Chapter 7
Vernacular GIS: Mapping Early Modern Geography and Socioeconomics

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7.1 Introduction

One of the key objections made against the use of Geographic Information Systems in the study of history is that they cannot contend with the variable and incomplete nature of sources and with the imprecision of maps and other geographical records from the early modern period.[1] Other criticisms are of the cost, complexity, and man-hours which can be involved in setting up the maps and databases necessary to use GIS.[2] As I have discovered during my own mapping of the scientific instrument trade of early eighteenth-century London, these issues can be sidestepped simply by creating digital maps which reflect contemporaries' "vernacular" concepts of physical and socioeconomic space rather than attempting a modern degree of geographical precision: Locations are depicted as contemporaries typically described and understood them, with respect to basic geography and natural and man-made landmarks, rather than striving for precision. In georeferencing (i.e., relating information to geographic location), this is akin to the "informal" descriptions of geographical locations which Linda Hill describes as those "which we use in ordinary discourse using placenames," as compared to "formal" representations which are "based on longitude and latitude coordinates and other spatial referencing systems, which we use in activities such as map making and navigating" today (Hill 2006, 2).

For example, a building in an early modern population center may be described and depicted as existing on a certain street near a certain church or inn, rather than

[1] Gregory and Ell (2007, 1), Corrigan (2010, 76), Knowles and Hillier (2008, 3) and Pickles (1999).

[2] Gregory and Ell (2007, 17, 41, 89), Martí-Henneberg (2011, 11–12), Knowles (2000) and Siebert (2000).

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in terms of Cartesian coordinates or in terms of the number of meters which lay between it and nearby features. Maps created and interpreted in such vernacular terms can be suitably flexible in the face of records which are uneven or incomplete, if one is researching a moderately large cohort of individuals or entities. They can also create more accurate representations of the ways in which the inhabitants of early modern communities actually viewed space and tried to depict it on paper, which were far more visual and socioeconomically relevant to the inhabitants' experience of place than cartographically precise. This was partially because of the comparatively small size of the spaces occupied by early modern settlements and even by the great metropolis of London. It was easy to navigate the entirety by foot and by other common conveyances, and the buildings and landmarks along many streets could be sighted once one arrived in the general area.

Also during this period, "precision" in all areas of human knowledge and practice beyond just geography and map making was conceived of differently and more varyingly than it is today. It was only as the 1700s progressed that Europeans would make great advances in settling locations and distances on land and eventually at sea through astronomy-based surveying and the so-called search for the longitude—improving maps and charts as a result—and that nations would begin to develop standards of weights and measures. Finally, the programs with which one can create vernacular maps are often made freely or affordably available today through institutions or through the Internet and can be employed by one scholar or student rather than demanding the talents and input of a research team.

Vernacular maps, like the more precise maps which can also be created with GIS, offer a range of benefits for the early modern historian (Knowles and Hillier 2008, xiii). As Ian Gregory and Paul Ell succinctly state with respect to GIS in general: "It provides a toolkit that enables the historian to structure, integrate, manipulate, analyze and display data in ways that are either completely new, or are made significantly easier" (Gregory and Ell 2007, 1). At the center of these advances is the ability of digital mapping to root visual representations of populations of individuals or of socioeconomic entities such as businesses in time as well as location and on both the smaller and larger scales depending upon the nature of the available data and maps. This firstly taps into the so-called "spatial turn" which has, quite rightfully, taken place in history within the past few decades (White 2008, ix). Santa Arias and Barney Warf summarize the point of this development as, "Geography matters, not for the simplistic and overly used reason that everything happens in space, but because *where* things happen is critical to knowing *how* and *why* they happen" (Arias and Warf 2009, 1–2). Vernacular and precision GIS mapping also feed into the recognition that historical analyses mean little without an understanding of change over time. Historical data, place, and time should be viewed as an integrated whole in order to fully understand past and thus present dynamics, as has been emphasized by diverse authors including Langton, Massey, Sack, and Gregory and Ell.[3]

[3]Gregory and Ell (2007, 7, 18–19, 21, 90), Langton (1972), Massey (1999), Massey (2005), Sack (1974), Sack (1972), Bunge and Sack (1973) and Butlin (1993, 51–61).

In terms of the setting of my own research into the production and sale of scientific instruments, the geography, economy, and society of early modern London were inextricably bound together. Communities were sometimes molded by the physical landscape with, for example, the eastern reaches of the metropolis becoming a center for shipping and related crafts and trades in part because ships with masts could not pass London Bridge. However, the characteristics of the socioeconomic groups that settled in different neighborhoods also strongly influenced the physical features there. For example, the trend toward "politeness" among the middling and upper classes during this period influenced the layout and appearance of new streets and buildings in the west and in parts of the central metropolis (Stobart et al. 2007, 3–6). The geography of London was therefore not just its physical form but also the socioeconomic influences and relationships embodied in this landscape. Recognition of this has increasingly molded research in recent decades, such as by informing examinations of the spaces in which shopping for wares such as instruments took place and of the effects of these activities upon the urban landscape.[4] As Arias and Warf suggest, the "spatial turn" encourages such interdisciplinary efforts because "so many lines of thought converge on the topic of spatiality" (Arias and Warf 2009, 1–2).

Digital maps facilitate this by not just pinpointing the locations of people or entities on a representation of the Earth's surface but by also allowing the researcher to attach other kinds of information to these geographical pinpoints. In my case, this included the dates between which members of the scientific instrument trade were at these locations, their livery company affiliation, the types of instruments which they made or sold, and so on.[5] Thus, instead of just being a traditional static map of location, a GIS map is an interactive visual representation of a database in which a researcher can store as much information as they want about their subjects in different "layers." As Gregory and Ell explain, "a layer in GIS is analogous to a table in a database, it is the basic unit of storage for information on one particular subject. It consists of both spatial and attribute data combined [and] usually, in GIS each layer is stored in a separate file" (Gregory and Ell 2007, 36). This means that a vernacular or more precise digital map can be used to easily view parts of a population or of a landscape during specific periods of time, such as one decade or year, and according to different attributes—for example, in my case, all of the scientific instrument makers who belonged to the Clockmakers' Company or who sold globes during a certain decade. The authors go on to emphasize that "as soon as the GIS database is created it can be mapped. This means that the spatial patterns within the data can be repeatedly re-explored throughout the research process, greatly enhancing our ability to explore and understand spatial patterns" (Gregory and Ell 2007, 10–11). This is true of vernacular maps of early modern populations as much as it is of the precision constructs to which the quote refers.

