted period is 1700–1704. All continuous variables are transformed using the inverse hyperbolic sine (arcsinh). Standard errors are clustered at the grid-cell level.*

Thirdly, Figure C.3 presents results using information on the location of death for all notable individuals as the dependent variable. This includes both, individuals born in a city and individuals who migrated to that city. The established pattern of trends is similar to regressions using places of death of migrated people.

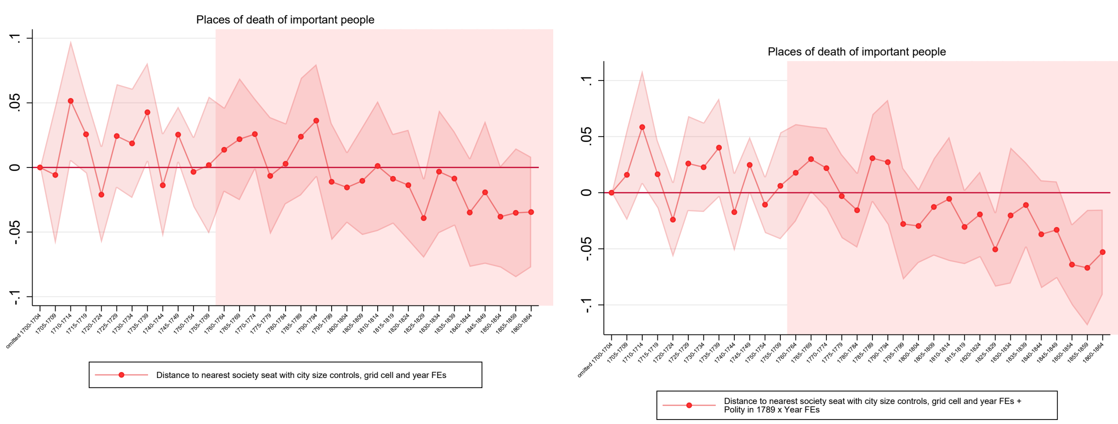


(a) Baseline results in a sample of cities

(b) Adding polity × year FEs

Figure C.4: Distance to society seat and attraction of notable individuals in a sample of cities

Notes: Figure plots β_τ coefficients estimated from Equation 2 with 95% confidence intervals. The omitted period is 1700–1704. The sample consists of grid cells that were the location of a city according to city size data by Pfister (2020). All continuous variables are transformed using the inverse hyperbolic sine (arcsinh). Standard errors are clustered at the grid-cell level.



(a) Baseline results using all places of death in a sample of cities

(b) Adding polity × year FEs

Figure C.5: Distance to society seat and places of death of notable individuals in a sample of cities

Notes: Figure plots β_τ coefficients estimated from Equation 2 with 95% confidence intervals. The omitted period is 1700–1704. The sample consists of grid cells that were the location of a city according to city size data by Pfister (2020). All continuous variables are transformed using the inverse hyperbolic sine (arcsinh). Standard errors are clustered at the grid-cell level.

Lastly, we restrict our sample to grid cells including one of the 131 cities with city size information from Pfister (2020) for the whole period of 1700–1864. This specification tests whether previous results were driven by measurement error in the city size controls for the whole sample.Figures C.4 and C.5 plot the β coefficients against time using this limited sample for both attraction and places of death. Given the substantial reduction in the sample size, results appear more volatile than in the full sample. The trends becomes more pronounced when adding polity-fixed effects. Nevertheless, the overall pattern remains robust, i.e., the post-treatment trend remains visible throughout all specifications and the pattern of coefficients do not indicate the presence of any pre-trends.

C.3 City size, society seat, and university location

Table C.2: City size, society seat, and university location

Rank	City	Population	Society Seat	University
1	Berlin	113	0	0
2	Hamburg	90	1	0
3	Koenigsberg	60	0	1
4	Dresden	57	0	0
5	Breslau	55	1	1
6	Danzig	48	0	0
7	Koeln	44	0	1
8	Leipzig	35	1	1
9	Frankfurt am Main	32	0	0
10	Muenchen	32	0	0
11	Augsburg	31	0	0
12	Braunschweig	30	0	0
	Nuernberg	30	1	0
14	Bremen	28	0	0
15	Mainz	25	0	1
16	Aachen	24	0	0
17	Luebeck	21	1	0
18	Mannheim	20	1	0
	Regensburg	20	0	0
20	Posen	20		
21	Magdeburg	18	0	0
22	Altona	17	0	0
	Erfurt	17	0	1
	Hannover	17	0	0
	Kassel	17	1	0
	Stuttgart	17	0	0
27	Elbing	16	0	0
28	Potsdam	15	1	0
	Ulm	15	0	0
	Wuerzburg	15	0	1
31	Halle	13	0	1
	Stettin	13	0	0
33	Bamberg	12	0	1
	Gotha	12	0	0
35	Goerlitz	11	0	0
	Halberstadt	11	0	0
	Hanau	11	0	0
38	Heidelberg	10	0	1
	Chemnitz	10	0	0
40	Duesseldorf	9	0	0
	Frankfurt an der Oder	9	0	1
	Freiberg	9	0	0
	Lueneburg	9	0	0
	Muenster	9	0	1
	Trier	9	0	1
	Wolfenbuettel	9	0	0
58-71	Schweidnitz	7	1	0
72-88	Rostock	6	1	1
89-114	Kiel	5	1	1
141-186	Celle	3	1	0
187-199	Lautern	2	1	0
-	Bad Homburg	-	1	0
-	Burghausen	-	1	0
-	Jauer	-	1	0
-	Mohrungen	-	1	0

Notes: Table shows cities in the German Empire ranked by population size in 1750, based on Bairoch (1988). Population in thousands. Society seat indicates whether a city was seat of an economic society according to the definition adopted in this paper. University indicates whether a city was location of a university in 1764 according to Naragon (2016).

C.4 Determinants of society seats

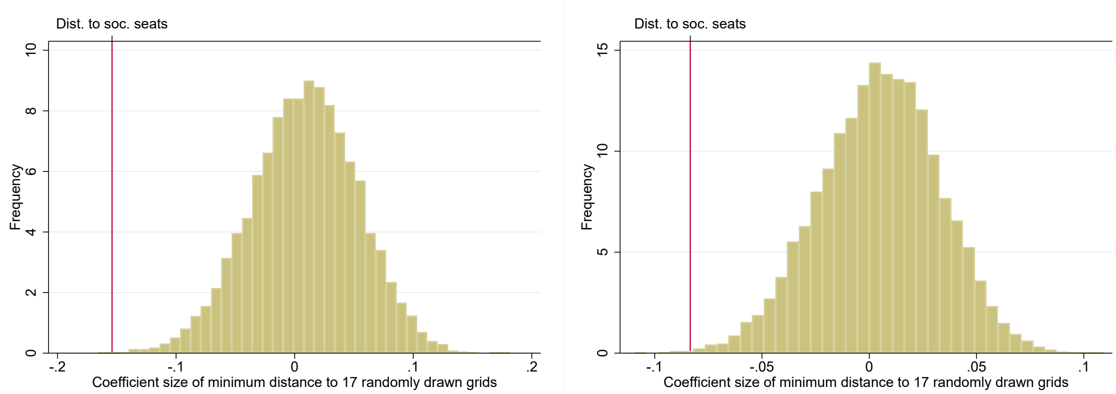
Table C.3: Determinants of society seats

Dep. var.:	Society seat (dummy)
	(1)
Altitude	-0.000**
	(0.000)
Annual Temperature Mean	-0.004**
	(0.002)
Average Monthly Precipitation	0.035
	(0.022)
Crop suitability	0.000
	(0.001)
Distance to River	-0.000
	(0.000)
Bairoch city pop 1750	0.005***
	(0.002)
No. Keyser cities	0.002
	(0.004)
Market access 1750	-0.000
	(0.002)
Hanse member	0.005
	(0.018)
Bishop in 1500	0.021
	(0.026)
Imperial / Free city	0.031
	(0.020)
Printing press in 1500	-0.001
	(0.009)
Market by 1760	-0.008
	(0.006)
No. constructions until 1750	0.003
	(0.004)
School by 1760	0.005
	(0.004)
Polity fixed effects	Yes
Observations	2698
R-squared	0.06

Notes: The table show results from estimating a linear probability model using an indicator that assumes the value one if a grid cell was the location of a society seat as dependent variable. Predictors of society seat location include all geogrphical and population controls included in the preferred specification of our main model. All other controls measure commercial and educational activity prior the emergence of societies. Polity-fixed effects, based on administrative borders of 1789, included. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

