

Transport networks and the adoption of steam engines in England and Wales, 1761-1800

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Abstract

The steam engine was the quintessential invention of the Industrial Revolution. It revolutionized mining, textile manufacturing, transportation, and many other important economic sectors in England from the 18th century through the mid-19th century. This paper investigates whether transport networks influenced the spatial diffusion of steam engines, and compares their effects with endowments like having coal and being a coastal location. Our preliminary results show that parishes closer to turnpike roads and inland waterways in 1770 had a much higher probability of adopting at least one steam engine between 1770 and 1800. Having coal and being a coastal parish were also positively related. The findings shed new light on how transport improvements affected technology adoption during the industrial revolution.

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The steam engine was the quintessential invention of the Industrial Revolution. It revolutionized mining, textile manufacturing, transportation, and many other important economic sectors in England from the 18th century through the mid-19th century. The story of the steam engine has three parts. The first story is about the development of the engine itself. The main innovators were individuals like Savory, Newcomen, and Watt, but there were many others who helped develop the engine. All played a role in making steam engines more fuel efficient, more reliable, and hence more productive.² The second story is about how steam engines changed the English economy. In this case, the focus is often on the macro-economic perspective, usually with an emphasis on the social savings.³ The third story is mainly about the spatial diffusion of steam engines. There are several explanations as to why steam engines were adopted in a given location. One focuses on the abundance of coal, which was important because the steam engine required coal as fuel. Another focuses on alternative sources of energy like water power. The third focuses on demand factors, in particular industrial activity and urbanization.⁴

While the literature to date has made important progress, many issues are unresolved especially concerning the adoption of steam engines. For example, one potentially important factor that has received less attention is the role of transport innovations. The role of transport is potentially important because England experienced a major change in its transport system in the mid to late 18th century. Improvements to roads, rivers and the construction of canals were the key developments. From 1680 to 1800 more than 15,000 miles of road were improved, 500 miles of river were made navigable, and approximately 2500 miles of canal were constructed in

² See Nuvolari and Verspagen (2009) for an analysis of engine innovation.

³ See von Tunzelmann (1978) and Crafts (2004) as examples of research on the macro-economic effects.

⁴ See Nuvolari, Verspagen, and von Tunzelmann (2011) and Kitsikopoulos (2015) for research on adoption and diffusion.

England and Wales. Collectively, they made inland transport by wagon, coach, and barge far more efficient compared to the late 17th century. Also remarkable is that most of these infrastructure investments were financed by turnpike trusts and joint stock companies. A permissive parliament allowed local landowners and business interests to establish new organizational forms, which bundled financing and organization tools to mobilize capital for projects.⁵

Lack of data has made it difficult to study the link between steam engine adoption, transport improvements, and other factors like coal endowments. Thus there is not an accepted view on whether transport improvements were quantitatively significant, say relative to having coal. This paper introduces a several new datasets that allow us to address these issues for the first time. The first dataset includes new highly localized GIS data on where the majority of steam engines installed in Britain between 1700 and 1800. The data originate from Kanefsky (1979) and Kanefsky and Robey (1980).⁶ The data names the year when an engine was installed, details on its specifications, details on its application, and a brief description of the location. The data contains 2268 engines and we are able to match 1688 engines to a precise location, generally at the level of a parish or town.⁷ This marks a major advance over previous studies which could only match engines based on county.

⁵ For an overview of this data and more background on turnpikes and inland waterways see Bogart (2017) and Satchell (2017).

⁶ We thank Alessandro Nuvolari for sharing a digitized version of the Kanefsky data.

⁷ See Bogart et. al. (2017c) for description of the steam engine data. For the moment if the stated location was unclear, then no match was made and the engine is omitted from our sample. We are working to match the remaining engines but this requires further resources.

The second new dataset contains highly accurate GIS data on the locations of turnpike roads and inland waterways, specifically navigable rivers and canals.⁸ The data include the polylines of turnpike roads established and waterways made navigable at different points in time. In particular, we can study the turnpike roads, navigable rivers, and early canals that were present or open from 1750 to 1770 when the adoption of steam engines accelerated.

The third dataset contains boundary files for more than 9000 quasi-parish units. They are the smallest geographical units in England and Wales, which we construct and have consistent boundaries from 1801 to 1881. The parish units have been created to study outcomes in the nineteenth century, like population and employment growth. They have been linked to the transport network data which allows us to calculate the distance between every parish and their nearest turnpike road, inland waterway, and port at several dates from 1680 to 1800.⁹ The parish units have been linked to geographic information on endowments, like exposed coal, coastline, elevation, and ruggedness.¹⁰ For this paper each steam engines has been linked with one of the approximately 9000 parish units. Specifically we know whether a parish ever had a steam engine adopted in its boundary and how many at any date from 1700 to 1800. The only caveat is that we have not yet matched all engines, and thus we currently have an estimate of engines adopted. Once the matches are complete then we will have a highly accurate estimate of which parishes had steam engines.

⁸ For an overview of this data and more background on turnpikes and inland waterways see Bogart (2017) and Satchell (2017).

⁹ See Bogart et. al. (2017a, 2017b) for an example of how the parish units are used to study the effects of railways, turnpike roads, and canals..

¹⁰ The exposed coal data was created by Satchell and Shaw Taylor (2013). See <http://www.campop.geog.cam.ac.uk/research/projects/transport/data/coal.html> for more details. For a discussion of the elevation and ruggedness data see Bogart et. al. (2017a, 2017b).

