The London water supply industry and the Industrial Revolution

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Abstract

This paper explores some of the ways in which the history of London’s water supply industry in the eighteenth century has relevance for the history of the Industrial Revolution. Established around 1600, private companies were supplying drinking water directly to tens of thousands of houses by 1700 and continued to grow thereafter. This water supply was anomalous as compared to other cities in Europe which were much smaller. The industry developed in Britain in part due to London’s status as a commercial hub and the existence of a large and wealthy market for water. Joint-stock financing was also important for water companies. Finally, this history shows the existence of technological inventiveness outside the traditional leading sectors of the Industrial Revolution.
1. Introduction
From 1660 to 1800, a new water industry became established in London. This new industry consisted of a number of supply companies that sold water, mostly for domestic consumption, to consumers through a large network of mains connected directly to houses. The emergence of this new industry in this period predates and overlaps with the period 1760–1830, the years traditionally assigned to the Industrial Revolution in Britain. Despite its emergence as a new industry at time, as well as the size it eventually achieved, the water industry is hardly mentioned within the historiography of the “leading sectors” of the Industrial Revolution (IR). These sectors are typically parts of the textile, transportation, iron and coal, and chemical industries. The water industry’s emergence as a new sector, however, offers an interesting perspective on some aspects of the IR. This paper how London’s water industry in this period experienced important technological change that sustained the industry’s growth. In addition, the role of joint-stock financing and incorporation is explored. These two themes, technological changes and business organization, are also situated within the broader historiography of the Industrial Revolution. It is argued that although joint-stock financing was crucial, incorporation itself, while common, was not indispensible. In regard to technology, the water industry shows the pan-European roots of technical change in the IR, while confirming the divergence of England from the Continent over time. The presence of a large and wealthy consumer market in London was very important in promoting the expansion in scale that motivated technological change.

2. Overview of London’s water industry
London’s water industry in the 17th and 18th centuries consisted of a number of private water companies. Before they arrived on the scene, London's water supply included the pumps and wells that existed in European cities well into the nineteenth century, as well as small, low pressure, gravity flow aqueducts that drew water from springs, lakes and rivers. These stone and lead aqueducts typically brought the water to cisterns and public fountains, as well as providing supply to some privileged buildings, such as palaces or baths. Medieval aqueducts were usually erected and maintained by local institutions such as the town corporation, or in some cases monasteries. The situation in London before the advent of private water companies around the turn of the seventeenth century was typical in this regard. The city, however, was becoming increasingly thirsty. It was growing rapidly in the late sixteenth century, with its population increasing from around 120,000 in 1550 to 200,000 in 1600, before reaching 500,000 by 1700. The local authorities in

London sought new supplies of water to meet this demand, particularly as many of the smaller rivers, such as the Fleet, were becoming too polluted and in a number of cases had been covered over. In the years before 1600, the City of London (the city corporation governing the relatively small area of the medieval city north of the Thames) gained new rights from the sovereign and Parliament to draw water from nearby sources, such as from Hampstead in 1543 and the River Lea in 1570.

Technological change also offered possibilities for increased water supply. The late sixteenth century was a time of growing interest in hydraulic engineering, with, for example, the reconstruction of some of Rome’s ancient aqueducts. Another innovation was the use of pumps instead of just gravity for water feeds, beginning first in Germany, and then spreading to other cities around 1600. These new forms of hydraulic engineering came to London in 1582 with a German or Dutch immigrant named Peter Morris, who proposed building a waterwheel driven mechanism to pump water from the Thames (figure 1). The City Corporation gave Morris a lease on the first two arches of London Bridge for 10 shillings per year. London Bridge, dating from the thirteenth century, was at the time the only one crossing the Thames. The establishment of the London Bridge Waterworks also gave an impulse to the model of direct domestic connections, an important feature of modern networks. Originally, Morris supplied public fountains, as the medieval conduits did, but he also began to supply individual buildings. Before Morris’s arrival, individuals petitioned the City of London to be allowed direct connections to their houses, but these were relatively few, were not always allowed, and were cleared away in times of scarcity. With the arrival of water companies, the dynamic shifted, and they sought to distribute water more widely, driving the extension of London’s water network over the coming decades, albeit haltingly.²