[4]Cf. Stobart et al. (2007), Walsh (1995), Walsh (1995), Davis (1966) and Jeffreys (1954).

[5]The livery companies were trade associations that were given royal permission to regulate their respective crafts in the metropolis, mainly within the original medieval walls, including the Mercers, Grocers, Merchant Taylors and Spectaclemakers.

Depending upon the quality of the map used as the basis for this effort, one can also zoom in or out of the landscape and as easily examine one neighborhood or street as one could an entire city or region. This goes a step beyond the superb parish-wide and regional work already being done in Britain with the aid of basic computer mapping by historians such as Craig Spence (2000a; 2000b). All of this can greatly facilitate the study of populations and locations over time and within their geographical and socioeconomic contexts, as well as the comparison of different populations and locations which have been given similar treatment (Gregory and Ell 2007, 203). This is as true for widespread populations, and for those characterized by socioeconomic rather than by geographic attributes, as it is for geographically constrained communities like those in a city. An impressive example of this is the work done by the recent 4-year research project "The French Book Trade in Enlightenment Europe," overseen at the University of Leeds by Professor Simon Burrows and Dr. Mark Curran. The project used digital mapping and database technology to great effect to map and to analyze the European trade of the late eighteenth-century Swiss publishing house Société Typographique de Neuchâtel.[6] The resulting resources will be made publicly available through the Internet in 2012, allowing anyone to generate new maps and other visual representations of the data.

As in the above case, vernacular and precision GIS can produce clear and engaging resources which can be shared online, in print, or during presentations (Martí-Henneberg 2011, 8). These include maps (and movies or slide shows thereof) of geographical change and of the different socioeconomic attributes of a population. As Richard White says of the purely didactic benefits of using such maps to express dynamics: "Relationships which jump out when presented in a spatial format such as a map tend to clog a narrative, choking its arteries, until—even if the narrative does not expire—the reader, overwhelmed by detail, is ready to die of tedium and confusion" (White 2008, x). As we shall see, these superb visual and analytical tools do not have to be very difficult or expensive to construct, since one can often opt for creating digital maps without recourse to geospatial precision. Especially when studying the early modern era, which was barely affected by such modern concepts, there is no need for such exactness.

7.2 Perceptions of Space and of Socioeconomic Networks in Early Modern Cities

Precision georeferencing has become incorporated into modern life in a wide variety of ways. As Hill writes, these include Internet mapping and GPS guidance, precise and sometimes interactive maps in news reports and print and online publications,

[6]The publications stemming from this project currently include Curran (2010a) and Curran (2010b).

and the increasing commercial and institutional use of GIS to "hold and analyze georeferenced data, leading to the discovery of geographic distribution patterns that support decision makers and planning" (Hill 2006, 2). Of course, vernacular geopositioning persists as well. People continue to view locales in terms of the roles which individuals and individual institutions and places play and have played in their lives, and in terms of visual landmarks which can be noted when giving directions to others, such as a specific shop or a garish sign. However, we must remember that this was the *predominant* way in which urban geography was understood in early modern Europe, before the introduction of civic innovations such as house numbering and before maps were made more physically accurate. There is thus little need for the geographical precision which is often the bedrock of GIS in order to examine populations whose own understanding and representation of space was far more visual and socioeconomic than cartographic.

In London before the second half of the eighteenth century, locations were still conceived of and described entirely in terms of streets, nearby physical and socioeconomic landmarks, and well-known shop signs and proprietors. For example, in 1717, Mrs. Hannam advertised Italian hair dye at the sign of the Three Angels near the Half Moon Tavern in Cheapside.[7] Three years later, George Markham advertised the medicament "the Imperial Essence" at the sign of the Seven Stars under St. Dunstan's Church in Fleet Street.[8] In 1721, Benjamin Workman advertised scientific instruments and medical equipment next to Tom's Coffee House in Russell Street in Covent Garden.[9] Proprietors might also describe their locations in terms of the socioeconomic networks to which they belonged, such as that of a specific trade. These networks were deeply embedded in the physical landscape of the metropolis, with the geographical clustering of occupations and of immigrant or religious groups being quite common.[10] This is partially why digital maps, whether vernacular or more precise in nature, can be such illuminating tools for the analysis and understanding of historical socioeconomic relationships as well as geography. For example, in the case of retail and wholesale shopkeepers, one can use the maps to help to identify: individuals' physical proximity to each other and to other relevant trades, institutions, and communities; the types of passing custom to which they were exposed; and the counterparts with whom they were in direct competition.

An example of socioeconomic relationships and concerns shaping early modern georeferencing comes from the advertisements published by two competing partnerships of opticians in early eighteenth-century London—George Willdey

[7] *Daily Courant* (London, England), 16 February 1717, Issue 4782.

[8] *Daily Post* (London, England), 23 January 1720, Issue 97.

[9] *Daily Courant* (London, England), 28 October 1721, Issue 6247.