C.5 Random placement of placebo society seats

C.5.1 Random placement using the full sample



(a) Dependent variable: patents

(b) Dependent variable: exhibitors

FIGURE C.6: Distribution of reduced form β-coefficients from 10,000 random draws

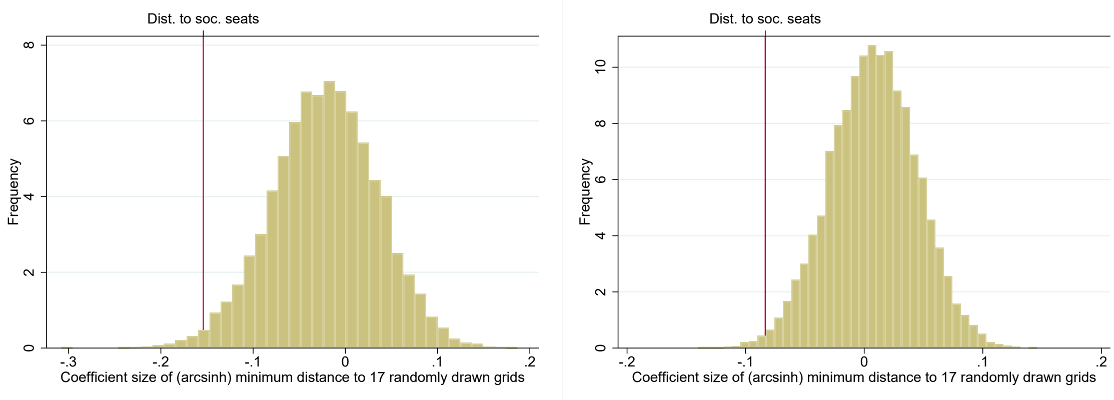
Notes: Histograms show frequency of 10,000 β-coefficients derived from reduced form estimations of patents (a) and exhibitors (b) on distances to nearest placebo society seat. Distance to nearest placebo society seat is calculated from random draws of 17 cells from the full population of grid cells, excluding grid cells with actual society seats. Red line indicates β-coefficient from reduced form estimation using distance to nearest actual society seat as main explanatory variable. Control variables include geographical controls (average temperature, average precipitation, altitude, soil suitability, distance to navigable river), population controls (Bairoch city pop 1750, No. Keyser cities, Berlin dummy), and polity fixed effects.

TABLE C.4: Descriptive statistics from random placement using the full sample

	Obs	Mean	Std. Dev.	Min	Max	Society seats
Panel A: patents (1877–1914)						
Coefficient	10,000	0.008	0.045	-0.166	0.181	-0.154
P-value	10,000	0.437	0.303	0.000	1.000	0.006
R2	10,000	0.490	0.001	0.489	0.495	0.495
Panel B: exhibitors (1873)						
Coefficient	10,000	0.005	0.028	-0.109	0.109	-0.083
P-value	10,000	0.444	0.300	0.000	1.000	0.003
R2	10,000	0.430	0.000	0.430	0.435	0.434

Notes: The table shows descriptive statistics for 10,000 reduced-form estimations of patents (a) and exhibitors (b) on distance to nearest placebo society seat. Distance to nearest placebo society seat is calculated from random draws of 17 cells from the full population of grid cells, excluding grid cells with actual society seats. Last column shows descriptive statistics from reduced form estimation using distance to nearest actual society seat as main explanatory variable. Control variables include geographical controls (average temperature, average precipitation, altitude, soil suitability, distance to navigable river), population controls (Bairoch city pop 1750, No. Keyser cities, Berlin dummy), and polity fixed effects.

C.5.2 Random placement using sample of grid cells with large cities



(a) Dependent variable: patents (b) Dependent variable: exhibitors

FIGURE C.7: Distribution of reduced form β-coefficients from 10,000 random draws in city sample

Notes: Histograms show frequency of 10,000 β-coefficients derived from reduced form estimations of patents (a) and exhibitors (b) on distance to nearest placebo society seat. Distance to nearest placebo society seat is calculated from random draws of 17 cells using a sample of grid cells that host a city with at least 5,000 inhabitant according to Bairoch (1988), excluding grid cells with actual society seats. Red line indicates β-coefficient from reduced form estimation using distance to nearest actual society seat as main explanatory variable. Control variables include geographical controls (average temperature, average precipitation, altitude, soil suitability, distance to navigable river), population controls (Bairoch city pop 1750, No. Keyser cities, Berlin dummy), and polity fixed effects.

TABLE C.5: Descriptive statistics from random placement using sample of grid cells with large cities

	Obs	Mean	Std. Dev.	Min	Max	Society seats
Panel A: patents (1877–1914)						
Coefficient	10,000	-0.022	0.057	-0.308	0.187	-0.154
P-value	10,000	0.436	0.300	0.000	1.000	0.006
R2	10,000	0.490	0.001	0.489	0.502	0.495
Panel B: exhibitors (1873)						
Coefficient	10,000	0.008	0.037	-0.140	0.146	-0.083
P-value	10,000	0.474	0.298	0.000	1.000	0.003
R2	10,000	0.430	0.001	0.430	0.437	0.434

Notes: The table shows descriptive statistics for 10,000 reduced-form estimations of patents (a) and exhibitors (b) on distance to nearest placebo society seat. Distance to nearest placebo society seat is calculated from random draws of 17 cells using a sample of grid cells that host a city with at least 5,000 inhabitant according to Bairoch (1988), excluding grid cells with actual society seats. Last column shows descriptive statistics from reduced form estimation using distance to nearest actual society seat as main explanatory variable. Control variables include geographical controls (average temperature, average precipitation, altitude, soil suitability, distance to navigable river), population controls (Bairoch city pop 1750, No. Keyser cities, Berlin dummy), and polity fixed effects.

C.6 Instrumental variable approach: first stages

Table C.6: First stage regressions of instrumental variable approach

Dep. var.:	Society members	
	(1)	(2)
	Full sample	Prussian sample
Distance to society seat	-0.351***	-0.479***
	(0.039)	(0.074)
Geographical controls	Yes	Yes
Population controls	Yes	Yes
Polity fixed effects	Yes	Yes
Observations	2698	718
R-squared	0.43	0.50
F-statistic	79.38	41.59

Notes: The table shows the first stage regressions of a 2SLS approach with the number of society members in a grid cell as the dependent variable. Dependent variable, instrumental variable, and city size are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Appendix D Robustness tests

Table D.1: Robustness to log transformation of variables

Panel A: Patents (1877-1914)						
Dep. var.:	Patents (1877-1914)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Geography	Urbanization	Polity FE	Society FE	Prussia	IV
Society members	0.625***	0.277***	0.318***	0.179**	0.403***	0.450**
	(0.109)	(0.069)	(0.047)	(0.086)	(0.087)	(0.172)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	No	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	No	No	Yes	Yes	Yes	Yes
Society dummies	No	No	No	Yes	No	No
Observations	2698	2698	2698	2698	718	2698
R-squared	0.18	0.44	0.51	0.52	0.54	
Kleibergen Paap F-statistic						80.36
Panel B: Exhibits (1873)						
Dep. var.:	Exhibits (1873)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Geography	Urbanization	Polity FE	Society FE	Prussia	IV
Society members	0.406***	0.176***	0.193***	0.149**	0.173***	0.228***
	(0.064)	(0.044)	(0.047)	(0.072)	(0.043)	(0.085)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	No	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	No	No	Yes	Yes	Yes	Yes
Society dummies	No	No	No	Yes	No	No
Observations	2698	2698	2698	2698	718	2698
R-squared	0.18	0.41	0.45	0.46	0.46	
Kleibergen Paap F-statistic						80.36

Notes: The table replicates Table 2 using the natural logarithm (+1), instead of the inverse hyperbolic sine to transform the dependent variables, the main explanatory variable, city size, and the instrumental variable. Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.2: Robustness to using regression models for count data

Dep. var.:	Patents (1877-1914)		
	(1)	(2)	(3)
	Poisson	NB	ZINB
Society members	0.456***	0.606***	0.563***
	(0.092)	(0.100)	(0.106)
Inflate Keyser city			-23.268***
			(0.378)
Geographical controls	Yes	Yes	Yes
Population controls	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	No
Observations	2690.00	2697.00	2697.00
Pseudo R-squared	0.81	0.15	

Dep. var.:	Exhibits (1873)		
	(1)	(2)	(3)
	Poisson	NB	ZINB
Society members	0.189	0.395***	0.397***
	(0.175)	(0.128)	(0.071)
Inflate Keyser city			-17.036***
			(0.495)
Geographical controls	Yes	Yes	Yes
Population controls	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	No
Observations	2662.00	2697.00	2697.00
Pseudo R-squared	0.66	0.18	

Notes: The table replicates Table 2 using regression models designed for count data. Column 1 estimates a Poisson model, column 2 estimates a negative binomial (NB) model, column 3 estimates a zero-inflated negative binomial (ZINB) model with the number of (Keyser) cities located in a grid cell as the predictor of zeros. Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.3: Robustness to alternative definitions of control variables