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The most important of the new water companies was the New River Company, which was created in 1616 by Sir Hugh Myddelton, a wealthy London businessman. The New River drew water from the River Lea and springs in Hertfordshire to the north of London. The City of London had originally won the rights to water from these springs in the early 17th century, but had not acted on them. It then delegated them to Myddelton. The New River, when completed, was an open aqueduct around 42 miles in length, bringing water to reservoirs at Islington, originally outside the city itself (figure 2). From there, the water entered a number of mains under city streets. The water was distributed directly into houses, or into private courts where a number of dwellings could draw from a common reservoir. The water was low pressure, and supply was intermittent. Typically, water flowed into a basement reservoir two or three times a week for a couple of hours at a time. Servants would then draw water from this reservoir and distribute throughout the house as needed.
For the first century of its existence to around 1710, the New River was a gravity-fed system. Most of the other water companies, however, followed the London Bridge Waterworks in using pumping mechanisms, with which they experimented over time. Some companies, such as the Chelsea established in 1722, used tidal waterwheels or horse pumps. In the early 18th century, steam engine pumps were introduced, first by the York Buildings Company situated on the Thames. The New River itself adopted pumping when it constructed higher reservoir after 1710, relying first on a wind-driven pump, before moving to horse, waterwheel, and then steam pumping late in the 18th century with a Boulton & Watt steam engine.

The London water industry in the 18th century is notable for the scale it acquired, and it was this large scale that financed the industries expansion, and prompted experiments in technological innovation. In terms of size, the New River Company was pre-eminent, representing about 75% of the industry in the city from the point of view of customers served. Although there was a period of fairly intense competition among the companies between 1670 and 1710 when many new companies were formed during a joint-stock boom, the New River became increasingly dominant from 1700. It generated consistently healthy profits for its shareholders (figure 3). It grew especially after the Great Fire of...
London in 1666 when much of the city was rebuilt, presenting an opportunity for the company to take on many new customers. The results of the New River’s growth became evident in its dividends. From around £33 per share in 1640, they reached £64 in 1665, the year before the fire. By 1670 it was at £70, £145 in 1680, and £222 in 1690. The rapid growth, however, was too fast for the company’s own good and it proved unable to keep up with the demand for water from all the new customers it was taking on. In 1682, John Aubrey recorded that “London is growne so populous and big that the new river of Middleton can serve the pipes to private houses but twice a weeke”.\(^3\) Competition from new companies also slowed its profit growth until after 1710, when it expanded its reservoir capacity, and introduced various technological changes, described below. The company was able to stabilize its situation by 1730, providing more regular supply. From that point, dividends increased regularly over the rest of the century, and especially after 1770.

![Figure 3: New River Company dividends and share price](image)

In contrast with the New River, the other London water companies experienced more difficulties, and were less profitable. The London Bridge Company survived and paid

\(^3\) Aubrey, 1898
dividends for much of its history. It was, however, under constant pressure from direct competition with the New River in its entire supply zone. Although it retained a firm customer base around London Bridge, was not able to raise prices for fear of losing them. As discussed below, this competition depressed water prices in that area. The Chelsea company had the good fortune of being shielded from direct competition with the New River and other companies in large parts of its supply zone because it was situated farther up the Thames. Although it struggled for many years before becoming sufficiently profitable to pay dividends to its shareholder, it began to do so in 1737, and they were paid consistently throughout the rest of the century, albeit with relatively increase (figure 4).

Figure 4. Approximate zones of supply around 1770.

The New River achieved its dominance in large part because it did not have to depend entirely on unreliable and intermittent pumping, meaning its supply was more consistent than that of other companies. The waterwheel pumps used by the London Bridge Waterworks were at the mercy of the Thames tides, and stopped working altogether twice per day at the lowest points in the tidal cycle. Steam engines were also difficult and expensive to run, requiring constant care from worker and a ready supply of coal. They were the cause of aggressive complaints from neighbours resentful of the black smoke they belched. Horse engines, which were occasionally used, proved to be simply too expensive to function on a large scale, and most were abandoned, or were used as secondary pumps.
3. Business structure and organization