[10] See, for example, Gwynn's description of the geographical clustering of Huguenot immigrants in London and Raven's description of the clustering of the London book and print trades near St. Paul's Churchyard. As Power points out, clustering was also influenced by the differing public exposure, rent levels, and types of accommodations to be found not only in different neighborhoods but also in different types of through streets and dead ends. Gwynn (1985, 35, 38), Raven (2004) and Power (1986, 212).

and Timothy Brandreth and their former livery company masters John Yarwell and Ralph Sterrop. Yarwell and Sterrop described their shop at the sign of the Archimedes and Three Spectacles as "the first Shop of that Trade from Ludgate," while the young upstarts Willdey and Brandreth described their shop at the sign of the Archimedes and Globe in Ludgate Street as "the Second Spectacle-Shop above that which was Mr. Yarwell's."[11] Both partnerships described their locations with respect to the local geography of the optical instrument trade, while Willdey and Brandreth also used their location to remind readers of their connections with the well-known Yarwell. The younger men's having opened a shop near their former masters, and having chosen a similar shop sign (i.e., pictorial symbol), suggests that they were trying to directly compete with the older craftsmen.

As previously mentioned, the stage upon which such episodes of London life played out was actually quite a small one, despite the continuing expansion of the capital's population during the early modern period. London was the most populous metropolis in Western Europe by the beginning of the eighteenth century with perhaps 575,000 inhabitants and the most populous in all of Europe by the middle of the century after an increase of at least 100,000 people. Perhaps one in ten English and Welsh men lived in London, as compared to one in forty Frenchmen living in Paris, and as many as one in six English adults lived in the capital at some point in their lives.[12] However, the early modern metropolis only occupied a few square miles of land, even if its borders were always expanding in all directions and on both sides of the Thames. It consisted of "the City," or the central square mile mainly contained within the walls and gates of the original medieval metropolis, and the areas of Westminster, Middlesex, and Surrey that adjoined it.

As a result of such large numbers of people living in such a small area, the total population density of London during this period was about three times greater than that of its inner boroughs at the end of the twentieth century (Guillery 2004, 7). This means that the activities, perceptions, and representations of the capital were molded by its being much smaller (albeit more crowded) than modern cities and being so easily traversed—even if contemporaries thought it gargantuan and labyrinthine.[13] This was essentially true of all of the metropolises and large cities of Europe at this time.[14] In London, inhabitants could easily move about on foot and by carriage, hackney cab, sedans, or waterman. There are differing thoughts on the comparative degree to which members of the different genders and socioeconomic groups

[11] *Daily Courant* (London, England), 6 May 1707, Issue 1630.

[12] Beier and Finlay (1986, 1), Wrigley (1987, 134), Rudé (1971, ix, 98), Barnett (1936, 18) and George (1925, 24, 329–330).

[13] Guillery (2004, 7), Merritt (2002, 9), Guillery (2004, 7) and Merritt (2002, 9).

[14] At the beginning of the 1700s, only London, Paris, Amsterdam, Naples, Palermo, Venice, Rome, and Lisbon had more than about 100,000 inhabitants. Vienna, Berlin, and perhaps Lyon reached that point by mid-century (Wrigley 1987, 134).

circulated about the metropolis. However, it is clear that many Londoners from all classes traveled relatively widely for jobs, commerce, religion, socialization, shopping, entertainment, and other interests.[15]

This can be seen in the financial and personal records of innumerable members of at least the upper and middling classes. The diary of the redoubtable Samuel Pepys records his constantly crisscrossing London by foot, coach, and water in pursuit of business and recreation during the second half of the eighteenth century. For example, on September 20, 1668, Pepys walked to church and home, took a coach to visit a beautiful female friend, went to a different church in the hope of seeing a potential paramour, walked to and about Gray's Inn without finding any company, and then ended the day by walking through the fields to Clerkenwell (north of the central city) in the hope of seeing another beauty, before walking home (Pepys 2006, 163). The widespread movement of different types of people for commerce and shopping or leisure is also reflected in the extant shop accounts from early modern retailers and craftsmen. For example, the London-based customers, agents, subcontractors, and business associates listed in the accounts of the aforementioned optician and toyman (i.e., seller of small expensive luxury wares for adults) George Willdey of St. Paul's Churchyard from 1710 to 1725, hailed from almost all parts of the sprawling metropolis north of the river and not just from the central city or the fashionable western neighborhoods.[16]

Thus, London and the other large cities of early modern Europe were mostly perceived visually and at ground and river level and in terms of the socioeconomic networks embedded in the human landscape—not in terms of the clean-cut and precise bird's-eye renderings of a modern map. As Max Byrd said of Daniel Defoe's descriptions of the capital, and Miles Ogborn quoted when discussing cartography, the metropolis in later maps "emerges as curiously featureless, as a collection of names—of streets, buildings, squares—, but not as a realised picture. [...] in the end London exists for us only as a network of traffic, a gigantic system for comings and goings."[17] In applying GIS technology to the analysis of the world before such maps existed, there is seldom a need to attempt geographical precision. Inhabitants of early modern cities lived in a world so much smaller than their modern counterparts that it could be almost entirely walked on foot. Directions more specific than a shop sign and street or proximity to a public landmark seldom needed to be given, since anyone arriving at said street or landmark would likely be able to see their destination or could easily ask for a bit of guidance. Hence, a useful digital map for this time period only needs to pinpoint locations to the street level and only occasionally to building level, and not down to meters of accuracy.

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[15] Berry (2002, 380–381), (Stobart et al. 2007, 142, 151–152, 155), (Merritt 2002, 10, 145, 149, 152–157, 159).

[16] *Fenhoulet v. Willdey, 1744*, The National Archives at Kew, C 104/21.

[17] Byrd (1978, 12–13) and Ogborn (1998, 31).