Dep. var.:	Patents (1877-1914)					
	(1) Bairoch city pop	(2) Pfister city pop	(3) Hyde pop	(4) Hyde city pop	(5) Hyde urbanization	(6) Polity FE 1820
Society members	0.439***	0.503***	0.615***	0.533***	0.529***	0.285***
	(0.164)	(0.179)	(0.167)	(0.154)	(0.158)	(0.062)
No. Keyser cities	0.361***	0.366***	0.403***	0.362***	0.368***	0.436***
	(0.046)	(0.044)	(0.048)	(0.044)	(0.043)	(0.018)
Bairoch city pop 1750	0.171***					0.195***
	(0.021)					(0.008)
Pfister city pop 1763		0.152***				
		(0.028)				
Hyde population 1760			0.038**			
			(0.017)			
Hyde urban population 1760				0.108***		
				(0.010)		
Hyde urbanization 1760					1.937***	
					(0.191)	
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2695
Kleibergen Paap F-statistic	79.38	82.04	80.36	79.44	80.58	113.58

Dep. var.:	Exhibits (1873)					
	(1) Bairoch city pop	(2) Pfister city pop	(3) Hyde pop	(4) Hyde city pop	(5) Hyde urbanization	(6) Polity FE 1820
Society members	0.238***	0.278***	0.380***	0.345***	0.337***	0.179**
	(0.086)	(0.089)	(0.091)	(0.087)	(0.086)	(0.074)
No. Keyser cities	0.269***	0.269***	0.304***	0.287***	0.287***	0.280***
	(0.032)	(0.030)	(0.033)	(0.032)	(0.032)	(0.017)
Bairoch city pop 1750	0.135***					0.142***
	(0.018)					(0.012)
Pfister city pop 1763		0.132***				
		(0.023)				
Hyde population 1760			0.023**			
			(0.009)			
Hyde urban population 1760				0.049***		
				(0.009)		
Hyde urbanization 1760					0.994***	
					(0.170)	
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic	79.38	82.04	80.36	79.44	80.58	111.87

Notes: The table replicates the IV results from Table 2 column 6, using alternative definitions of control variables. Dependent variables, main explanatory variable, city size, and instrumental variable are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Prussian city pop 1816, No. Prussian cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. Column 1 controls for population in cities in 1750 using information from Bairoch (1988). Column 2 controls for population in cities in 1763 using information from Pfister (2020). Columns 3–5 control for total population, urban population, and urbanization rate, respectively using information from the Hyde dataset of gridded population (Klein Goldewijk et al., 2017). Column 6 uses polity-fixed effect based on administrative borders as of 1820 instead of 1789. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.4: Robustness to pre-determined (long-run) controls

Dep. var.:	Patents (1877-1914)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Society members	0.439***	0.306**	0.440**	0.438***	0.441***	0.435***	0.439***	0.425**	0.443***	0.275**
	(0.164)	(0.138)	(0.167)	(0.164)	(0.164)	(0.163)	(0.162)	(0.170)	(0.166)	(0.135)
Market access 1750		0.091*								0.103*
		(0.052)								(0.053)
Hanse member			0.352**							0.345**
			(0.161)							(0.156)
Bishop in 1500				0.117						-0.039
				(0.185)						(0.288)
Imperial / Free city					0.701***					0.705***
					(0.112)					(0.134)
Printing press in 1500						0.210				0.211
						(0.130)				(0.212)
Market by 1760							-0.057			-0.127*
							(0.075)			(0.074)
No. constructions until 1750								0.047*		0.071*
								(0.027)		(0.040)
School by 1760									-0.044	-0.111
									(0.074)	(0.080)
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Polity Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic	79.38	79.08	80.31	80.54	79.31	80.17	83.69	83.31	81.45	82.72

Dep. var.:	Exhibits (1873)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Society members	0.238***	0.279***	0.238***	0.238***	0.240***	0.237***	0.238***	0.220**	0.225**	0.256***
	(0.086)	(0.088)	(0.086)	(0.087)	(0.083)	(0.086)	(0.086)	(0.091)	(0.088)	(0.085)
Market access 1750		-0.028*								-0.027
		(0.016)								(0.016)
Hanse member			0.068							0.002
			(0.093)							(0.090)
Bishop in 1500				-0.046						-0.101
				(0.159)						(0.214)
Imperial / Free city					0.777***					0.738***
					(0.120)					(0.121)
Printing press in 1500						0.076				0.108
						(0.130)				(0.163)
Market by 1760							0.019			-0.090**
							(0.041)			(0.043)
No. constructions until 1750								0.061**		0.028
								(0.027)		(0.032)
School by 1760									0.152***	0.156**
									(0.052)	(0.072)
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Polity Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic	79.38	79.08	80.31	80.54	79.31	80.17	83.69	83.31	81.45	82.72

Notes: The table replicates the IV results from Table 2 column 6, controlling for various pre-treatment long-run controls. Column 2 adds market access in 1750; Column 3 a dummy for ever belonging to the Hanseatic League; Column 4 a dummy for having a Bishop seat in 1500; Column 5 a dummy for Free or Imperial cities during the Holy Roman Empire; Column 6 a dummy for having a printing press in 1500; Column 7 a dummy for having a market charter by 1760; Column 8 the number of constructions built until 1750; Column 9 a dummy for having a primary school by 1760. Dependent variables, main explanatory variable, city size, and instrumental variable are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.5: Robustness to controlling for notable individuals

Dep. var.:	Patents (1877-1914)					
	(1)	(2)	(3)	(4)	(5)	(6)
Society members	0.439***	0.353**	0.425**	0.389**	0.394**	0.365**
	(0.164)	(0.167)	(0.161)	(0.172)	(0.169)	(0.168)
Upper-tail human capital attraction 1720-60		0.591***				
		(0.131)				
Upper-tail human capital attraction 1760-65			0.664***			
			(0.241)			
Upper-tail human capital attraction 1760-80				0.456***		
				(0.164)		
Upper-tail human capital attraction 1760-90					0.375***	
					(0.134)	
Upper-tail human capital attraction 1760-00						0.415***
						(0.113)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic	79.38	66.28	70.85	70.83	70.61	63.53
Dep. var.:	Exhibits (1873)					
	(1)	(2)	(3)	(4)	(5)	(6)
Society members	0.238***	0.186**	0.229***	0.198**	0.201**	0.184**
	(0.086)	(0.085)	(0.086)	(0.090)	(0.087)	(0.087)
Upper-tail human capital attraction 1720-60		0.358***				
		(0.092)				
Upper-tail human capital attraction 1760-65			0.414			
			(0.260)			
Upper-tail human capital attraction 1760-80				0.366***		
				(0.125)		
Upper-tail human capital attraction 1760-90					0.312***	
					(0.097)	
Upper-tail human capital attraction 1760-00						0.303***
						(0.088)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic	79.38	66.28	70.85	70.83	70.61	63.53

Notes: The table replicates the IV results from Table 2 column 6, controlling for the stock of notable individuals according to the Deutsche Biographie that died in the respective grid cell during the period indicated in the variable label but were born in another grid cell. Dependent variables, main explanatory variable, measures of upper-tail human capital attraction, city size, and instrumental variable are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.6: Robustness to controlling for other distances

Dep. var.:	Patents (1877-1914)				
	(1)	(2)	(3)	(4)	(5)
	Baseline	Dist. Uni	Dist larg. cit	Dist Lit.	Dist Read.
Society members	0.439***	0.406**	0.415**	0.352**	0.341**
	(0.164)	(0.174)	(0.168)	(0.155)	(0.154)
Distance to university in 1760		-0.041			
		(0.036)			
Distance to 17 largest Bairoch cities 1750 (w/o soc seats)			-0.187***		
			(0.032)		
Distance to literary society seat				-0.129***	
				(0.045)	
Distance to reading society seat					-0.132***
					(0.024)
Geographic controls	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes
Polity Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic	79.38	66.34	84.04	70.99	71.58

Dep. var.:	Exhibits (1873)				
	(1)	(2)	(3)	(4)	(5)
	Baseline	Dist. Uni	Dist. larg. cit.	Dist Lit.	Dist Read.
Society members	0.238***	0.246**	0.226**	0.217**	0.192**
	(0.086)	(0.099)	(0.094)	(0.087)	(0.078)
Distance to university in 1760		0.010			
		(0.032)			
Distance to 17 largest Bairoch cities 1750 (w/o soc seats)			-0.090***		
			(0.021)		
Distance to literary society seat				-0.031	
				(0.019)	
Distance to reading society seat					-0.062***
					(0.014)
Geographic controls	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes
Polity Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic	79.38	66.34	84.04	70.99	71.58

Notes: The table replicates the IV results from Table 2 column 6, controlling for distances indicated in the variable labels. Dependent variables, main explanatory variable, city size, and instrumental variable are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.7: Robustness to university distance sample restrictions

Dep. var.:	Patents (1877-1914)				
	(1)	(2)	(3)	(4)	(5)
	Baseline	Uni dist > 20km	Uni dist > 50km	Uni dist > Median	Uni dist > Mean
Society members	0.286***	0.215***	0.192***	0.197***	0.172**
	(0.041)	(0.037)	(0.053)	(0.059)	(0.070)
Geographical controls	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	2698	2312	1526	1342	1110
R-squared	0.51	0.49	0.46	0.45	0.45