From the point of view of business organization, one of the salient features of the London water industry is that almost all the companies operating within it were joint-stock companies. Moreover, most of the largest among them were corporations created by royal or parliamentary charter, giving them legal personality, with the ability to enter contracts and hold property in their own names. They may also have had limited liability, although whether corporations enjoyed this privilege at this time has been a point of disagreement among historians. ⁴

Within the context of the business organization in the Industrial Revolution, the water industry stands in contrast to the sectors that have traditionally been identified as leading in technological and industrial changes, such as manufacturing and metallurgical industries, textiles, chemicals, and iron. Historians have usually argued that the firms at the centre of these industries were small, usually with a single owner or partnerships consisting of a few people. ⁵ They financed their growth largely from capital generated through internal channels. Although it could be quite expensive to develop and deploy new technologies, such as textile machines, the capital needed was nevertheless well within the resources of these small partnerships. Only in a very few cases did firms involved in classic IR industries become large, and even fewer were joint-stock. Large joint-stock firms certainly existed during the 18th century, but they were concentrated in the finance, insurance, and mercantile trade, rather than in any of the leading sectors of the IR. The joint-stock form was also increasingly used in canals, especially from the 1780s onwards. The water companies, however, became joint-stock companies from the 1610s onwards, with most getting this status in the period 1680–1720. The reason they did so was their need to find capital to meet the vast expenditures incurred in building their infrastructure.

The first water company, the London Bridge Waterworks, was originally the personal business of its founder, Peter Morris. After his death around 1600, the company seems to have become a partnership between Morris’ family and a friend, George Digby. It continued in this form with some modifications until around 1700 when a major reorganization took place. Under pressure from the New River Company, the Morris family was no longer inclined or perhaps capable of continuing in the business in its current form. It entered into what was a complex sale and expansion that resulted in the company leasing another arch of London Bridge from the City Corporation to add more


pumping capacity through new waterwheels. In addition, it was reorganized into an unincorporated joint-stock company with 500 shares, a form it continued to hold until it was finally purchased by the New River Company in 1822. The reorganization into a joint-stock company was an important step because it allowed the London Bridge Waterworks to gain access to capital it needed to expand. The new shareholders invested thousands of pounds rebuilding all the existing waterwheels, adding new ones, and expanding the company’s pipe network. From occupying two small arches in the bridge, the company had waterwheels in six arches by 1767, and was supplying south of the Thames as well.

As described above, the New River Company was the largest among London companies. It was first formed in the earliest era of the corporation, which was dominated by mercantile companies, most famously the East India Company. The New River became a corporation by a two-step process. At first, the company’s founder, Hugh Myddelton, tried to build the infrastructure relying largely on his own funds and that of a few partners. Building the aqueduct through the countryside north of London proved to be costly, however. There were other troubles as well, with significant opposition emerging from landowners losing land to the project. Facing these difficulties, Myddelton and his fellow proprietors decided they could not prevail alone, and recruited the king James I himself to become involved with the company as an investor in an agreement formalized in May 1612. Myddelton and his ‘adventurers’, as the shareholders were known, kept half the shares, and the king got the other half, agreeing to pay half of all costs. The agreement placed the full weight of the king’s authority behind the venture, helpful in dealing with the reluctant landowners and other opponents. After James I became a proprietor, work on the channel progressed rapidly, finishing in September 1613. Its construction required about 1700 labourers, and total construction costs from 1609 to 1614 ran to £18,524 (about £1,800,000 today), with many more expenses still to come. The second step towards incorporation came in 1619. James had been unsatisfied with the profits that company was generating and decided to grant the New River a charter of incorporation because “it had not hitherto yeilded such profitt as was hoped for partly by reason of the expences dailie arisinge farr greater and heavier than by the said adventurers was expected and partly for want of power in them to settle the carriage”. This new corporation was unique among the charter companies of the period because of the crown’s direct ownership stake in the company. This stake did last long after the incorporation. Charles I succeeded his father and sold his shares in 1630, also unhappy with the meager profits the company produced. The New River remained a corporation for its entire existence into the 20th century. It retained its original structure defined in its
charter during this entire time, with 72 shares. Unlike the London Bridge Waterworks, it did not require outside investment after its early years. The enormous profits it began to generate especially after 1660 were enough to meet the capital required to build and maintain its infrastructure. There seems never to have been a capital call, and it issued no debt. For the shareholders, New River stock was a dependable source of dividends.