7.3 Mapping the Scientific Instrument Trade of Early Modern London

This is clear in my own use of digital maps to depict and to help analyze the scientific instrument trade of London during the first half of the 1700s, for the doctorate which I completed at the University of Oxford in 2010 (cf. Baker 2006, 2009a,b). Although today the products of this eighteenth-century trade are often called "scientific" instruments as a form of shorthand, they were not actually labeled so until well into the next century, after the words "science" and "scientist" adopted their modern meanings and replaced natural and experimental philosophy in learned usage. Early modern instruments were instead classed as optical, mathematical, or philosophical or were specified as being for use in individual subjects such as astronomy and natural philosophy or in "practical" mathematics-oriented pursuits including surveying and navigation (Warner 1990; Field 1988). Most mathematical instruments such as drawing tools, quadrants, and octants had a graduated scale for performing calculations or for measuring angles and distances. Optical instruments employed lenses or mirrors and included microscopes, telescopes, eyeglasses, and some instrument sights. Philosophical instruments were used in the demonstration or investigation of natural phenomena including magnetism, electricity, and the attributes of air. They could be employed in exciting public demonstrations, with electrical machines sparking and sizzling, or air pumps threatening to suffocate small birds and mammals. Many trade members sold multiple types of instruments—as you can see in the trade card in Fig. 7.1 which

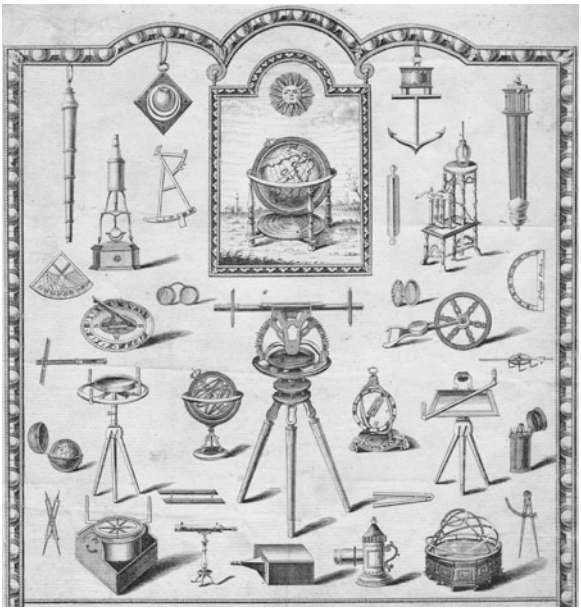

Fig. 7.1 A trade card advertising the wares sold by the mathematical instrument and globe maker Nathaniel Hill (working 1746–1764) and likely before him by the mathematical instrument maker and engraver John Coggs (working 1718–1740), both of Fleet Street in London (With permission from the Museum of the History of Science at Oxford)

was likely used by John Coggs of Fleet Street (working in at least 1718–1740) and then by his commercial successor Nathaniel Hill (working 1746–died 1768)—or instruments alongside other wares and services.

During the first half of the eighteenth century, the London instrument trade became the most extensive and renowned instrument trade in Europe, which it would remain for at least a century and a half (Morrison-Low 2007). It was still in its traditional craft-based form, centering upon shops and workshops mainly owned by members of the London livery companies and staffed by apprentices, journeymen, and employees—with a significant contribution of work, materials, and goods coming from outside subcontractors. Most of the surviving information about the trade regards its few hundred known shop-owning members and sometimes their on-site apprentices and employees, which lent itself to my employing geographically oriented technologies from other fields to aid in comprehending and analyzing this population. The same would be true of most other skilled crafts in early modern London, such as clock or jewelry making, and of retail specialties such as the luxury or print trades. Ironically, technologies such as GIS mapping have been very rarely applied to the historical study of technology, despite their success in other fields. One exception is Richard Kremer's mapping of the smaller scale instrument trade which existed along the New England frontier (Kremer 2007).

When I decided to embark upon digital mapping, I consulted Nigel James at the Map Room of the Bodleian Library at the University of Oxford, which serves scholars and students of geography but also other academics interested in incorporating maps and GIS into their research. We decided to employ MapInfo to create my interactive digital maps, which I knew would not require a very high level of geographical precision in order to be productive. In fact, it would have been impossible to pinpoint the locations of most instrument makers and sellers with a high degree of precision, given the aforementioned ways in which the inhabitants of the early modern metropolis viewed and described locations, the changes which have since been made to the streets and buildings of the capital, and the variable nature of the evidence for the specific houses in which trade members lived and worked from sources such as the rate books. I chose to map my research subjects on the well-known map *Plan of the Cities of London and Westminster and Borough of Southwark*, completed by the French Huguenot surveyor and cartographer John Rocque in 1746 and published the following year (Hyde 1981, vii). This was perhaps the earliest map of London to move toward the tidy, geometric, overhead presentation of streets, fields, important buildings, and other landmarks which we associate with modern maps. This did make it easier to assign members to the streets, allies, courts, and other spaces in which they conducted business. The map was in fact unusually precise for its day, with Rocque and the engraver John Pine having employed a surveying instrument known as a theodolite—purchased from the respected instrument maker Jonathan Sisson (working 1722–died 1747) of the Strand—and having garnered public testimonials about the rigor and usefulness of their work from Fellows of the Royal Society (Hyde 1981, v–vi).

We were able to obtain a high-resolution scan of the map from the historical digitization company Motco Ltd., which Mr. James then set up in MapInfo so that

I would be able to zoom in on the different segments of the map. I spent some weeks visually inputting 287 known trade locations—rather than trade members, since many instrument makers moved one or more times over the course of their independent working lives—according to the streets and other features depicted on the map rather than according to mathematical coordinates. These trade locations were drawn from Gloria Clifton's *Directory of the British Scientific Instrument Makers 1550–1851* and from my own research to that date (Clifton 1995). There were sometimes multiple locations in early modern London which bore the same name, and Rocque's map also did not record all locations or all landmarks such as inns and taverns. Therefore, I frequently had to consult sources such as Henry Harben's *A dictionary of London* and Ralph Hyde's *The A to Z of Georgian London* in order to finalize the points on my map (Harben 1918; Hyde 1981). I did not employ the locations of trade members for which there were no dates provided, since they could not have been incorporated into analyses that reflect the passage of time. In GIS programs, the locations which you pinpoint on the map are tied to databases, so I was able to attach relevant biographical data to each shop site. I originally had grandiose plans of storing all of the information which I collected about trade members in this database but concluded that it would be most time-efficient, in the course of a doctorate, to only input the data most relevant to geographical and time-based analyses of the instrument trade. These included name, known years at work, livery company affiliations (Clockmakers, Spectaclemakers, Grocers, etc.), and job specialties (globe maker, mathematical instrument maker, "multiclass" instrument maker, etc.). The results were more than satisfactory.