Dep. var.:	Exhibits (1873)				
	(1)	(2)	(3)	(4)	(5)
	Baseline	Uni dist > 20km	Uni dist > 50km	Uni dist > Median	Uni dist > Mean
Society members	0.182***	0.171***	0.162**	0.145*	0.166*
	(0.043)	(0.051)	(0.063)	(0.075)	(0.084)
Geographical controls	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	2698	2312	1526	1342	1110
R-squared	0.44	0.45	0.48	0.48	0.49

Notes: The table replicates the OLS results from Table 2 column 3 in samples that exclude the cells surrounding universities. Column heads indicate the respective sample restrictions with respect to distance to the next university. Dependent variables, main explanatory variable, and city size are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.8: Robustness to sample restrictions

Dep. var.:	Patents (1877-1914)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	w/o soc seat	Bairoch cities	w/o Bairoch	West of Elbe	East of Elbe
Society members	0.286***	0.230***	0.370***	0.194***	0.325***	0.272***
	(0.042)	(0.045)	(0.128)	(0.049)	(0.080)	(0.045)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2681	191	2507	1415	1283
R-squared	0.51	0.49	0.68	0.33	0.51	0.42

Dep. var.:	Exhibits (1873)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	w/o soc seat	Bairoch cities	w/o Bairoch	West of Elbe	East of Elbe
Society members	0.182***	0.144***	0.103	0.118***	0.286***	0.107*
	(0.043)	(0.040)	(0.074)	(0.035)	(0.051)	(0.057)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2681	191	2507	1415	1283
R-squared	0.44	0.42	0.56	0.29	0.41	0.45

Notes: The table replicates the OLS results from Table 2, column 3 in various samples. Column 2 drops grid cells with society seats; column 3 uses only grid cells that host a city according to Bairoch (1988); column 4 drops grid cells that host such cities; column 5 uses only grid cells located west of the river Elbe; column 6 uses only grid cells located east of the river Elbe. Dependent variables, main explanatory variable, and city size are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.9: Robustness to larger grid-cell size

Dep. var.:	Patents (1877-1914)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Geography	Urbanization	Polity FE	Society FE	Prussia	IV
Society members	0.629***	0.313***	0.326***	0.196***	0.440**	0.196**
	(0.086)	(0.069)	(0.042)	(0.058)	(0.167)	(0.069)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	No	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	No	No	Yes	Yes	Yes	Yes
Society dummies	No	No	No	Yes	No	No
Observations	342	342	342	342	174	342
R-squared	0.44	0.69	0.72	0.76	0.67	0.58
Kleibergen Paap F-statistic						103.38

Dep. var.:	Exhibits (1873)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Geography	Urbanization	Polity FE	Society FE	Prussia	IV
Society members	0.500***	0.254***	0.261***	0.190***	0.298*	0.139**
	(0.045)	(0.060)	(0.063)	(0.057)	(0.130)	(0.059)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	No	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	No	No	Yes	Yes	Yes	Yes
Society dummies	No	No	No	Yes	No	No
Observations	342	342	342	342	174	342
R-squared	0.46	0.66	0.70	0.72	0.59	0.53
Kleibergen Paap F-statistic						103.38

Notes: The table replicates Table 2 using grid cells of 45×45 km size (instead of 15×15 km). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.10: Correcting for spatial autocorrelation

Dep. var.:	Patents (1877-1914)					
	(1) OLS 50km	(2) OLS 100km	(3) OLS 200km	(4) IV 50km	(5) IV 100km	(6) IV 200km
Society members	0.286***	0.286***	0.286***	0.439***	0.439***	0.439**
	(0.043)	(0.044)	(0.026)	(0.139)	(0.157)	(0.178)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Polity fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic				108.05	86.89	77.10

Dep. var.:	Exhibits (1873)					
	(1) OLS 50km	(2) OLS 100km	(3) OLS 200km	(4) IV 50km	(5) IV 100km	(6) IV 200km
Society members	0.182***	0.182***	0.182***	0.238***	0.238***	0.238**
	(0.035)	(0.034)	(0.048)	(0.078)	(0.086)	(0.096)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Population controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2698	2698	2698	2698	2698	2698
Kleibergen Paap F-statistic				108.05	86.89	77.10

Notes: The table replicates the results from Table 2, columns 3 and 6. Standard errors, in parenthesis, are adjusted for spatial autocorrelation using the method introduced by Conley (1999) with radii of 50km, 100km, and 200km, as indicated in the column heads. Dependent variables, main explanatory variable, city size, and instrumental variable are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table D.11: Reduced form results, splitting the sample by members' presence

Dep. var.:	Patents (1877-1914)	
	(1)	(2)
	Members	No members
Distance to society seat	-0.235***	-0.016
	(0.067)	(0.057)
Geographic controls	Yes	Yes
Population controls	Yes	Yes
Polity fixed effects	Yes	Yes
Observations	662	2022
R-squared	0.57	0.42

Dep. var.:	Exhibits (1873)	
	(1)	(2)
	Members	No members
Distance to society seat	-0.115***	-0.024
	(0.033)	(0.035)
Geographic controls	Yes	Yes
Population controls	Yes	Yes
Polity fixed effects	Yes	Yes
Observations	662	2022
R-squared	0.53	0.36

Notes: The table replicates the OLS results from Table 2 column 3. Column 1 restricts the sample to grid cells with at least one member in an economic society. Column 2 restricts the sample of grid cells with no members in economic societies. Dependent variables, main explanatory variable, and city size are transformed using the inverse hyperbolic sine (arcsinh). Geographical controls: average temperature, average precipitation, altitude, soil suitability, distance to navigable river. Population controls: Bairoch city pop 1750, No. Keyser cities, Berlin dummy. Standard errors clustered at the 1789 polity level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

D.1 Simulations of randomly generated spatial noise

Table D.10 presents results when correcting standard errors for spatial noise with the method proposed by Conley (1999). However, another way to gauge the degree to which our results depend on the spatial structure of the data, is to perform Fisher randomization tests. We formulate the null hypothesis that our members variable has no more explanatory power than randomly created spatial noise with the same correlation structure as the members variable. Following Voth (2021), we exclusively focus on spatial noise simulations for the independent variable.

In simulating spatial noise we follow the method proposed by Kelly (2021). The process of generating spatial noise can be summed up in three basic steps. First, we estimate the underlying parameters of the spatial distribution underlying the variation in our explanatory variable that is orthogonal to the other control variables. Here, we follow the kriging procedure suggested by Kelly (2021) which uses a Matérn function as a kernel.[D.1] Second, we take 10,000 random draws from a spatial noise distribution with the estimated parameters. Third, we run 10,000 regressions of equation (1) as specified in table 2, column 3, where we replace the society member variable with the random draws. The specification uses our full set of geographical and urbanization controls and imposes polity fixed effects. The results of this exercise are presented in table D.12. It compares the summary statistics of the coefficients, t-statistics, and R^2 from regressing spatial noise on our measures of innovation. In comparison to the spatial noise results, the right hand side of the table presents the actual coefficients of society members from table 2, column 3. In line with Kelly (2021), we can use the proportion of how often the coefficient of spatial noise is more significant than the coefficient of the observed explanatory variable as our randomized significance level. We illustrate the distribution of t-statistics of random draws from the spatial noise distribution in comparison to the actual t-statistic for the member coefficient in figure D.1. It shows that none of the random draws from the spatial noise distribution have a t-statistic that is larger than the actual member coefficient. The randomized significance level is exactly 0. Hence, we can confidently reject our null hypothesis of our member variable having no more explanatory power than randomly created spatial noise.

Table D.12: Simulation 3: Spatial noise simulation for table 2, column (3) with clustered SEs

Variable	Obs	Mean	Std. Dev.	Min	Max	Member est.
Coefficient	10,000	-0.000	0.034	-0.122	0.131	0.286
T-statistic	10,000	-0.010	1.080	-4.042	4.386	6.930
R2	10,000	0.482	0.000	0.481	0.485	0.499

Notes: The t-statistic of random noise were in 0% of all simulations rounds greater than the estimated t-statistic of society members.

[D.1] We further assume a search range between 40 to 1000km kilometers and a smoothness parameter of 0.5 for the Matérn function, as suggested by Kelly.

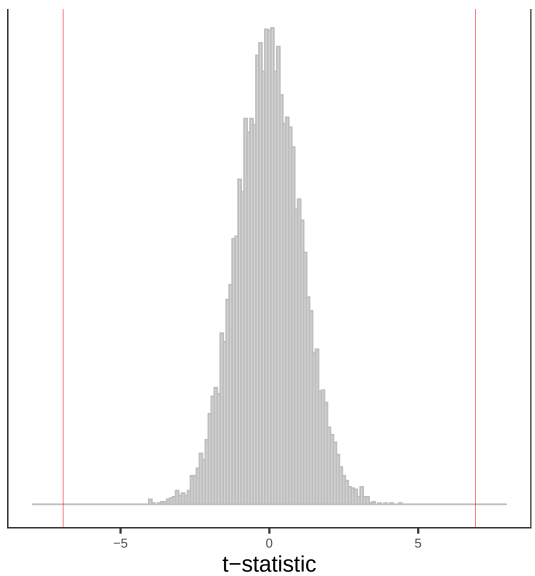


Figure D.1: T-statistics of spatial noise simulations

Notes: This figure shows the distribution of t-statistics for the coefficients of spatial noise from regressions using the model from equation (1) specified as in table 2, column 3. The t-statistic for the actual coefficient of society members is indicated as a red vertical line.