The third largest water company was the Chelsea. It was one of the few London water companies north of the river created in the 18th century. The company was last of a flurry of companies formed in a joint-stock boom beginning around 1670 and ending with the South Sea bubble in the 1710–20s, with a pause in between. The Chelsea was created to serve Westminster and especially the rapidly growing suburbs to the west of the City. Originally formed in 1721, the company’s original investors successfully won an act of incorporation in the following year. The company had enormous capital needs as it built its pumping facilities on the Thames, reservoirs in Hyde Park and St James Park, and a network of pipes throughout the city. It soon exhausted the funds raised by selling the original shares, and was forced to go ever deeper into debt. It even faced a period of crisis around 1730 when it lost many customers due to dissatisfaction with its service. It survived, however, by buying a steam engine for more pumping capacity. This gave it sufficient supply to quell unhappiness, and it soon resumed growing, giving its first dividend in 1737. Like the New River, its need for external capital existed only when it was first being built. After its early years, it generated sufficient profits that it did not have to go back to its shareholder, or even borrow, in the eighteenth century.

Even some of the minor water companies in London were joint-stock companies, and some were incorporated. The Shadwell company, serving the east end of the city, was formed in 1669, became a joint-stock company by royal patent in 1680, and finally was incorporated by Parliament in 1692. The York Buildings Company was formed in 1675 to serve areas around Charing Cross. It was incorporated by Parliament in 1691, and subsequently had a colorful history because its proprietors decided in the 18th century to use its status as corporation to venture in other fields, notably real estate in Scotland, leaving water supply as an afterthought. It was eventually sued for pursuing an activity other than that specified by its charter. Other London joint-stock water companies included the Hampstead Waterworks (1692) and Marchant’s waterworks (1694), both serving the west end of the city.

The London water industry was, therefore, built almost exclusively by joint-stock companies, most of which were corporations. The joint-stock form clearly enabled the investment of capital needed to build the infrastructure in the early years of almost all the water companies. The manifestly large capital requirements of the water industry in the
18th century was evident to Adam Smith, who, when discussing the sorts of economic activity that should be allowed to operate as joint-stock companies because of their “greater and more general utility” and the capital they required, included water companies among the four he identified. After their early years, however, the water companies required no further capital from their shareholders, being sufficiently profitable to meet these needs internally. The only exception to this was the London Bridge Waterworks when it expanded and rebuilt all its works after 1700. It is less clear, however, that incorporation brought indispensable benefits to the companies. The second largest, the London Bridge seemed not to suffer any disadvantage from being unincorporated. This was also true of smaller companies. This analysis of the importance of the joint-stock form agrees with a number of recent studies that have argued that in fact joint-stock firms were far more common than previously supposed.\(^6\) The restriction the Bubble Act imposed in 1718 that all new joint-stock companies be formed by act of Parliament proved not to be a great hindrance, as many companies succeeded in getting such acts. Furthermore, many joint-stock companies were formed regardless of the act, which was left in effect unenforced until the early nineteenth century. The water industry was a clear example of this.

4. Technological innovation
The expansion of London’s water industry was clearly made possible by technological innovation that spanned most of the 17th and 18th century, albeit mostly in slow incremental steps, with long periods of stagnation. In the Industrial Revolution, technological innovation in the leading sector has largely been seen to be especially concentrated in the second half of the eighteenth century, although some historical research has emphasized the deep, and even medieval roots of European technological dynamism. According this view, the Industrial Revolution was not truly a major break from the past, but was rather fed by pan-European streams of technological innovation that coalesced and matured most clearly in Britain, and was present throughout the Continent.\(^7\) The history of the water industry very much supports a long-term thesis of technological innovation in a couple of ways. Firstly, the technology was not exclusively English, but became increasingly so over time. The non-English roots of London water industry’s origins in the late 16th century is evident from its origins in three technological