A third and final step involves linking parish units with hundreds. This is an ancient administrative unit that is smaller than a county but larger than a parish. The hundreds are valuable because there are population figures for each hundred dating back to 1761 (Wrigley 2007). Therefore it is possible to study think between steam engines and population density at the hundred-level.

In our empirical analysis we study how distance to transport networks c.1770 affected the probability of a steam engine being adopted in a parish from 1771 to 1800 and also the number of engines adopted in a parish from 1771 to 1800. We also study the effect of having coal, being coastal, and having higher population density in 1771. Our preliminary results show that the probability of adopting at least one engine decreases with distance to the nearest turnpike road and inland waterway. We find a similar effect on the number of engines adopted but the effect is much larger for inland waterways than turnpike roads. Also as expected we find that having coal and being coastal are both positively related to the probability of adopting at least one engine and the number of engines adopted between 1771 and 1800. Interestingly, greater population density at the hundred level is not significant.

This paper adds to a large historical literature on turnpike roads, rivers, and canals.¹¹ This paper is an advance over previous studies because it uses new highly localized data on the adoption of steam engines and new highly accurate GIS data on turnpike roads, rivers, and canals from across England and Wales. It confirms some existing theories on the diffusion of steam engines, like the importance of coal, but it also offers a new perspective through its focus on transport networks. Transport improvements are often linked with population and employment

¹¹ See Jackman (2016), Willan (1964), Freeman (1980), Turnbull (1987), Szostak (1991), Bagwell (2002), Bogart (2005a, b, 2009), Gerhold (1996, 2014), Crompton (2004), Maw (2013).

change. Increasingly the literature is linking transport with a wider range of outcomes. Some studies have shown a link to health outcomes and bank failures (Atack et al. 2014, Tang 2015), but there are few studies linking transport improvements with technological innovations. The only example is Perlman (2016), who studies the link between US railroads and patents.

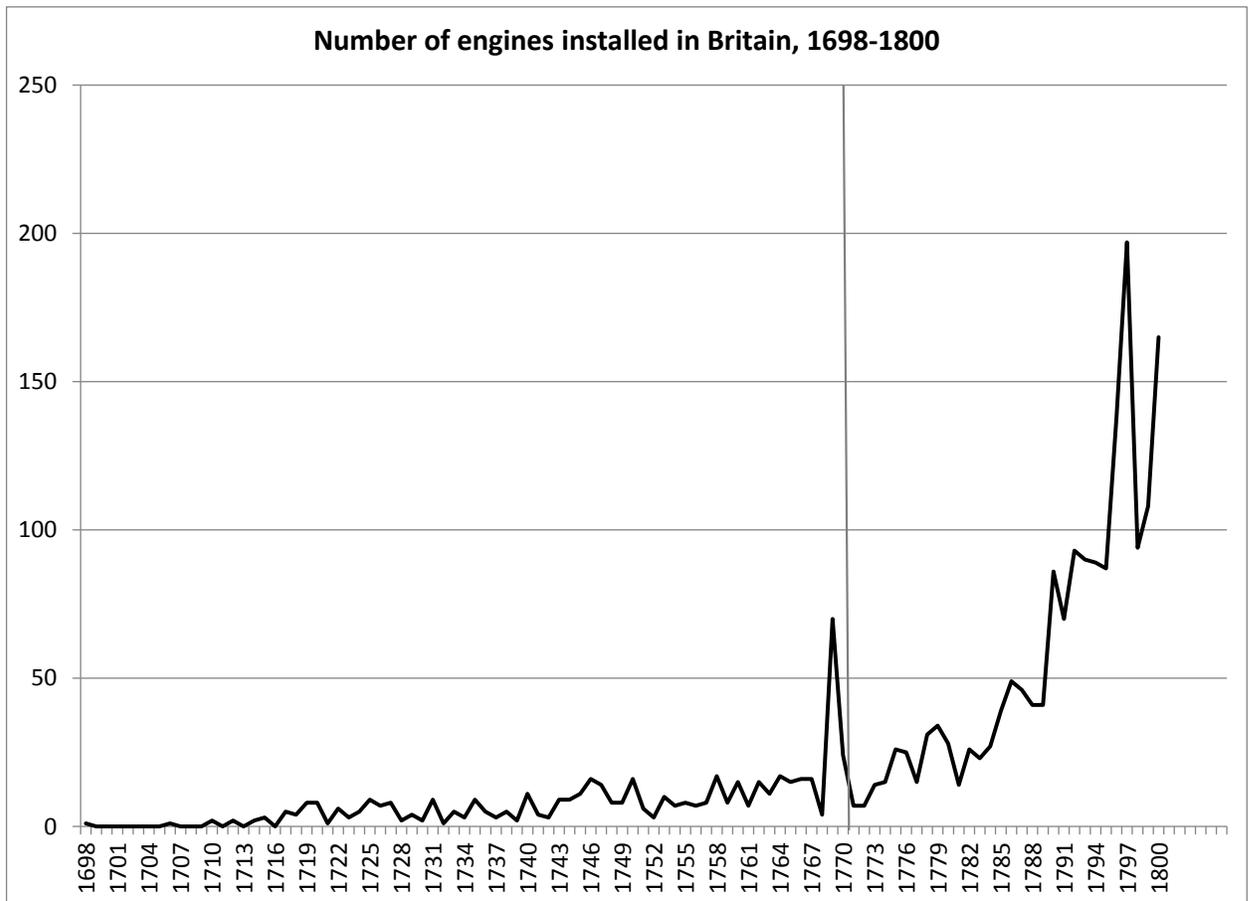
The paper is organized as follows. Sections I, II, and III give background on steam engines, turnpike roads, and inland waterways. They include a preview of the novel datasets used in this paper. Section IV describes the empirical framework. Section V shows the results. Section VI concludes.