Appendix E Immediate effects for the local economy

This Appendix describes the data used to estimate the immediate impact of the Saxon economic society seated in Leipzig on the local economy. It also presents several robustness checks.

As reported in Appendix Tables A.2 and A.3, the Saxon society held a number of prize competitions and inspected various products. These tables document substantial activity directed at improving the local manufacturing sector, especially in textile production. Of the 23 competitions, 11 targeted improvements in textile manufacturing, whereas six targeted improvements in agriculture.

To test the impact of the society on the local economy, we geo-referenced a list of manufactories established in Saxony collected by Forberger (1958). This allows us to test whether regions with more society members experienced an increase in manufactory establishment after the emergence of the Saxon society. The list of manufactories includes 252 firms with their year of establishment covering the period between 1550 and 1845. We restrict our main analysis to the 191 firms established in the period 1700–1800.

Of the 191 firms included in the main analysis, 130 are associated with the textile sector. In the period 1700–1763, 42 firms were established, of which 26 focused on textiles (62%). In the period 1764–1800, 149 firms were established, of which 104 focused on textiles (70%).

Manufactories were geo-located and matched to the Saxonian counties (Ämter) in their borders of 1790, using a shapefile derived from census maps presented by Blaschke and Jäschke (2008). While county borders remained unchanged between the 1755 and 1792 censuses (Blaschke and Jäschke, 2008, pp. 7, 10), some population counts were only reported for the union of multiple counties. Hence, for the purpose of the analysis, the counties were first matched to a list of historical counties in 1790 and then aggregated to common county units.

E.1 Variable definitions

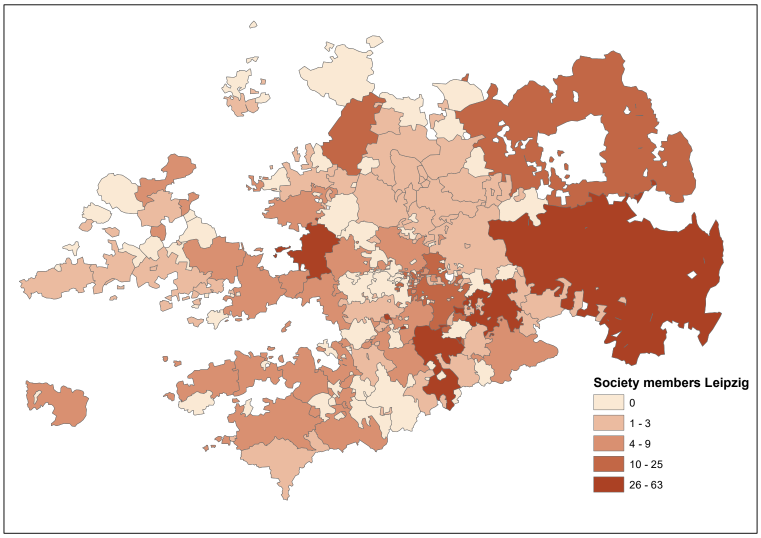
Number of new manufactories. The number of manufactory foundations in a county in the period 1700-1763 (pre society) or 1764–1800 (post society). Data obtained from Forberger (1958).

Society members. The number of members in the Saxon society as reported in membership registers published in the period 1764–1789. The place of residence is matched to the Saxon counties. Data obtained from LÖG (1790, pp. 258–300).

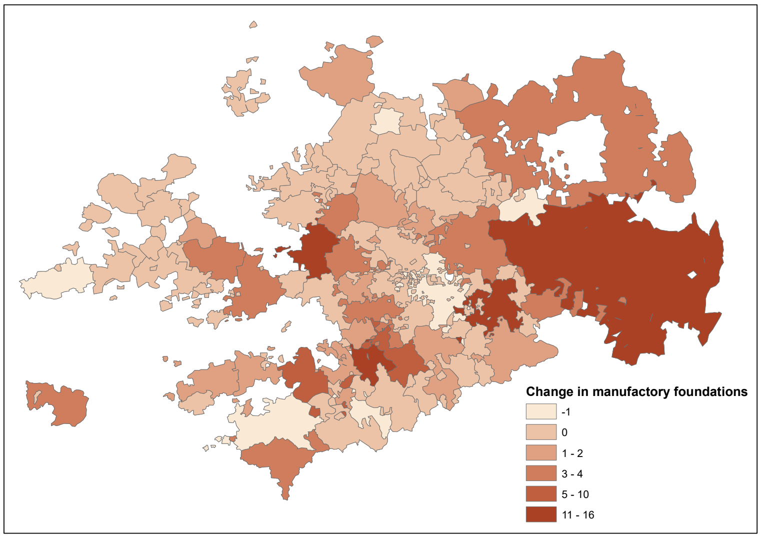
Census population 1755/1792. The total population of a county in the years 1755 and 1792. Data obtained from Saxon administrative statistics. These have been compiled based on the original archive material located at the *Hauptstaatsarchiv Dresden* (Geheimes Konsilium, 1755; Geheimes Kabinett, 1793).

Attraction of upper-tail human capital. The total number of notable individuals as recorded in the *Deutsche Biographie* that died in a given grid cell during a given period (1700–1763, 1764–1800 in the main analysis) and were born in a different grid cell. Data obtained from (BADW).

E.2 Descriptive statistics



(a) Society members



(b) Manufactory growth

FIGURE E.1: Spatial distribution of members and manufactory growth in Saxony

Notes: Panel (a) presents the spatial distribution of members in the Saxon society at the county level. Panel (b) presents a map of the difference in manufactory establishments between the periods 1764-1800 and 1700-1763 across Saxon counties.

Figure E.1a presents the spatial distribution of members in the Saxon society during the period 1764–1789 at the county level. Figure E.1b presents a map of the difference in manufactory establishments between the periods 1764-1800 and 1700-1763 across Saxon counties.

E.3 Robustness with respect to the analyzed period and data accuracy

In a first robustness check in Table E.1, we extend the analysis to all manufactories included in the source, i.e., those established during the entire period (1550–1845). We find that the results are qualitatively similar. While the results for all manufactories seem a bit smaller, they are somewhat larger for textiles and close to zero for all others.

Table E.1: Society members and manufactory establishment, full sample 1550–1845

	Number of new manufactories			
	(1)	(2)	(3)	(4)
	All	All	Textiles	Other
Society members × Post 1764	0.118**	0.115*	0.205***	0.0358
	(0.0591)	(0.0604)	(0.0532)	(0.0920)
Census population 1755/1792		0.00102	0.127	-0.202
		(0.177)	(0.169)	(0.206)
Attraction of upper-tail human capital, 1550-1845		-0.0184	0.140	-0.135
		(0.130)	(0.140)	(0.116)
County fixed effects	Yes	Yes	Yes	Yes
Period fixed effect	Yes	Yes	Yes	Yes
Observations	190	190	190	190
R-squared	0.86	0.86	0.85	0.70

Notes: The table shows results from estimating equation 3. The unit of observation is the county × time period (1550–1763, 1764–1845). Dependent variables, main explanatory variable, population and attraction of upper-tail human capital are transformed using the inverse hyperbolic sine (arcsinh). Column 1 estimates the difference-in-difference model with county-fixed effects; column 2 adds control variables; column 3 uses only textile firms for the dependent variable; column 4 uses all non-textile firms. Standard errors clustered at the county level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

The manufactory list by Forberger (1958) derives from careful archival work. To this date, it constitutes the most comprehensive source on early Saxon manufacturing. However, since Forberger (1958) was not always able to find precise information on year of establishment, some of the dates are measured with error. Below, we test robustness when omitting such cases.

Forberger's work mainly draws on the collections of the *Hauptstaatsarchiv Dresden* that entails, among other sources, the records of the absolutist bureaucracy of the Saxon state in the eighteenth century (see Forberger, 1958, pp. 370–384). Within these collections, Forberger often uses official documents confirming the privilege of manufactory establishment or describing the history of a manufactory or region. However, in several cases the establishment years of manufactories are inferred from secondary material that counted the manufactories in a region or described specific aspects of the economy. The resulting list thus includes manufactories with known years of foundation (i.e., confirmation of its privileges) and manufactories with known years of first mention (i.e., in regional descriptions of the economy). Furthermore, the year of establishment may not always be equivalent to the start of operations.

As (Forberger, 1958, pp. 306–363) draws predominantly on surveys and reports of the state administration, e.g. the *Landes Oeconomie-Manufactur- und Commercien-Deputation*, or *the Commission zu Untersuchung des Commercien-Wegs*, these arguably should provide a representative assesment of manufactories in Saxony. However, the quality of the records might have increased with the expansion of the bureaucracy. Specifically, the end of the Seven Years' War led to reconstruction efforts by the state and increased record keeping. Thus, time-trends should be interpreted with care.