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innovations imported from the Continent. The first was waterwheels and pumping technologies. These mechanisms gave access to a quantity of water that surpassed what existing wells and hand-carried buckets could provide. Although waterwheels had been used in the ancient world, they were employed prolifically during the Middle Ages to drive mills. In the later Middle Ages in particular, waterwheels were being put to an ever increasing range of uses such as slitting mills and fulling mills. In terms of water supply, the wealthy Hanseatic city of Lübeck in northern Germany was recorded as having a bucket wheel providing drinking water in 1294. The wheel supplied less than 200 houses through wooden pipes made from hollowed-out logs. A number of other German cities similarly introduced bucket pumps with waterwheels to supply drinking water, such as Hannover (1352), Breslau (1386), Bremen (1396), Bautzen in Saxony (1496), among others. Many of these bucket waterwheels, such as the ones in Lübeck and Hannover, were replaced over the course of the sixteenth century with piston pumping mechanisms to provide greater quantities of water. Although it is not clear when piston pumps were invented in Europe, they first appear in manuscripts in Italy in the fifteenth century. Besides for use in urban water supply, these piston pumps were employed in eastern European mines, as described by Agricola. In mining as well, the earliest mechanisms from the late fourteenth century were of the chain-of-bucket type, but by the early sixteenth century, piston pumps were finding greater use. These waterwheel-driven piston pumping mechanisms, with their greater capacity, spread from Germany and arrived in England at the end of the sixteenth century (figure 5).
Figure 5. A suction piston pipe, from Agricola, *De Re Metallica* (1561)

A second hydraulic technology that came to be used much more extensively in London at this time was wooden pipes. The innovation lay not with pipe itself, but in the scale of their use to connect directly to points of consumption. Wooden pipes, like waterwheels, had a long history going back to Antiquity. Although the evidence is not conclusive, they were not much used in Britain during the Middle Ages. Rather, lead and stone were the preferred materials, as they were in France. Wood was much more common in Germany, where it was used for urban water supply. One of the earliest cities for which evidence exists with such pipes was Grosal in Saxony. It had wooden pipes supplying bronze fountains in the city centre around 1200. From the end of the thirteenth century, more cities had such water supply networks. Some inhabitants in Bremen founded a
waterworks cooperative in 1396, which, once functioning, served a network of pipes that in some parts of the city connected directly to buildings. People paid to join the society, and it cost an additional \( \frac{1}{2} \) mark for a water connection. However, the high cost of these connections meant that this network was not used as a source of drinking water supplied to houses, but rather by brewers and bakers for their needs. A few hundred years later, in 1790, the network still only had about 450 connections.

The third technology which created new possibilities in how water was supplied in the sixteenth century was pipe boring machines (figure 6). Pipe boring had long been done by hand, but new machines meant that the wooden pipes could be produced more rapidly, in increasing quantities and at lesser expense than had been previously the case. They thereby opened the door to the construction of larger networks of wooden pipes. Better pipe boring machines, like piston pumps, seemed to have originated in Italy and Germany in the fifteenth century. Mariano Taccola described such a machine around 1470. In the sixteenth century, however, these machines were being used in new ways. For example, artillery came be manufactured with boring mechanisms, as described Vannoccio Biringucci in *De la pirotechnia* (1540). These were driven either by water or horse power. All these technologies came to England in the sixteenth century.

![Figure 6. A pipe boring machine, *Les raisons des forces mouvantes* (1625), Salomon de Caus](image)

The new London water industry was therefore stimulated by continental technology brought to England by foreign engineers, Peter Morris in particular. Where a difference
between the continental and the English model emerged over time was in scale and intensity of use. Whereas the continental water supply networks supplied a couple hundred taps, and usually only public ones, the London model evolved into one where tens of thousands of houses were supplied directly. This transition marks the distinctively English phase of the technological innovation, and can be seen in changes introduced to facilitate water distribution. Most notably, the New River Company’s growth in the late 17th century began to strain its ability to distribute water to the many houses that it was serving spread throughout London. Supply grew inadequate, and complaints more frequent. The New River had to cut back the frequency of its service from three to two days per week, and it lost customers to its newly emerging rivals. Furthermore, it found itself unable to supply the wealthy and rapidly growing West End. In order to address these problems, the company devised a host of means of controlling and preserving water pressure in its network.