7.4 Reaping the Benefits of Vernacular GIS

These efforts initially produced a map of the known locations, rooted in time, of all of the instrument makers and sellers known to have been at work in London during the first half of the eighteenth century (see Fig. 7.2). This revealed that the instrument trade in the capital was more expansive and comprehensive than had previously been understood—extending from St. James's in the west to Shadwell in the east and from Clerkenwell in the north to Southwark and Bermondsey in the south. The highest concentration of locations extended in a rough line from the western end of the Strand along Fleet Street to the area of Ludgate Street and St. Paul's Churchyard and then in clusters appearing further east near the Royal Exchange, the Tower, and the wharves of Wapping beyond the walls of the central metropolis. As could be seen in my ensuing cartographic examinations of specific neighborhoods and of trade specialties, the locations in Wapping represented trade members who mainly targeted customers involved in shipping and trade—for example, compass makers and instrument makers and sellers who were also ship chandlers—while the rest of the concentrations of trade members aligned with the major thoroughfares and shopping areas of the metropolis.

Fig. 7.2 My initial digital map of the members of the London scientific instrument trade who were at work within the period 1700–1750, created with MapInfo (Source of underlying map: Motco Enterprises Ltd., with permission)

While it was very useful to have such a visual representation of the geographical extent and clustering of the trade as a whole, the renowned geographer E.G.R. Taylor similarly mapped the locations of a number of trade members by hand in 1954 (Taylor 1954). What significantly set my efforts apart, and made the time spent setting up the database in MapInfo and creating hundreds of maps worthwhile, was my being able to attach the variable of time and biographical information to each of the geographical locations. With this information incorporated, the initial map made it much easier to track the interrelations and potential competition between trade members in different neighborhoods and streets, since I could swiftly check the details attached to each point on the map. It could also be used to spawn hundreds of further maps to aid in examining different interconnected geographical, socio-economic and time-based aspects of the trade. By "querying" the interactive map—for example, asking it, for example, for only the locations of trade members who belonged to the Grocers' Company and made or sold globes from 1740 to 1745—I generated more than 250 different maps that depicted these trade members and their known locations with respect to different variables and with respect to the passing decades.

By producing maps of the instrument makers at work in London during each of the decades of the first half of the eighteenth century, I was able to chart the increasing expansion of the trade in all directions as time passed, alongside the expansion of the metropolis but especially toward the fashionable west.[18]

[18]See additional discussion of the role of GIS technology in allowing a researcher to create his or her own maps in the chapter in this volume authored by von Lünen and also the chapter by Mares and Moschek.

During the final decade, there was increased clustering in traditional areas as well, including the stretch from the Strand to St. Paul's and the neighborhoods of the Royal Exchange and the Tower, which was probably a result of the continued growth of the trade as a whole. It was also a result of the increasing popularity of the optical and the "tri-class" instrument specialties (the latter selling optical, mathematical, and philosophical wares), which appealed to the affluent customers who frequented most of those locations. While some of these trends may have been expected, given our understanding of the instrument trade and of the nature of demand in different areas, they had never before been proved or analyzed in depth. Incorporating these maps into publications and presentations had a great didactic impact upon readers and listeners as well, by making it easier for them to visually grasp the extent and dynamics of a trade spread across hundreds of shops and diverse urban neighborhoods. A PowerPoint "movie" of the successive decadal maps was particularly well received at a conference since it exhibited, visually and dynamically, how the trade expanded across and clustered in London as time passed.

The maps of the locations of trade members who pursued specific instrument making specialties or combinations thereof revealed settlement patterns that seem to have been shaped by the locations of strongest demand for different types of instruments and by differing rent levels. For example, all but one of the compass makers and sellers were located in Wapping and Ratcliff to the east of the medieval city walls. The east was largely oriented toward the workers and crafts that served shipping and trade and also offered lower rents than could many other areas of London, which would have especially been important to trade members who pursued the typically lower paying instrument specialties such as compass making. In comparison, the makers of globes and timekeepers were mostly located near the Royal Exchange and to the west, as befits the production and sale of instruments that were generally more luxurious and could be displayed in affluent homes as well as being put to practical and educational use. Trade members who pursued one of the publishing trades in addition to instrument making, including map and print selling, mainly congregated in their traditional neighborhoods from the Strand to Fleet Street. Most of the rule makers and sellers settled in an arc from Ludgate Street over St. Paul's Churchyard to Cheapside, most likely because of their ties to the trades in publications and in other mathematical instruments.

As a whole, the optical instrument makers and sellers were mainly concentrated from Temple Bar to Ludgate Street and St. Paul's Churchyard, near the Exeter and Royal Exchanges, and near the Tower, and they increasingly expanded into the west and later somewhat to the east. General optical instrument makers and sellers were also scattered across the neighborhoods of Holborn, west Wapping, and Redriff. The main concentrations of mathematical, philosophical, and tri-class instrument trades shifted westward during this period as well. The mathematical instrument makers and sellers covered the most ground, likely because of the variety of professions and economic classes that purchased and used their instruments and because mathematical instruments were so often sold alongside other goods from maps to fashionable trinkets. The core concentration of mathematical instrument makers and sellers extended from St. James's and especially from Covent Garden

east to the Royal Exchange, and then reappeared in clusters in the Minories and near the Tower, with their northernmost point being Moorfields. Their locations expanded in all directions and slightly to the south bank of the Thames over time before largely consolidating in the west, and they reflected the economic range of the specialty from the higher-end neighborhoods between St. James's and the Royal Exchange to the lower-end areas on the periphery.