I. Steam engine diffusion.

The diffusion of steam engines is discussed more fully elsewhere in the literature.¹² Here we focus on the main temporal and spatial trends. Figure 1 below shows the number of steam engines installed in each year. The total from 1698 to 1800 was 2268. There is a rising trend in the number of engines installed with spike in 1769 and again from 1797 to 1800.

¹² See Nuvolari, Verspagen, and von Tunzelmann (2011) and Kitsikopoulos (2015) for research on adoption and diffusion.

Figure 1: Number of Steam engines installed

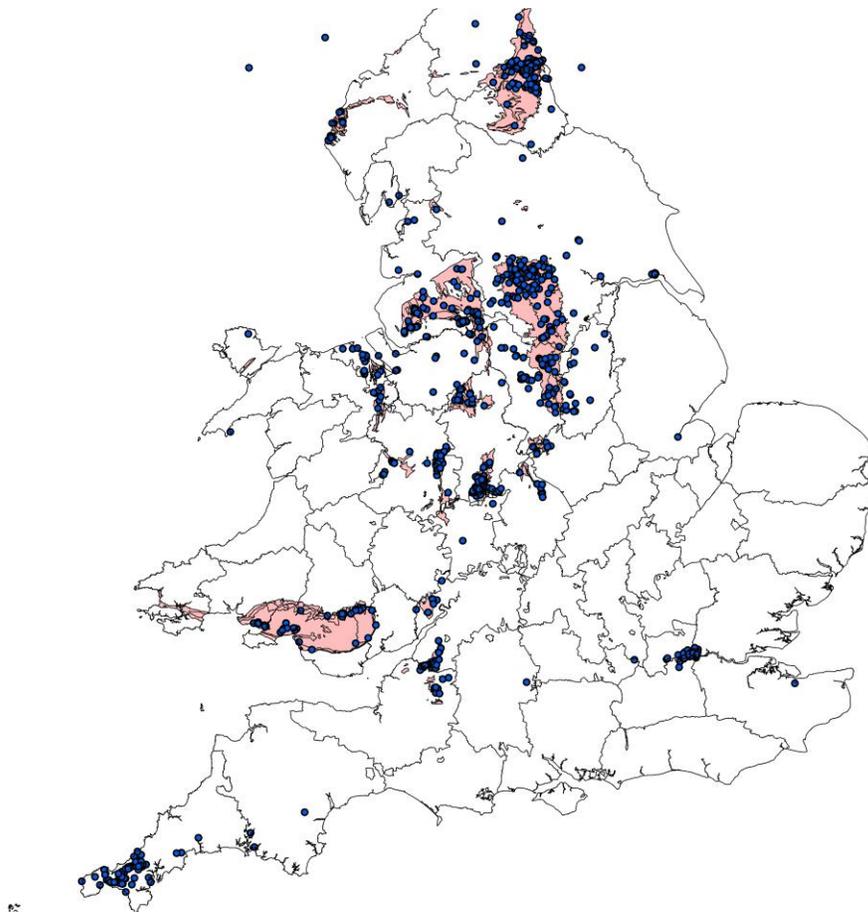


Source: Kanefsky (1979) and Kanefsky and Robey (1980)

The spatial distribution of engines installed is shown in figure 2. Engines are represented by the blue circles. Pink areas represent the exposed coal fields (Satchell and Shaw Taylor (2013). Exposed coalfields are those where coal bearing strata are not concealed by rocks laid down during the Carboniferous Period. The GIS does not capture a handful of tiny post carboniferous coal deposits, such as that at Cleveland (Yorkshire) which was worked in the 19th

century.¹³ One can see that the adoption of steam engines is fairly clustered and that there is a strong overlap with the coal fields. One hotspot of engine adoption is near the northeast coalfield next to Newcastle. Another hotspot is in the West Yorkshire and Lancashire coalfield around Leeds and Manchester. A third hotspot is in around the coalfield in South Wales. A fourth hotspot is in Cornwall near the tin and copper mining region. A fifth hotspot is near Birmingham. Finally, there are two smaller hotspots near London and Bristol.

Figure 2: Map of the engines installed



Source: Bogart, D, Satchell, A.E.M., Gill, M., Bottomley, S., and Shaw Taylor, L., 'Steam Engines of Britain, 1706-1804', 2017.

¹³ The exposed coal data was created by Satchell and Shaw Taylor (2013). See <http://www.campop.geog.cam.ac.uk/research/projects/transport/data/coal.html> for more details.

II. Background on turnpike trusts

England and Wales had a large network of roads and pathways going back to the Middle Ages. Responsibility for maintenance was placed upon local governments known as parishes. Parishes financed road improvements by forcing their residents to work without pay and by levying property taxes. The public and local method of road financing became unsatisfactory during the 17th and 18th centuries. There was a growing use of large wagons and carriages, which caused damage to roads. The problem was especially acute in the southeast around London.