One of the first was to expand its supply capacity by building a higher reservoir, called the upper pond, supplied by a pumping mechanism driven by horses, water, and later a steam engine. This new reservoir increased the pressure in the company’s network serving the West End. Beyond the upper pond, the New River company’s engineers worked at find ways of stabilizing and making the water supply more reliable. The company began to use a double pipe network, whereby larger pipes, called mains, were used to transport water from the New River reservoirs to various districts of the city. Smaller pipes, called service pipes or simply services, were either attached to these mains, and ran through the street to distribute water to homes or public courts. The connections to buildings were through lead ferrils that linked into the wooden services. As the eighteenth century progressed, the company tried to differentiate between the mains and services more clearly. This meant that it avoided having ferrils drawing water from the mains. To further isolate the mains, the company began using another set of pipes called riders that ran beside the mains to provide water service to the buildings on those streets, thereby removing the need to connect them directly to the mains. This system ensured that water flow in the mains remained relatively constant, even as it was distributed across various zones through service pipes. It also served as a means of isolating service areas into zones of approximately equal elevation.
The shift to a double arrangement of pipes was quite a slow, perhaps a reflection of the chaos in the pipe network and the difficulty in reforming such a widespread system. Although some distinctions between mains and service pipes can be found in the company’s records from the early eighteenth century, the court of governors ran a couple of concerted campaigns to move all customers off the mains and onto service pipes in the 1770s and 1780s. References abound in the company’s minutes from this period, ordering the installation of new service pipes in streets so as to move any customers in those streets from the mains to service pipes. Customers, however, were not so keen to see this change implemented. For them, being connected to main meant a much better water supply because it was at higher pressure with regular flow. Nevertheless, the company by the 1770s maintained a strict rule that no customer should have any connection to the mains, with the exception of a few cases where no service pipes existed.

Other parts of the system also evolved over the course of the eighteenth century, including ways to make the load on the system more predictable. Originally, the ferrils into homes had no valves, and water would flow into the reservoir when the street valves were opened by the turncocks. Even if there were some sort of valve in the house, some people would leave them open all the time, allowing water to overflow. Over time, the company thought that some of its customers were drawing far too much water and abusing their supply. This problem of drawing too much water was not, however, limited to paying customers. Sometime people paid plumbers to attach ferrils to the company’s pipes and mains without the company’s knowledge. Ways of addressing this included legal and technical means. On one hand, the company petitioned the crown for special
powers and edicts against such meddling. The powers granted were to search houses in the presence of a constable if there was suspicion of abuse. On the other, the company relied on new technological innovations. One new such measure came around the 1720s with the introduction of ball-cocks. These were valves regulated with floats that shut the water intake pipe once the water level in the in-house reservoir reached a certain level, taking the regulation of water flow out of the hands of the buildings’ occupants. In 1724, the company’s Court of directors ordered that all tenants must have such ball-cocks or face being cut off.

By the late eighteenth century, the New River Company’s network of pipes and mains had grown to approximately 400 miles (640 km). Although the period of its most rapid growth occurred earlier in the eighteenth century, it continued to lay pipes and take on new customers over time. Maintaining this massive network required a variety of operations. This included several crews of pipe borers. The company would buy thousands of loads of elm trees a year, and bored out the interiors of trunks to serve as pipes. Most of the pipes were three to five inches in diameter, with the mains being constructed of six to eight inch diameter pieces. The sections of pipes were narrowed at one end, with the other made larger, so that they could fit together snugly (figure 7). Later on in the eighteenth century, the company began using metal hoop to bind the nose of the pipe to the butt of its neighbour. The wood would rot over time, and finding and fixing leaking pipes became a constant job for the company. By 1751, the company was employing 20 borers at its pipe yard. The pipes they churned out added up to over 20,000 yards (over 11 miles, or 17.6 km) per year in the last decades of the eighteenth century, meaning that the entire 400 miles of pipes would be replaced every 20 to 40 years. The company employed 12 teams of labourers constantly laying pipes, headed by foremen. Given the relatively slower growth of the network in the late eighteenth century, most of this work was in repairing smaller sections of existing pipe. At times blowouts occurred and caused water to flood into basements, leading to at times severe water damage, for which the company paid compensation. At other times, however, there were drops in pressure without the location of the leak being evident. These would be particularly difficult to find if the water ran out of the pipes into sewers, since that no subterranean flooding would be evident from the surface. When pipes ran besides sewers, the company’s labourers would descend into them, searching for the leaks. This job was so distasteful that the company paid extra compensation to labourers who went more than 100 yards in sewers in search of leaks.
By achieving a new level of technological sophistication in this way, the water industry followed the model of many other IR technologies: from roots in continental European technologies, a new innovation was adopted in Britain, and through incremental innovation became the germ of a new industry. It took on a specifically English character over time. The process of divergence in the English model of water supply from the continental one was slow and incremental, but was evident by the late 17th century when the ever-increasing numbers of customers being supplied water forced the water companies to confront a series of problems associated with scale.