The philosophical and tri-class instrument trades skewed more toward affluent and learned customers and were thus even more strongly oriented toward the west. The philosophical instrument makers and sellers were located entirely to the west of the metropolis, especially: at St. James's; near Fleet Street and the nearby hospitals; and in Holborn. The tri-class trade only existed in Fleet Street until the last decade of this period. By then, the specialty had increased in popularity or perhaps profitability, and locations also appeared near Piccadilly, Ludgate Street and St. Paul's Churchyard, the Royal Exchange, and the Tower. It is clear that the places in which instrument makers and sellers decided to settle were in large part determined by the types of wares that they sold and the types of customers they courted. This resulted in members of the instrument trade frequently being located near trades that courted similar customers and employed similar skills and materials, including the making of timekeepers and jewelry and the trade in maps, prints, and publications.

However, many other factors could play a role in geographical decision-making as well, including the location of the neighborhoods in which the trade members had been raised or had served their apprenticeship, and the foci of the immigrant or religious communities to which they belonged. My maps also facilitated the study of these factors by making it easy to check the proximity of trade members to their fellows and to key landmarks which either already appeared on Rocque's map or which I added. These could include a Dissenting church, an educational institution, the hall of a livery company, or an important institutional customer for instruments. Such mapping contributed significantly to the otherwise textual study of the diverse socioeconomic factors which influenced the lives and businesses of most trade members. For example, the maps made it clear how much such ties influenced the shop location and business of the mathematical instrument maker Richard Bates (apprenticed 1714–died 1750). Bates had attended Christ's Hospital School, later supplied rules for its Drawing School, and was apprenticed to William Haddon. His master's son was later one of his own apprentices, and Bates' shop facing the Old Bailey was not far from Haddon's shop and Christ's Hospital. In his will, the instrument maker left most of his estate to his wife but also left one guinea for "his friend John Farmer" to buy a mourning ring.[19] Farmer was a mathematical instrument and rule maker whose shop was not in the neighborhood but who had served his apprenticeship nearby at the same time as Bates. Farmer's nephew and successor, Richard Bates Gearing, was Bates' final apprentice, which no doubt strengthened the two men's relationship even more.

[19]Will of Richard Bates, 20 November 1750, The National Archives, PROB 11/783.

The digital maps also assisted my study of other subsets of the trade, whether the customers and business associates of a specific trade member or trade members from a specific immigrant or religious group such as the French Huguenots. At least 5–7% of known instrument makers and sellers seem to have been of French Huguenot descent or to have married into that community, if not more, and it was easy to produce a map of those trade members alone. The French Huguenots formed the single largest, most cohesive and most influential immigrant group in the instrument trade of this period, being bound together by shared persecution, blood, language, and communal institutions including churches, hospitals, and charities (Scouloudi 1987; Gwynn 1985). Since this community could offer many contacts in the luxury metalworking trades, it seems to have been relatively common for instrument makers who married into it to expand their businesses to include wares like toys and jewelry as well as instruments. The maps assisted me in tracing the geographical and socioeconomic attributes of this dynamic and in seeing what competition these individuals likely faced from within the trade.

The instrument trade's intersections with the trades in toys and other luxuries mainly took place in the central City of London and on the western side of the capital, since those were the main centers of fashion and high-end retail shopping during this period. All but one of the French Huguenot individuals or partnerships who practiced this combination of trades seem to have lined the important retail corridor of Fleet Street, Ludgate Street, and St. Paul's Churchyard—as did other members of the trade who sold similar combinations of wares. MapInfo also made it easy to map and thus to geographically analyze relevant individuals outside of the instrument trade, as in the aforementioned case of the London customers and business associates of the toyman and optician George Willdey. I created a separate basic database of these individuals, which allowed me to chart their locations on Rocque's map, and with respect to Willdey's shop location, while ignoring the other members of the instrument trade. The results emphasized how commercial traffic moved throughout the early modern metropolis, and how the socioeconomic networks of relationships upon which an instrument business was often based were embedded in the landscape of London.

In addition to these more innovative uses of digital mapping as a representational and analytical tool, I was of course able to consult the basic map of all trade members as one would a traditional version—to judge whether a given neighborhood, street, or court might have supplied the types of buildings which an instrument maker would require for production or for attracting passing custom. They required enough sunlight and sufficient space for the conduct of their trade specialty, with the makers of large mathematical and astronomical instruments needing far more space for their work and storage than did most spectaclemakers and opticians. For a business that involved retail sale, it was best to be positioned on or as close as possible to a major thoroughfare, one of the more fashionable squares or a prominent landmark such as St. Paul's Churchyard or the Royal Exchange. Some shop-owning instrument makers operated in courts, alleys, and yards, but the more distant they were from passing trade, the more effort they had to invest in attracting potential customers. Although I did not go to such lengths, one could also enhance such

digital maps with related data like the local rent levels, drawn from the rate books. A single neighborhood or even a single street might encompass a range of rents due to different types of housing and to the positioning of buildings, but there were still differences in the overall rent levels to be found in different parts of the metropolis.

Since GIS programs can be used to zoom in on or out from individual streets and neighborhoods, as well as to look at the overall picture, the technology lends itself to the study of the nature of different neighborhoods and their inhabitants. Each area of London had its distinctive personality resulting from factors such as the trades, institutions, and socioeconomic nature of individual located therein. However, my digital maps of the instrument trade reinforced that there was a good deal of traffic between and interrelationships connecting the different parishes and neighborhoods, as well as many similarities. As historians including Derek Morris have emphasized in recent years, the eastern side of London above the Thames was not simply a crumbling warren of houses fit only for roughhousing sailors as has sometimes been represented, and the west was not an idyllic and orderly grid of mansions that only housed the titled and the *nouveaux riches* (Morris 2002; Morris and Cozens 2009). Varying proportions of the poor, servants, laborers, shopkeepers, craftsmen, professionals, intellectuals, the wealthy, and different institutions inhabited both sides of the capital north of the Thames. However, there were real socioeconomic differences between many of the parts of the metropolis, and these were especially dramatic between east and west and produced significant differences in the nature of the instrument trade in both locations.