In the empirical analysis, a uniform increase in recorded foundations after the emergence of the Saxon society is captured by a time-fixed effect. However, if the emergence of the society induced better record keeping in counties with more members, the estimated effect may simply reflect this. We argue that such changes should improve the records of the first mention of manufactories rather than the records of the foundation year. Therefore, Table E.2 presents robustness checks where all manufactories without a known year of establishment (or confirmation of its privileges) are dropped from the sample. Table E.3 extends this robustness check to the full length of the Forberger list. The results are reassuring. Coefficient sizes of the society member treatment effect are very close to the coefficients from the full sample of manufactory foundations.

In sum, the results prove to be robust both to extending the sample to the full list and to dropping firms for which only the year of first mention is known. As both robustness checks address two shortcomings regarding the representativeness of Forberger's list, the results are reassuring with respect the quality of the data.

Table E.2: Society members and manufactory establishment, only precise establishment years, 1700-1800

	Number of new manufactories			
	(1)	(2)	(3)	(4)
	All	All	Textiles	Other
Society members × Post 1764	0.135**	0.126**	0.127**	0.108*
	(0.0540)	(0.0594)	(0.0533)	(0.0646)
Census population 1755/1792		0.00634	-0.0388	-0.00763
		(0.229)	(0.219)	(0.0848)
Attraction of upper-tail human capital, 1700-1800		-0.124	-0.0786	0.0107
		(0.187)	(0.180)	(0.183)
County fixed effects	Yes	Yes	Yes	Yes
Period fixed effect	Yes	Yes	Yes	Yes
Observations	190	190	190	190
R-squared	0.84	0.85	0.83	0.76

Notes: The table shows results from estimating equation 3. The unit of observation is the county × time period (1700–1763, 1764–1800). The dependent variable is the count of manufactory establishments from Forberger (1958) for which the precise year of foundation is known. Manufactories with only a known year of first mention are excluded. Dependent variables, main explanatory variable, population and attraction of upper-tail human capital are transformed using the inverse hyperbolic sine (arcsinh). Column 1 estimates the difference-in-difference model with county-fixed effects; column 2 adds control variables; column 3 uses only textile firms for the dependent variable; column 4 uses all non-textile firms. Standard errors clustered at the county level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

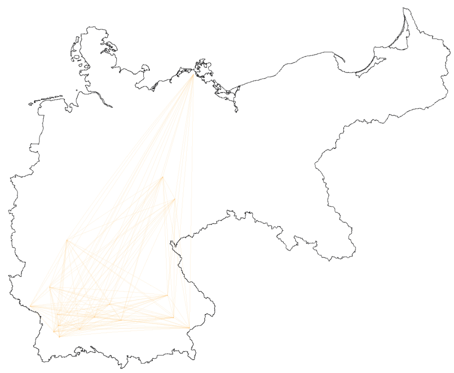
Table E.3: Society members and manufactory establishment, only precise establishment years, 1550-1845

	Number of new manufactories			
	(1)	(2)	(3)	(4)
	All	All	Textiles	Other
Society members × Post 1764	0.111**	0.130**	0.174***	0.0421
	(0.0556)	(0.0560)	(0.0559)	(0.0774)
Census population 1755/1792		0.149	0.190	-0.136
		(0.210)	(0.195)	(0.186)
Attraction of upper-tail human capital, 1550-1845		0.106	0.230**	-0.100
		(0.101)	(0.110)	(0.0989)
County fixed effects	Yes	Yes	Yes	Yes
Period fixed effect	Yes	Yes	Yes	Yes
Observations	190	190	190	190
R-squared	0.84	0.84	0.83	0.73

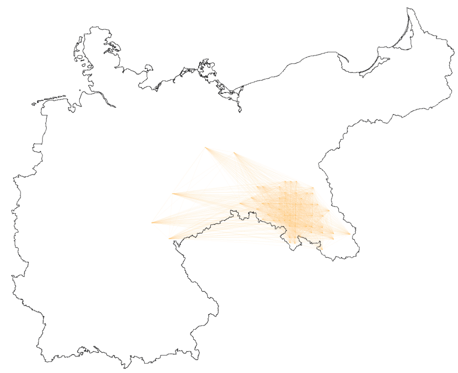
Notes: The table shows results from estimating equation 3. The unit of observation is the county × time period (1550–1763, 1764–1845). The dependent variable is the count of manufactory establishments from Forberger (1958) for which the precise year of foundation is known. Manufactories with only a known year of first mention are excluded. Dependent variables, main explanatory variable, population and attraction of upper-tail human capital are transformed using the inverse hyperbolic sine (arcsinh). Column 1 estimates the difference-in-difference model with county-fixed effects; column 2 adds control variables; column 3 uses only textile firms for the dependent variable; column 4 uses all non-textile firms. Standard errors clustered at the county level in parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Appendix F Knowledge diffusion in society networks

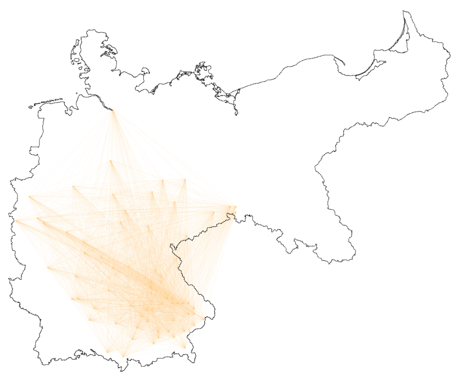
F.1 Illustration of spatial networks for societies



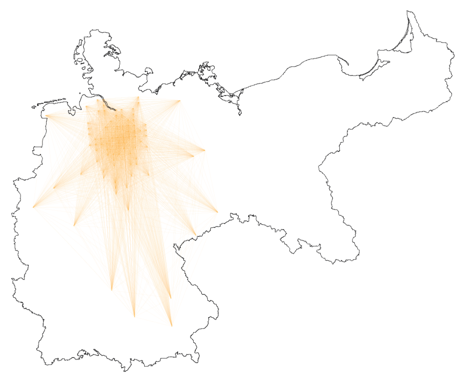
(a) Network of Bad Homburg members



(b) Network of Breslau members



(c) Network of Burghausen members



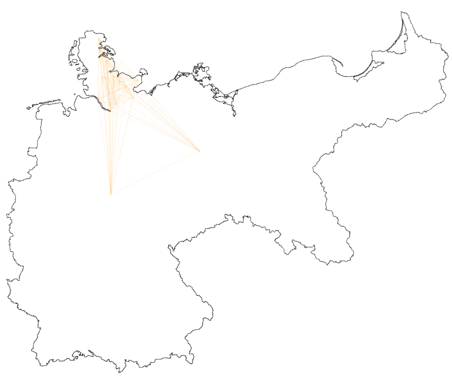
(d) Network of Celle members

Figure F.1: Networks of societies

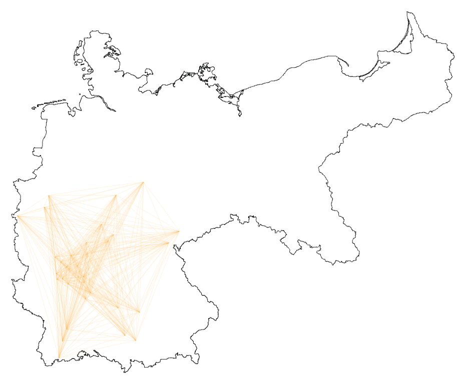
Notes: Spatial networks of members in economic societies by society. Each member of a given society is connected with a line to every other member.

(e) Network of Jauer / Schweidnitz members

(f) Network of Kassel members



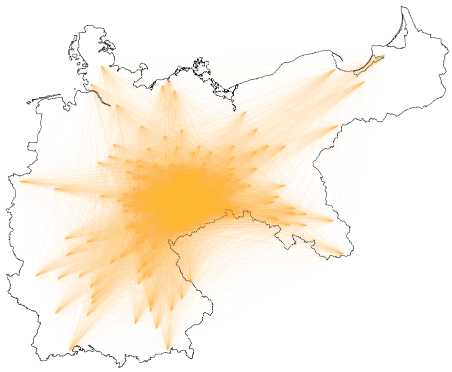
(g) Network of Kiel members



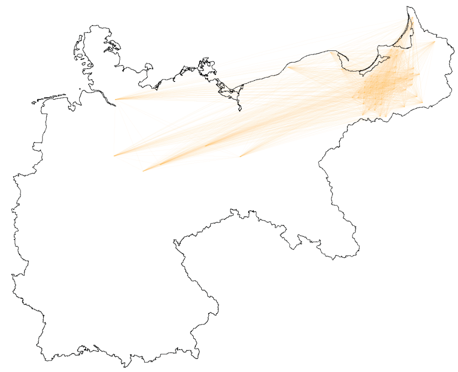
(h) Network of Lautern / Mannheim members

FIGURE F.1: Networks of societies (cont.)