Why did London diverge from its Continental peers in water supply technology? The causes are not immediately evident. Rather being impelled by greater technological innovativeness in Britain, they seem to be rooted in three points: demand for water; wealth; and business model. The contrast with a city like Hamburg is instructive.

Although Hamburg had a number of pumping mechanisms supplying a network of mains for the entire time that London’s water industry was developing, the network there never grew to the same size. The reasons for this began with potential demand: Hamburg was nowhere near the size of London, which was rapidly becoming the largest city in Europe in the 18th century, passing Naples and Paris. Moreover, London was also becoming wealthier, with more of its residents adopting consumerist attitudes as wide networks of overseas trade brought more goods into the city as England’s commerce grew. The Restoration of the monarchy and peace in 1660 heralded a pattern of change in cities that Peter Borsay has described as an ‘urban renaissance’ in England.8 Inspired by Continental cities, the landed gentry began acquiring urban properties, leading to the development of the West End, the affluent suburb growing west of the City. This influx of wealth to the metropolis spurred demand for domestic goods, luxuries, services, and entertainment. Water proved to be among the goods these new consumption-oriented town dwellers sought. A further impetus came with the Great Fire of London of 1666. It engulfed a sizable portion of the City, especially near the Thames, but spared the north end of the city, including the New River Company. Many reconstructed buildings took on a water connection that they had not had previously.

The expansion of water supply into homes fit with changing patterns of consumption. In the past decades, historians have described how the consumption of goods expanded in the West, both in volume and across social strata. Neil McKendrick and others described the birth of a commercialized consumer society in the mid-eighteenth century, encompassing not only the access to more goods, but also the growth of channels of

8 Borsay, 1989.
distribution, production, and marketing. Consumption was commercialized on a large scale, shifting away from predominantly domestically produced goods towards remotely manufactured and traded ones. The dating of this revolution has, however, been challenged by historians who draw attention to the domestic consumption of non-luxury goods in late seventeenth century households. Examples of these new domestic goods include coal, metalware dishes, tobacco pipes, and thimbles. Water can also be added to this list. The intensification of network-supplied water to homes in London moved the most mundane of consumer goods—water—into a commercial market run by companies and made possible by technological innovation. This was an increasingly mass-market phenomenon, whereby more households were served water directly by a few companies in their homes. To be sure, ubiquity and constant reliability that later water supply networks afforded was still some way off. The New River was, for example, willing to decline supply to houses that requested it if the directors judged the house to be unprofitable. Nevertheless, how water was being consumed was slowly being transformed by, and acting as an encouragement to, the elaboration of London’s network water supply. The consumer revolution which has figured prominently in the historiography of the Industrial Revolution was, therefore, also driving the demand for water, with a key difference in timing. Rather than beginning in the 18th century, demand for water was clearly growing in the 17th.

By the 18th century, demand for water was brisk in London, as many commentators observed. John Strype in 1720 wrote that “there is not a street in London but one or other of these waters runs through it in pipes conveyed underground and from these pipes there is scarce a house whose rent is 15 or 20 £. per annum but hath the convenience of water brought into it by small leaden pipes laid into the great ones and for the smaller tenements such as are in courts and alleys there is generally a cock or pump common to the inhabitants so that I may boldly say that there is never a city in the world that is so well served with water.” The water companies by 1700 were no longer only serving a wealthy elite as in its early years. Water supply reached well into the middle class of the metropolis. In terms of number of houses served directly with water, the New River expanded from around 10,000 tenants in 1670 to 17,000 in 1683 (figure 8). The New River’s growth persisted after the turn of the eighteenth century as London’s population continued to increase, reaching 700,000 around 1750, and over 1,000,000 in 1800. In 1769, the New River Company did a full audit of all its customers following a fire at its

9 Stow and Strype, 1720. Richards, Payne, and Soper, 1899. The Travels Of Tom Thumb over England and Wales, 1746.
main office. This revealed that it then had 28,000 customers. Although the majority of these were houses, other buildings, such as brewers, taverns, and stables, also received water.