Turnpike trusts emerged as a solution to this problem. Turnpike trusts were created through a legislative process shared by many types of private and local bills. A bill to create a turnpike trust almost always began with a petition to the House of Commons, often from landowners and commercial interests. The petitions normally stressed the need for road improvement, and the inadequacy of the law. Once turnpike bills were written and passed by the Commons, Lords, and Monarch they became known as a 'turnpike act.'

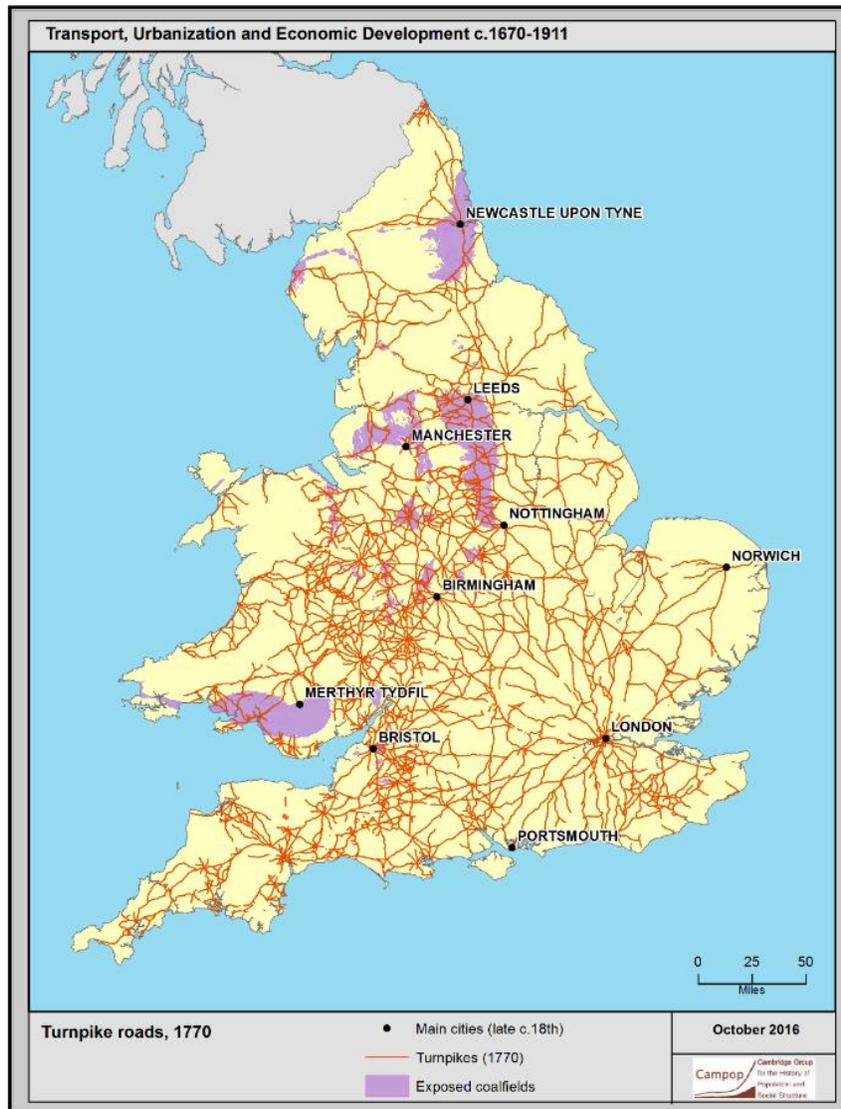
Each act established a body of trustees with authority over the road. They were usually composed of the promoters and other local elites. Trustees were given the right to levy tolls and issue bonds. As an added bonus, trusts could also claim statute labor from the parishes along their route. Turnpike acts also placed restrictions on trustees. For example, they could not charge tolls above a maximum schedule, and they could not earn direct profits. Turnpike acts did not give permanent powers. They were only valid for 21 years, at which point the trustees had to apply for what became known as a 'renewal act.' The vast majority of renewal acts were approved by parliament. In this manner, turnpike trusts became a fixture in England and Wales transportation system through the mid-19th century.

Importantly, the main function of turnpike trusts was not to build new roads, but rather to improve the quality of existing roads. The usual official rationale for creating turnpikes was that the ‘ordinary’ laws for repairing a particularly highways needed to be amended if a particular group of roads were to be improved. Did turnpike trusts meet these goals? Bogart (2005) has analyzed the road spending of parishes in the five years before a turnpike trust was established in their jurisdiction. The evidence shows less than 5% of parishes levied highway rates (i.e. taxes on property owners) in those five years, implying that the only spending that was occurring through other means like unpaid labor. The same study also estimated average turnpike trust road spending during their first 20 years of operation. They spent between 10 and 20 times more than the parishes they replaced.¹⁴

Importantly, this paper uses new GIS data accurately identifying the location of every turnpike road and the data associated with them, like their date of establishment. The data features and sources are described in Rosevear et. al. 2017. Figure 1 uses the data to map all turnpike roads in 1770 along with the largest cities of 1700. By 1770, turnpike roads diffused widely across England and Wales. Large cities like London, Leeds, Birmingham, and Bristol all had many turnpike roads. A particularly dense network of turnpike roads also formed in the West Midlands and West Yorkshire, especially near the coalfields. This development is notable because these areas were beginning to industrialize. Turnpike trusts also reached areas like the Southwest and Wales.