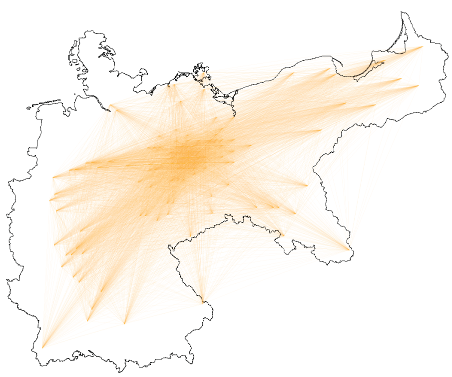
Notes: Spatial networks of members in economic societies by society. Each member of a given society is connected with a line to every other member.



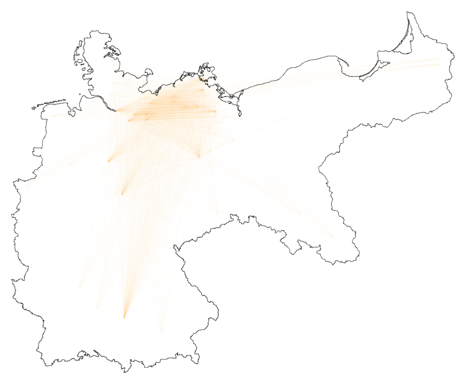
(i) Network of Leipzig members



(j) Network of Mohrungen members



(k) Network of Potsdam members



(l) Network of Rostock members

Figure F.1: Networks of societies (cont.)

Notes: Spatial networks of members in economic societies by society. Each member of a given society is connected with a line to every other member.

F.2 Summary statistics

Table F.1: Descriptive statistics

Variable	Mean	SD	Min	Max	Obs
Technological similarity (Jaffe index)	0.06	0.16	0.00	1.00	365938
Members from same society	0.03	0.18	0.00	1.00	365938
Members from different society	0.12	0.32	0.00	1.00	365938
Geographic distance	3.83	2.10	0.09	13.30	365938
Both access to road	0.67	0.47	0.00	1.00	365938
Both access to railroad	0.65	0.48	0.00	1.00	365938
Both access to river	0.11	0.31	0.00	1.00	365938
Both urban	0.63	0.48	0.00	1.00	365938
Same polity	0.05	0.22	0.00	1.00	365938

Notes: The table shows summary statistics for the variables used in the gravity type estimations. The level of observation is a grid-cell pair. *Technological similarity* is an index based on Jaffe (1986) capturing the level of technological similarity in patents across grid-cell pairs. *Members from same society* is an indicator that assumes the value one if both cells in a pair are home to at least one member of the same economic society. *Members from different society* is an indicator that assumes the value one if both cells in a pair are home to members from different economic societies. Geographic distance is reported per 100 kilometers. Access to road refers to 1848; access to railroad to 1875; access to river to 1874. *Same polity* is equal to one if a grid-cell pair belongs to the same polity as in 1789.

F.3 Gravity-type model: Variable definitions

Technological similarity. This variable captures the level of technological similarity between grid cells i and j based on Jaffe (1986). In particular, the index measures the degree of overlap across technological classes between cell pairs and is defined between zero and one. The number of technological classes in our sample is equal to 86. A value of the index equal to one indicates perfect technological similarity of the granted patents; a value equal to zero indicates no technological similarity of the granted patents.

Members from same society. This is an indicator variable that takes on value one if both cells of a grid-cell pair have at least one member from the same economic society. Grid-cell pairs can have common members from different societies.

Members from different society. This is an indicator variable that takes on value one if cells of a grid-cell pair have only members from different economic societies.

Geographic distance. This variable measures the shortest geographic distance, based on an ellipsoid, for each cell pair. Distance is reported per 100 kilometers.

Both access to road. This is an indicator variable taking value one if both cells of a grid-cell pair have access to a road as observed in 1848. The map of historical roads is from Andreas Kunz, IEG-MAPS (http://dx.doi.org/10.25359/ISSN.1614-6352.MAP455).

Both access to river. This is an indicator variable taking value one if both cells of a grid-cell pair have access to a navigable river or canal as observed in 1874. The map of navigable rivers and canals is from Andreas Kunz, IEG-MAPS (http://dx.doi.org/10.25359/ISSN.1614-6352.MAP052).

Both urban. This is an indicator variable taking value one if both cells of a grid-cell pair are urban defined as having at least one city with city rights awarded until 1760 based on Keyser (1939–1974) or a city with at least 5,000 inhabitants in 1750 from Bairoch (1988).

Same polity. Indicator variables taking the value one if a grid-cell pair is located within the territory of a state in the Holy Roman Empire in 1789. Polities that contain five centroids or less are grouped into a single indicator. Polity borders obtained from Huning and Wahl (2020), based on a map by Wolff (1877).

Appendix References

(BADW) - Bayerische Akademie der Wissenschaften. 2021. "Deutsche Biographie." *www.deutsche-biographie.de.*

Bairoch, Paul. 1988. *Cities and Economic Development: From the Dawn of History to the Present.* Chicago, IL: University of Chicago Press.

Blaschke, Karlheinz, and Uwe Ulrich Jäschke. 2008. *Kursächsischer Ämteratlas 1790.* Chemnitz: Klaus Gumnior.

Bogucka, Edyta P., Davide Cantoni, and Matthias Weigand. 2020. "Princes and Townspeople: A Collection of Historical Statistics on German Territories and Cities. 1: City Locations and Border Maps."

Conley, Timothy G. 1999. "GMM Estimation with Cross Sectional Dependence." *Journal of Econometrics* 92 (1): 1–45.

De la Croix, David, and Omar Licandro. 2015. "The Longevity of Famous People from Hammurabi to Einstein." *Journal of Economic Growth* 20 (3): 263–303.

Dittmar, Jeremiah E, and Ralf R Meisenzahl. 2020. "Public Goods Institutions, Human Capital, and Growth: Evidence from German History." *Review of Economic Studies* 87 (2): 959–996.

Eulenburg, Franz. 1904. *Die Frequenz der deutschen Universitäten von ihrer Gründung bis zur Gegenwart.* Leipzig: B. G. Teubner.

Feldman, Naomi E., and Karine Van der Beek. 2016. "Skill Choice and Skill Complementarity in Eighteenth Century England." *Explorations in Economic History* 59: 94–113.

Fischer, Christian Friedrich Emanuel, ed. 1822. *Verhandlungen und Arbeiten der ökonomisch-patriotischen Societät der Fürstenthümer Schweidnitz und Jauer im Jahre 1821.* Breslau: Wilhelm Gottlieb Korn.

Forberger, Rudolf. 1958. *Die Manufaktur in Sachsen - Vom Ende des 16. bis Anfang des 19. Jahrhunderts.* Berlin: Akademie Verlag.

(GBVIN) – Gesellschaft zur Beförderung vaterländischer Industrie in Nürnberg. 1833. *Verzeichniss der Mitglieder der Gesellschaft zur Beförderung vaterländischer Industrie in Nürnberg.* Nürnberg: Sebaldsche Offizin.

Geheimes Kabinett. 1793. *Vergleichungs-Tabelle über die Anzahl der in den Jahren 1792 und 1793 in dem Churfürstenthum Sachsen und dazu gehörigen Landen aufgezeichneten Consumenten.* Dresden: Hauptstaatsarchiv Dresden, 1026 Geheimes Kabinett - Loc. 00563/1.

Geheimes Konsilium. 1755. *General tabelle Über den Getreyd–zuwuchs und die Anzahl derer Consumenten im Chur-Fürstenthum Sachsen, deren incorporirten und übrigen Landen 1755.* Dresden: Hauptstaatsarchiv Dresden, 1025 Geheimes Konsilium - Loc. 05351/08.

General-Direction der Weltausstellung. 1983. *Welt-Ausstellung 1873 in Wien - Officieller General-Catalog.* Wien: Verlag der General-Direction.

Gesellschaft zur Beförderung der Naturkunde und Industrie Schlesiens. 1806. *Verhandlungen der Gesellschaft zur Beförderung der Naturkunde und Industrie Schlesiens.* Breslau: Graß und Barth.

Graf, Sieglinde. 1993. *Aufklärung in der Provinz – Die sittlich-ökonomische Gesellschaft von Ötting-Burghausen 1765-1802.* Göttingen: Vandenhoeck & Ruprecht.

Hammel-Kiesow, Rolf. 2014. *Die Hanse.* Munich: C.H. Beck.

Heller, Ludwig. 1859. *Geschichte der Lübeckischen Gesellschaft zur Beförderung gemeinnütziger Thätigkeit von ihrer Gründung bis zum Jahre 1857.* Lübeck: v. Rohden'sche Buchhandlung.

HGIS Germany. 2019. *Germany State Boundaries, 1820, German Historical GIS.*

Hijmans, Robert J, Susan E Cameron, Juan L Parra, Peter G Jones, and Andy Jarvis. 2005. "Very high resolution interpolated climate surfaces for global land areas." *International Journal of Climatology: A Journal of the Royal Meteorological Society* 25 (15): 1965–1978.