The west was, broadly speaking, a much more affluent, fashionable, and politically and socially influential area. The east was mainly oriented toward shipping and related crafts and trades, as well as to larger scale manufacturers. These differences are reflected in the instrument trade specialties practiced in each location, with the trade members in the west containing a large proportion of optical instrument makers and spectaclemakers, in addition to a majority consisting of mathematical instrument makers including globe makers and sellers. They also encompassed some makers of timekeepers, a number of toymen and jewelers, and most of the trade members who sold philosophical instruments or all classes of instrument. In comparison, almost all of the trade members on the eastern side of the metropolis were mathematical instrument makers and sellers, including a number of rule and especially compass makers who did not appear further west, and they were sometimes ship chandlers as well. Sources including Wills and Sun Insurance policies and records of royal and institutional patronage show that this resulted overall in greater wealth being accumulated, and more public acclaim being garnered, by the trade members in the west than in the east.

As can be seen through all of these examples from my doctoral research, GIS mapping, as Knowles and Hillier have said, "offers an unprecedented range of tools to visualize historical information in its geographic context, examine it at different scales, interrogate its spatial patterns, and integrate material from many sources on the basis of shared location" (Knowles and Hillier 2008, xii). It provided me with very useful maps of the entire instrument trade and of a myriad of subsets of said trade, such as the trade members who belonged to a specific livery company

during a specific decade. It would have taken much longer to produce hundreds of variable-based maps using traditional methods than it did using GIS, and the traditional versions would not have been interactively tied to other data. With these maps, it was much easier to trace the geographical and socioeconomic dynamics for hundreds of shops and workshops and at different scales. They aided me in tracing the ties and competition which existed between different trade members, and between trade members and other individuals, institutions, and geographical features. Since GIS provides an interactive rather than a static system of mapping, I could also generate new maps in the future based upon my original sample or add additional individuals and types of information. Furthermore, I can easily turn these maps into evocative digital or print images for sharing my research with others. Tools such as these can do much to help historians to avoid the tendency to examine the past "as if it were packed solidly on the head of a pin, in a fantasy world with virtually no spatial dimensions"—as Edward Soja famously first commented about Marshall and Pigou's view of the economy (Soja 1989, 32).

7.5 Addressing Concerns About the Use of GIS in Historical Research

My experiences with digital mapping show that employing vernacular rather than precise GIS maps can answer many of the key concerns about applying such technology to early modern historical research. One of the most common objections is that GIS cannot take into account the variable and incomplete nature of sources from the early modern period.[20] There are often gaps in the individual and institutional records which were produced or have survived from before the nineteenth century, as well as great variability in their accuracy and degree of detail. Some geographers and historians have investigated different methods of representing uncertain or incomplete information on a map in order to overcome these obstacles but so far with little success. The majority perception of maps remains that they are dependent upon data sets being accurate and complete, which is seldom the reality for pre-modern material. GIS technology can perpetuate this misconception since, as Anne Kelly Knowles and Amy Hillier have said, it "tends to reinforce the naïve acceptance of maps as authoritative statements because the software so swiftly produces maps behind whose veneer of professionalism may lie all manner of unseemliness" (Knowles 2008, 19).

Some proponents of the use of GIS in the humanities have suggested overcoming this problem by using multimedia approaches to make the technology "more fluid and ambiguous," but so far, the more successful response seems to be to avoid unnecessary geographical precision whenever possible (Corrigan 2010, 76). In terms of working with gaps in the data, research into early modern populations is almost

[20] Gregory and Ell (2007, 1), Corrigan (2010, 76), Knowles (2008, 3) and Pickles (1999).

always a matter of combining individual stories with the best-possible statistical analyses of the surviving evidence about the whole, since records from this period are almost never complete nor homogeneous. Such records can be incorporated into digital maps as easily as they can into these case studies and statistical analyses, as long as they have some geographical component and ideally (but not necessarily) the added variable of time. If a certain attribute is not known for some individuals—for example, in my case, to which livery company an instrument maker belonged—then it can simply be set to "unknown" rather than invalidating the incorporation of that individual. If the information on some individuals is less precisely known than for others—for example, their location only being known to the level of a city parish rather than to the street level—then it can simply be provided with a different symbol or color on the digital maps and included or omitted at will. As you can see in Fig. 7.2, I utilized green squares rather than the usual red circles to delineate which of the trade members on my maps were only located according to parish. If the information displayed is generally a bit questionable, such as the exact dates of employment for some individuals, then this is equivalent to the uncertainty reflected in the textual and statistical analyses of the same sample; one could choose to add a field which notes the existence of this ambiguity. For this period, digital maps and case-based and statistical analyses of a population can all reveal key dynamics despite any imprecision at the individual level.

Similar concerns have been raised about the precision of GIS base maps, since the maps and other geographical records of European cities were not very accurate until at least the later 1700s if not the 1800s. To address this issue, Craig Spence combined information from multiple maps of London for his research into the late seventeenth-century capital, noting, "[t]he quality and detail of seventeenth and eighteenth-century maps is both varied and unpredictable, furthermore none meet modern surveying criteria for accuracy" (Spence 2000b, 34). These included Morgan's map of the City and Westminster from 1682, the parish maps printed in Strype's *Survey of London* in 1755, Rocque's map, other local maps to define the boundaries of the original assessment districts, and the Ordnance Survey Maps of the 1860s. In working with GIS, there are additional issues of the time and cost involved in attempting to scan a map at a high enough resolution to allow zooming in and out of the landscape and sometimes in joining up the individual sheets of a multipart map, and with precision GIS, there is also the complication of connecting the map to modern GIS coordinates with georeferencing techniques.