¹⁴ Additional evidence comes from an assessment of each trusts’ road condition in 1838. A parliamentary committee asked all trusts to describe their road. They used terms like “Bad”, “Good”, “Tolerable”, “Good” or “Very good”. Over 60% were characterized as “Good” or “Very good.” A relatively small number, 15%, were classified as “Bad” or “Not Good”. While a assessment of turnpike road quality by the trustees themselves is subject to bias, it provides more evidence that greater expenditures by turnpike trusts generally resulted in a good road network.

Figure 1: Turnpike roads and major cities in 1770



III. Background on inland waterways

The importance of travel by inland waterway was recognized by contemporaries as early as the Middle Ages and by many scholars since.¹⁵ The first major improvements came to rivers, where the width and depth were extended to make them navigable. In terms of organization, river

¹⁵ See Satchell (2017b) for a more complete background on the inland waterways of England and Wales.

navigations were financed and implemented by a variety organizations, including partnerships, trusts and municipal government. They received their authority from an act of parliament similar to turnpike trusts. The act authorized levying of tolls and powers to purchase land.

Canals were the next major improvement. Canals were fundamentally different navigable waterways in that their routes were chosen by people, whereas hydrology dictated the route of rivers. Canals were generally built by joint stock companies. The capital requirements for building a canal were considerable. Collectively canals were the largest infrastructure investment in England by 1830. Much of the financing for canals came from local landowners and business interests.

The technology of a pound lock was fundamental to improving rivers and constructing canals. Elevation changes made it difficult to haul or sail a barge through a waterway. Locks were chambers that filled with water and equaled elevation on a slope. They required enormous amounts of water so in many circumstances purpose-built reservoirs had to be built to supply them which added further to the expense. The most spectacular examples are called *lock flights* - sets of locks which ran staircase like up a hillside.

Compared to roads, inland waterways were a more efficient way to carry low value non-perishable bulky goods such as coal and grain. If comparison is made between the weight that could be typically carried by one horse wagons on the pre-turnpike roads of the seventeenth century, and loads that could be hauled by a single-horse barge on a broad canal of the eighteenth century it can be seen that 96 horses pulling wagons would be needed to carry the same load as that drawn by one horse on a broad canal. Or put another way a single horse barge could move almost eighty times as much freight as a one-horse wagon.

In 1600 England and Wales had about 950 miles of navigable waterway. By c.1760 it had increased to 1400 miles, nearly all of which were navigable rivers. The evolution of the inland waterway network can be mapped in a high degree of detail thanks to a new GIS data set created by Satchell (2017). The first panel in Figure 2 shows the extent of the river network to 1756 the year before first proper canal was constructed. Natural and improved rivers connected much of the interior with the coast. Most significant were the river navigations that connected burgeoning industrial towns to coastal and international shipping networks. Of major importance was the extension of the Aire and its tributary the Calder to Leeds and Wakefield (West Riding). Both towns were situated on the Yorkshire coalfield and Leeds was a major textile center.

Canals changed the inland waterway network radically from 1757 to 1830. The pink lines in figure 2 show the first generation of canals built between 1757 and 1770. Nationally the network did not change radically from 1757 to 1770 though there were some very important developments (see map 5). In addition to the Sankey Canal, canals linking coal mines to established regional centres include a canal linking Coventry to the Warwickshire coalfield at Bedworth in 1769, a canal linking Birmingham to the Warwickshire coalfield at Wednesbury, the same year of the opening of the Sankey and Manchester canals.

The canal and turnpike networks continued to evolve from 1770 to 1800 but for the purposes of this paper we restrict the analysis to the state of the network in 1770. This will enable us to examine the effects of network on the adoption of steam engines from 1770 without being concerned with reverse causation. The next section delves into the empirical framework.

Figure 2: The inland waterway network c.1770



IV. Methodology

In this section, we propose an empirical model to study the effects of turnpike road and inland waterway networks on the adoption of steam engines. The aim is to estimate the elasticity of adoption with respect to infrastructure access measured by distance. The elasticity is grounded

in a theory that transport infrastructure contributed to better consumer and producer access, which made individuals and firms want to locate and innovate near these infrastructures (Redding and Turner 2014).

Our specification is meant to be straightforward. The main variable of interest here is distance to infrastructures, like turnpike roads and inland waterways. We also include distance to ports, which did not change much over time. Our unit of observation is a parish unit. The adoption specification is the following:

$$Prob(y_{ij} = 1) = \text{Logit}(\alpha + \beta_1 \ln(\text{popden}_j) + \beta_2 \ln(\text{distanceinfrastucture1770}_i) + \beta_3 x_i)$$

where $y_{ij} = 1$ if parish unit i in hundred j gets at least one steam engine in its boundary between 1771 and 1800 and otherwise $y_{ij} = 0$, $\text{Logit}(\cdot)$ is the logistic function, $\ln(\text{popden}_j)$ is the population density of hundred j in 1771, $\ln(\text{distanceinfrastucture1770}_i)$ is the natural log of the distance to infrastructure in 1770, either a turnpike road, an inland waterway or a port, and x_i is a vector of controls for endowments, including coal and being coastal. The control variables are time invariant. One variable is the shortest distance to one of the largest ten towns (Birmingham, Bristol, Leeds, Liverpool, London, Manchester, Newcastle, Plymouth, Portsmouth, Sheffield). It captures the effects of economic geography. The other main controls are measures of endowments including exposure to coal, coastal location, and ruggedness measures. Exposed coalfields are those where coal bearing strata are not concealed by rocks laid down during the Carboniferous Period. The GIS does not capture a handful of tiny post carboniferous coal deposits, such as that at Cleveland (Yorkshire) which was worked in the 19th century.¹⁶ Coastal units are identified using shapefiles for parish boundaries in England and

¹⁶ The exposed coal data was created by Satchell and Shaw Taylor (2013). See <http://www.campop.geog.cam.ac.uk/research/projects/transport/data/coal.html> for more details.