The New River’s 1770 audit of customers listed them all of them by address and fees paid. This has been used to reconstruct a map of water use in London at that time (figure 9). Water usage has been calculate by first reconstructing the company’s entire pipe network. Individual users were then maps along the pipes corresponding to their street addresses. Finally, the concentration of water usage was calculated by dividing London into a grid of 5700 squares and water usage summed within each square. The results were then plotted as a contour map. A second contour map (figure 10) represents the water price paid by consumers. This contour plot was created by mapping the fees paid by individual consumers, and fitting a curve onto this prices paid.

Figure 8. Number of houses with connections to water networks
Figure 9: Price paid to the New River Company for a water connection in London in 1770. The contour lines are drawn at 10s per year fee for water.
Figure 10: Water usage intensity in London in 1770, as supplied by the New River Company, assuming fees paid correspond to usage.
A number of observations can be made from the maps. The price map shows a number of spikes in the relatively poor east end of the city. This indicates that industrial water use dominated that area. The large users were typically brewers, distillers, sugar bakers, and fishmongers. Areas to the north of the City, and especially the wealthy West End, which was the primary area of growth for water companies in the eighteenth century, had generally higher average prices. Furthermore, the area where competition was present had lower prices in some places. The large area of overlap between the London Bridge Waterworks and the New River, and between the York Buildings and the New River, show lower average prices. In the wealthiest West End areas closer to Hyde Park do not show this drop, despite the New River and the Chelsea competing there.

The usage map reveals more details of how water was consumed in London. There was little total use in the east end, indicating that apart from the commercial clients who paid very high prices for water, the New River Company had few domestic customers in that area of London. The area of the City of London around London Bridge used very little New River water, but not because it was poor. Rather, the London Bridge Waterworks completely dominated that area. The areas around St Paul’s, however, were different. There, the New River was pre-eminent over the London Bridge Waterworks, likely because the water pressure it was able to supply in that zone was higher. Water use was highest in the area around the Fleet market in the west of the City, perhaps because inns, coffeehouses, and vendors used more, combined with denser housing. The Smithfield Market area to the northwest of St. Paul’s also consumed much water. In the West End, usage was very high as well, spread over a large area. There was, however, a very large drop off in use towards Hyde Park. This indicates that although competition with the Chelsea in that area did not depress prices, the Chelsea was better able to serve customers. This zone was at the edge of what the New River could supply due to the elevation of the land.

In terms of market penetration, definite figures for the number of buildings in London have been difficult to calculate, but estimates can be made for the years 1737, 1757, 1777 and 1801. Richard Price, a nonconformist preacher interested in demography, reported the number of houses in the metropolitan area derived from window tax assessments and bills of mortality for those years (85,805, 87,614, 90,570 and 110,669). Based on these figures, the New River Company was reaching around 30–40% of buildings, with the rest of the companies adding another 10–13%. The cost of the water

10 Landers, 1993
varied, but for most of the time before 1800, it was typically around 20–40s per year, or around 10% the yearly wage of a labourer. Pipes water supply was, therefore, no longer a luxury by 1770, although it was by no means ubiquitous.

6. Conclusions

London’s water supply developed from the late 17th through the 18th century into a large industry consisting of a number of joint-stock companies. Most of the largest were corporations. These companies functioned as utilities, providing what was at first a luxury service to the wealthy, but increasingly became a commonplace convenience for a fair portion of London’s population. Within the context of the IR, this new industry offers some interesting features. In terms of timing, the technological innovation within the industry, especially that which allowed it to expand in scale, was evident in the late 17th century, earlier than the IR. In recent years, the causes of the Great Divergence between the West and the rest of the world has received renewed interest in the context of global history. The California school in particular has situated the causes of the divergence in a number of specific historical circumstances of the late 19th century, and eschewed longer terms explanations. The history of London’s water industry suggests, however, that this industry, and the industrial model of urban utilities, had much deeper roots than 17th century, and was based on many contemporary trends.
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