As previously discussed, this level of precision is unnecessary for most early modern research because of the ways in which contemporaries typically perceived and depicted their surroundings and because of the small geographical spaces inhabited by urban populations before the modern era. If, for example, one scientific instrument shop was within sight and easy walking distance of another on a London street, why would the precise distance between them really matter? The important point to be considered when you want to employ digital mapping is to find an early modern or contemporary depiction of the main features and thoroughfares of the location that you are examining, which reflects their basic spatial relationship to each other, and upon which you can roughly locate the entities in your sample.

Choosing the map and geographical features which can best accomplish this without incorporating precise mathematical coordinates is similar to the process of "satisficing" which Hill describes with the respect to precision GIS. This involves deciding which shapes, from points to multisided geometric figures, are sufficient for approximating each of the features being mapped without losing time and money to unnecessary attempts at optimization. The example which the author provides is of a point often being sufficient to represent an individual or a "point-like" entity such as a monument but often not being sufficient to represent the position of a river with respect to neighboring features (Hill 2000, 288–289). If a suitable early modern depiction of your target area does not exist or cannot easily be scanned at a high enough resolution, then it may be possible to simply produce a modern drawing of the basic streets and landmarks. This provides a platform for representing the general spatial arrangement of the locale, and perhaps the inhabitants' understanding of their surroundings, upon which you can build an incredibly useful visualization and analytical tool for your overall research—even if it is not as aesthetically pleasing as an early modern map.

The use of vernacular mapping can overcome many other common objections to the application of GIS to the study of the humanities as well, including to the cost and labor and time demands of such an enterprise.[21] Relevant programs are often made freely or affordably available through different institutions or online, and as previously discussed, vernacular mapping seldom requires as much effort being spent on producing the base map as does precision mapping. Creating the databases for the maps is considered another costly step in using GIS, with some authors estimating that it accounts for up to 85 % of the total cost (Longley et al. 2005, 201). However, it should cost no more than it would to construct other databases for collaborative research, and in the case of studies of smaller populations such as my hundreds of instrument makers, it can be accomplished by a lone researcher. It is often stated that GIS is a tool best used by a research team rather than by an individual due to not only cost but also to the time investment needed to create the associated databases and due to the diverse skills involved in exploiting a geohistorical technology (Gregory and Ell 2007, 11). However, this is clearly not the case with vernacular mapping that does not incorporate great geographical precision, since it can be set up by one scholar or student (in my case with initial assistance from a Map Librarian) as long as they restrict the amount of information which they intend to input.

Finally, some sources warn that researchers and students can misuse technology like GIS, such as by poorly interpreting the maps produced with it or by viewing them as an end in themselves rather than as a tool for aiding in rigorous academic scholarship.[22] The same concern was raised before I began the digital mapping of the London instrument trade for my doctorate, and I have since heard it repeated at a number of GIS-related meetings and lectures. I would argue that this is not a problem that is specific to GIS but simply a potential complication of

[21] Gregory and Ell (2007, 17, 41, 89), Martí-Henneberg (2011, 11–12), Knowles (2000) and Siebert (2000).

[22] Gregory and Ell (2007, 1, 12) and Knowles and Hillier (2008, 19).

historical research. If a scholar applies the proper amount of consideration and contextualization to their sources and to other forms of analyses, then there is no reason for them to not do the same with their digital maps and information. In my own research, the maps were always consulted in conjunction with a wide range of primary sources, statistical analyses, and case studies.

For example, they were very useful in conjunction with documentary sources in analyzing the scientific instrument trade cluster which existed during the early 1700s in Wapping on the eastern side of London, near the bridge over the Hermitage Dock and near the Hermitage Stairs close by. The maps made it clear what a pronounced cluster there was at that location and how close it was to the Hermitage Dock, which was the southwestern entrance to the London wharves, and to works including the Hermitage Pothouse and wharves for coal and timber. They also aided me in examining the interrelationships of the trade members located there and their trade specialties, which were mostly river- and sea-oriented. However, it was the diverse primary sources that began to fill in the large gaps which existed in the history of this area and exposed the complicated networks of commercial and livery company associations and of blood and marriage which bound most of these men together. Statistical analyses then allowed me to compare the nature and affluence of this cluster to those of trade clusters in other parts of the metropolis. GIS and other digital technologies are useful tools, while it is the resources, analyses, and publications which emerge from them that are the actual outputs of the research.

A valid concern for the usage of GIS is planning, which of course applies to most elements of research and to the production of any digital technology such as standalone databases. The creation of a map depicting a significant population will take some time, even if it does not require the achievement of great geographical precision or the inputting of very many database fields (i.e., name, dates, livery company, trade specialty). It is therefore vital on a set-length project for a researcher or research team to decide as early as possible which types of the following would be most useful and time-efficient for the research being conducted: mapping program; base map; sample size and makeup; and database fields. It is often difficult to predict at the outset of a project what will prove most useful, and one can always add additional database fields and sample members at a later date. However, an early and organized start can keep a GIS mapping initiative a valuable analytical and visualization tool for historical research rather than a hindrance.

Digital mapping is a technology which is only becoming more accessible and less expensive as the years pass. It holds untold promise for contributing to the analysis of historical populations and events which are firmly rooted in their geographical and socioeconomic contexts. It is also continues to facilitate the sharing of observed dynamics and research conclusions with other researchers and with the general public. One interesting result of this has been the publication of social atlases like those of Spence, Woods and Shelton, and Kennedy et al.[23] However, the future will likely see a greater move toward the electronic publication and hosting of such

[23] Spence (2000b), Woods and Shelton (1997) and Kennedy et al. (1999).

maps and toward their incorporation in electronic databases and libraries, in order to allow users to interact with them in full and at lower cost (Gregory and Ell 2007, 11, 145–160). While a research team would typically be required to produce such resources when precision GIS is involved, the usage of vernacular maps makes it likely that even individual researchers and students will be able to contribute maps and databases of early modern populations to such an interconnected digital future.

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