Wales. The ruggedness measures are the average elevation, the average elevation slope in the parish, and the standard deviation in the elevation slope in the parish (see Bogart et. al. 2017c). A final set of controls capture soil types. We use the highly detailed National Soils Map data from the Land Information System (LANDIS).¹⁷ Soils are classified into 10 broad categories following Clayden and Hollis (1984).¹⁸ They include: (1) Raw gley, (2) Lithomorphic, (3) Pelosols, (4) Brown, (5) Podzolic, (6) Surface-water gley, (7) Ground-water gley, (8) Man made, (9) Peat, and (10) other including water features. We use GIS to calculate the percent of parish land area with these 10 soil categories.

A second specification examines the number of engines. It is the same as the equation above except we define the outcome variable q_{ij} , which is the number of engines installed in parish i in hundred j between 1771 and 1800. Here the specification is either negative binomial as q_{ij} is a count variable. Here we run two specifications, one where the sample includes all parishes and one where only parishes with at least one engine installed.

The summary statistics of all the variables are shown in the following table. The probability of adopting at least one steam engine from 1771 to 1800 was 0.031. If an engine was adopted the average number was 8.31, although in one parish 172 engines were adopted. The distance to the nearest turnpike road in 1775 was quite small on average. The distance to inland waterways was greater on average. The endowment characteristics are also of interest. 15% of parish units were on the coast and 8% had exposed coal.

¹⁷ See Landis for more details, <http://www.landis.org.uk/index.cfm>

¹⁸ See http://www.landis.org.uk/downloads/classification.cfm#Clayden_and_Hollis for more details.

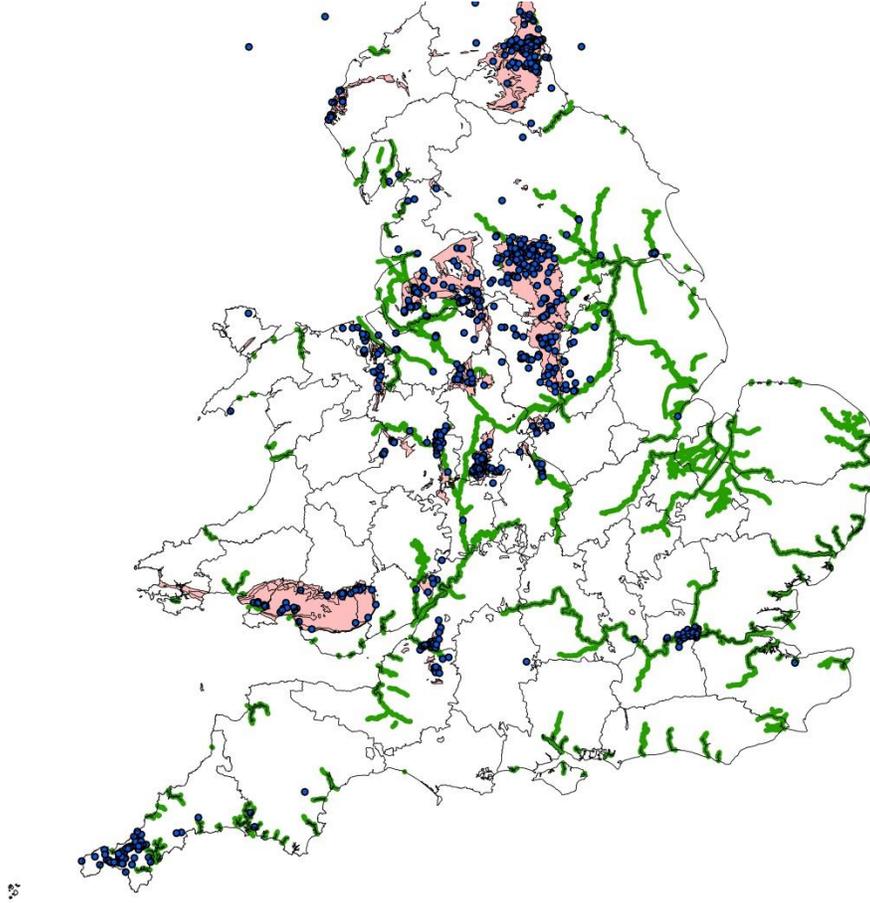
Table 1: Summary Statistics	mean	Std. Dev.	Min	Max	N
Probability of adopting a steam engine 1771-1800	0.0312	0.1741	0	1	9,491
Number of steam engines adopted if any	8.3097	19.0507	1	172	297
distance nearest turnpike road in 1775 in km	3.192	4.4801	0	34.0507	9,491
distance nearest inland waterway in 1770 in km	11.176	9.1203	.00579	52.749	9,488
distance nearest port in km	33.4115	22.531	.05920	99.7120	9,488
Population density of the hundred in 1771	484.24	3746.6	10.548	49503.7	8,629
Distance to nearest large town in 1801 in km	136.390	67.9921	0	418.740	9,497
Dummy for exposed coal	0.0802	0.2716	0	1	9,498
Dummy for being on coast	0.1479	0.355	0	1	9,499
Slope elevation average	4.7675	3.6157	0.4849	37.4272	9,500
Slope elevation standard dev.	3.4324	2.7174	0	23.1755	9,501
Elevation average	89.7215	74.0256	-1.243	524.384	9,502
Percent land with raw gley soils	0.0847	1.3279	0	76.496	9,489
Percent land with lithomorphc soils	8.6151	19.8301	0	100	9,489
Percent land with Pelosols soils	8.2038	20.6374	0	100	9,489
Percent land with Brown soils	41.5641	33.1188	0	100	9,489
Percent land with Podzolic soils	4.6249	14.3262	0	99.565	9,489
Percent land with Surface-water gley soils	24.6329	29.4604	0	100	9,489
Percent land with Ground-water gley soils	10.1871	20.1177	0	100	9,489
Percent land with Man made soils	0.3638	3.2621	0	94.9904	9,489
Percent land with Peat soils	1.1875	5.2798	0	91.4403	9,489
Percent land with Other soils	0.5354	1.9668	0	65.1538	9,489