Hockerts, Hans Günter. 2008. "Vom nationalen Denkmal zum biographischen Portal. Die Geschichte von ADB und NDB 1858-2008." In *... für deutsche Geschichts- und Quellenforschung". 150 Jahre Historische Kommission bei der Bayerischen Akademie der Wissenschaften*, edited by Lothar Gall, 229–269. München: Oldenbourg.

Howes, Anton. 2017. "The Spread of Improvement: Why Innovation Accelerated in Britain 1547–1851." Brown University mimeo, Manuscript.

Huning, Thilo R., and Fabian Wahl. 2020. "You Reap What You Know: Appropriability and the Origin of European States." University of Hohenheim mimeo.

Kelly, Morgan. 2021. "Persistence, randomization, and spatial noise." CEPR Discussion Paper 16609.

Keyser, Erich. 1939–1974. *Deutsches Städtebuch-Handbuch städtischer Geschichte.* Vol. 1–5. Stuttgart: Kohlhammer.

(KGCBLL) – Königlich Großbrittanisch Churfürstlich Braunschweigisch Lüneburgische Landwirthschaftsgesellschaft. 1772. *Der Königl. Großbritt. Churfürstl. Braunschw. Lüneb. Landwirthschaftsgesellschaft Nachrichten von Verbesserung der Landwirthschaft und des Gewerbes.* Celle: Carl Gsellius, königl. privil. Buchhändler.

Klein Goldewijk, Kees, Arthur Beusen, Jonathan Doelman, and Elke Stehfest. 2017. "Anthropogenic Land Use Estimates for the Holocene–HYDE 3.2." *Earth System Science Data* 9 (2): 927–953.

(KLGC) - Königliche Landwirthschafts-Gesellschaft zu Celle. 1864. *Festschrift zur Säcularfeier der Königlichen Landwirthschafts-Gesellschaft zu Celle am 4. Juni 1864: 1. Festschrift Zur Säcularfeier Der Königlichen Landwirthschafts-Gesellschaft Zu Celle Am 4. Juni 1864.* Hannover: Klindworth's Verlag.

(KOMPÖ) - Königlich-Ostpreußisch-Mohrungsche physikalisch-ökonomische Gesellschaft. 1796. *Acta der Königlch-Ostpreußisch-Mohrungschen physikalisch-ökonomischen Gesellschaft, zur Nachricht der Mitglieder.* Königsberg: G. L. Hartung, königl. preuß. Hofbuchdrucker.

Kopitzsch, Franklin. 1980. "Die Hamburgische Gesellschaft zur Beföderung der Künste und nützlichen Gewerbe (Patriotische Gesellschaft von 1765) im Zeitalter der Aufklärung. Ein Überblick." In *Deutsche patriotische und gemeinnützige Gesellschaften*, *Wolfenbütteler Forschungen*, edited by Rudolf Vierhaus, 51–70. München: Kraus International Publications.

(KPÖG) - Kuhrpfälzisch Physikalisch-ökonomischen Gesellschaft. 1771. *Bemerkungen der kuhrpfälzischen physikalisch-ökonomischen Gesellschaft, vom Jahre 1771.* Mannheim: C. F. Schwan, kuhrfürstl. Hofbuchhändler.

(KPÖG) - Kuhrpfälzisch Physikalisch-ökonomischen Gesellschaft. 1773. *Bemerkungen der kuhrpfälzischen physikalisch-ökonomischen Gesellschaft, vom Jahre 1771.* Mannheim: C. F. Schwan, kuhrfürstl. Hofbuchhändler.

(KPÖG) - Kuhrpfälzisch Physikalisch-ökonomischen Gesellschaft. 1776. *Bemerkungen der kuhrpfälzischen physikalisch-ökonomischen Gesellschaft, vom Jahre 1774.* Mannheim: im Verlage der Gesellschaft.

(KPÖG) - Kuhrpfälzisch Physikalisch-ökonomischen Gesellschaft. 1779. *Bemerkungen der kuhrpfälzischen physikalisch-ökonomischen Gesellschaft, vom Jahre 1775.* Mannheim: im Verlage der Gesellschaft.

(KSAB) - Kaiserliches Statistisches Amt Berlin, ed. 1903. *Die Volkszählung im Deutschen Reich.* Berlin: Puttkammer & Mühlbrecht.

Leipziger ökonomische Gesellschaft. 1790. *Schriften der Churfürstl. Sächsischen gnädigst bestätigten Leipziger ökonomischen Gesellschaft.* Dresden: Walthersche Hofbuchhandlung.

Matzerath, Horst. 1990. *Prussia's urbanization, 1815 to 1939.* Cologne: GESIS Data Archive.

Michel, Jean-Baptiste, Yuan Kui Shen, Aviva Presser Aiden, Adrian Veres, Matthew K Gray, Joseph P Pickett, Dale Hoiberg, Dan Clancy, Peter Norvig, Jon

Orwant, et al. 2011. "Quantitative Analysis of Culture Using Millions of Digitized Books." *Science* 331 (6014): 176–182.

Mokyr, Joel. 2009. *The Enlightened Economy: An Economic History of Britain 1700–1850.* Yale University Press.

Motschmann, Uta, ed. 2015. *Handbuch der Berliner Vereine und Gesellschaften 1786–1815.* Berlin, Boston: De Gruyter Akademie Forschung.

(MPV) – Mecklenburgische Patriotische Verein. 1827. *Landwirthschaftliche Annalen des Mecklenburgischen Patriotischen Vereins.* Rostock: Im Verlage der Stillerschen Hof-Buchhandlung.

Mützell, Alexander August. 1823–1825. *Neues Topographisch-Statistisch-Geographisches Wörterbuch des Preussischen Staats.* Vol. 5-6. Halle: Karl August Kümmel.

Naragon, Steve. 2016. "Universities founded before 1815." *https://users.manchester.edu/facstaff/ssnaragon/kant/Universities/UniList.html – accessed 11/02/2021.*

Pache, Oskar. 1896–1905. *Handbuch des Deutschen Fortbildungsschulwesens.* Vol. 1–7. Wittenberg: R. Herrose's Verlag.

Pfister, Ulrich. 2020. "Urban population in Germany, 1500–1850." University of Münster, Center for Quantitative Economics Working Paper 90.

Reinert, Matthias, Maximilian Schrott, Bernhard Ebneth, and Malte Rehbein. 2015. "From Biographies to Data Curation-The Making of www. deutsche-biographie. de." 13–19.

Rübberdt, Rudolf. 1934. *Die ökonomischen Sozietäten: ein Beitrag zur Wirtschaftsgeschichte des XVIII. Jahrhunderts.* Vereinigten Friedrichs-Universität Halle-Wittenberg.

Rubin, Jared. 2014. "Printing and Protestants: an empirical test of the role of printing in the Reformation." *Review of Economics and Statistics* 96 (2): 270–286.

Runde, Justus Friedrich, ed. 1773. *Vom Surrogat der Hand- und Spanndienste. Zwo Abhandlungen, denen die hochfürstlich Hessen-Casselische Gesellschaft der Ackerbaus und der Künste am 5. März 1775 den Preis zuerkannt hat.* Cassel: Verlag des Waisenhauses.

(SGVC) – Schlesische Gesellschaft für vaterländische Cultur. 1826-1840. *Übersicht der Arbeiten und Veränderungen der schlesischen Gesellschaft für vaterländische Cultur.* Breslau: Barth und Comp.

Slack, Paul. 2014. *The invention of improvement: information and material progress in seventeenth-century England.* Oxford: Oxford University Press.

(SPG) – Schleswig-Holsteinische patriotische Gesellschaft. 1812. "Verhandlungen der Schleswig-Holsteinischen patriotischen Gesellschaft." In *Neue Schleswig-Holsteinische Provinzialberichte (2)*, edited by Georg Petersen. Kiel: C. F. Mohr.

(SPHH) – Société patriotique de Hesse-Hombourg. 1777. *Programme de la Société patriotique de Hesse-Hombourg.* Hombourg-ez-monts: de l'Imprimerie de la Société-Patriotique.

Statistisches Bureau zu Berlin. 1851–1855. *Tabellen und amtliche Nachrichten über den Preussischen Staat für das Jahr 1849.* Vol. 1–6b. Berlin: A. W. Hayn.

Streb, Jochen, Jörg Baten, and Shuxi Yin. 2006. "Technological and Geographical Knowledge Spillover in the German Empire 1877–1918." *Economic History Review* 59 (2): 347–373.

Tabellini, Guido, and Michel Serafinelli. forthcoming. "Creativity Over Time and Space." *Journal of Economic Growth* forthcoming.

van Dülmen, Richard. 1986. *Die Gesellschaft der Aufklärer: Zur bürgerlichen Emanzipation und aufklärerischen Kultur in Deutschland.* Frankfurt am Main: S. Fischer Verlag.

Voth, Joachim. 2021. "The Handbook of Historical Economics." edited by Alberto Bisin and Giovanni Federico, Chapter Persistence: Myth and Mystery. Elsevier.

Wolff, Carl. 1877. *Carl Wolff's historischer Atlas.* Berlin: Reimer Verlag.