Sources: see text.

IV. Results

We begin with some visual evidence. The following map again shows all steam engines that were adopted. In green it adds the navigable waterways in 1770. There appears to be some association with steam engines and waterways. For example, see the around London and Bristol.

Figure 4: Steam engines adopted and inland waterways 1770.



Sources: see text.

The logit regression results for adopting steam engines are shown in table 2. The specification in column 1 does not include county fixed effects. The results show that greater distance to turnpike roads, inland waterways, and ports are all negatively and significantly related to the probability of adopting at least one steam engine from 1771 to 1800. The indicators for having coal and being coastal are also positive and significant as expected. The population density of the hundred in 1761 is negative but highly imprecise. Column (2) includes county fixed effects. As a result, the sample size decreases from 8629 to 5253 because not all

counties had a steam engine. The results for all the variables are very similar except distance to ports. The coefficient in this case becomes smaller and is not precisely estimated.

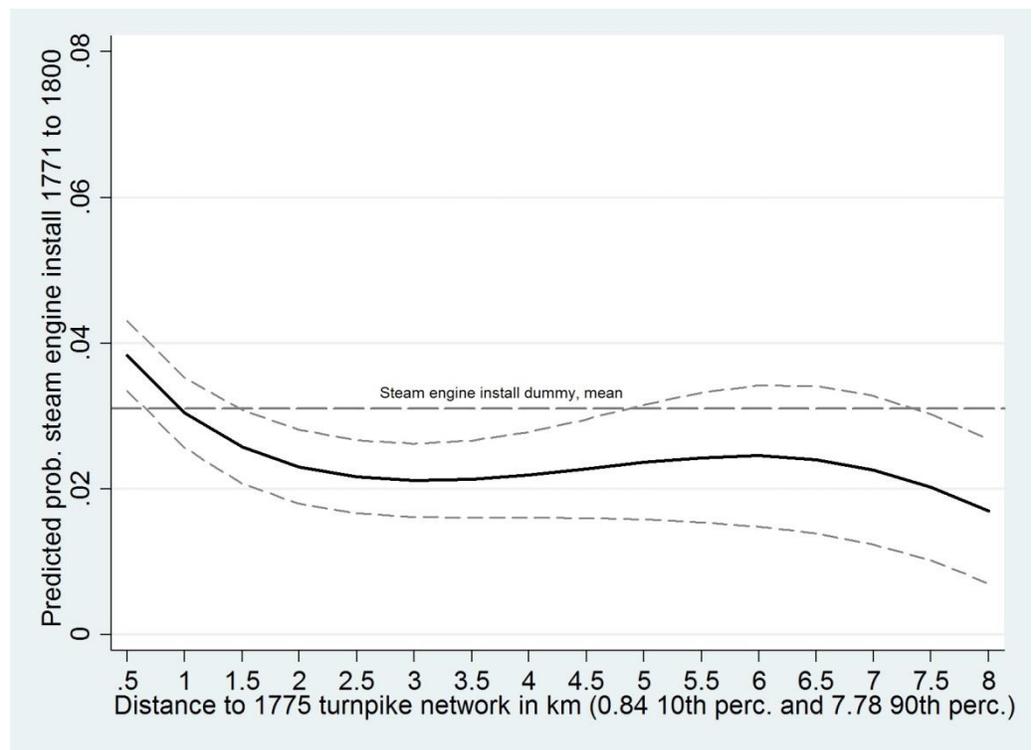
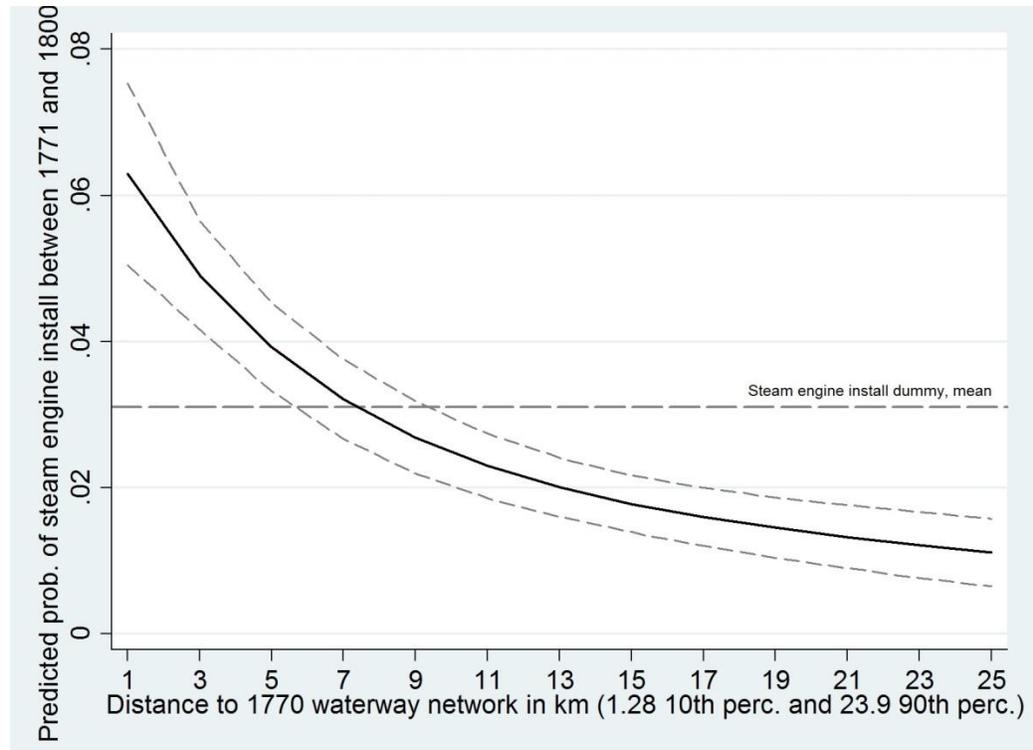
Table 2: Probability of adopting a steam engine between 1771 and 1800
Dep. Var.: 1 if a parish adopts at least one engine

variable	(1) Coeff. (Stan. Err.)	(2) Coeff. (Stan. Err.)
distance to nearest turnpike road 1775	-0.2249*** (0.0381)	-0.1891*** (0.0389)
distance to nearest inland waterway 1770	-0.0967*** (0.0140)	-0.0814*** (0.0166)
distance to nearest port	-0.0073* (0.0040)	-0.0040 (0.0070)
Indicator for coastal	1.431*** (0.2119)	1.658*** (0.2456)
Indicator for coal	2.9327*** (0.1904)	2.4660*** (0.2369)
pop. density hundred 1771	0.000011 (0.00001)	-0.000045 (0.000031)
controls for soils, elevation and ruggedness	Y	Y
county FE	N	Y
Pseudo R-square	0.3415	0.3502
N	8629	5253

Notes: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

We run another specification, where the distance to turnpike roads and inland waterways is captured by a third-order polynomial. The effects of varying distances on the probability of an engine being adopted are shown in figure 5. The mean probability of adoption is also shown. Moving just a few km away from a waterway significantly reduces the probability. For turnpikes the effects are less and greater very close to the turnpike road.

Figure 5: Probability of an engine being adopted as a function of the distance to inland waterways and turnpike roads



We also examine the effects of transport networks, coal, and coastal on the number of engines adopted if any were ever adopted. Those results from a negative binomial model show that distance to inland waterways has a large negative effect on the number of steam engines adopted. This holds irrespective of whether county fixed effects are included. Distance to turnpikes does not affect the number of engines installed. Being coastal and having coal are positively associated with the number of engines but the coefficients are only significant if county fixed effects are excluded. These results are available upon request.

VI. Conclusion

The steam engine was the quintessential invention of the Industrial Revolution. It revolutionized mining, textile manufacturing, transportation, and many other important economic sectors in England from the 18th century through the mid-19th century. One aspect of its history is concerned with the temporal and spatial adoption of the engine. There are several explanations as to why steam engines were adopted in a given location. One focuses on the abundance of coal, which was important because the steam engine required coal as fuel. Another focuses on alternative sources of energy like water power. The third focuses on demand factors, in particular industrial activity and urbanization.¹⁹

While the literature to date has made important progress, many issues are unresolved especially concerning the adoption of steam engines. For example, one potentially important factor that has received less attention is the role of transport innovations. This paper introduces a

¹⁹ See Nuvolari, Verspagen, and von Tunzelmann (2011) and Kitsikopoulos (2015) for research on adoption and diffusion.

several new datasets that allow us to address these issues for the first time. The first dataset includes new highly localized GIS data on where the majority of steam engines installed in Britain between 1700 and 1800. The second new dataset contains highly accurate GIS data on the locations of turnpike roads and inland waterways, specifically navigable rivers and canals. The third dataset contains boundary files for more than 9000 quasi-parish units. They are the smallest geographical units in England and Wales, which we construct and have consistent boundaries from 1801 to 1881.

In our empirical analysis we focus on how distance to transport networks c.1770 affected the probability of a steam engine being adopted and the number of engines adopted from 1771 to 1800. We also study the effect of having coal, being coastal, and having higher population density in 1771. Our preliminary results show that the probability of adopting at least one engine between 1771 and 1800 decreases with distance to the nearest turnpike road and inland waterway c.1700. We find a similar effect on the number of engines adopted between 1771 and 1800 but the effect is much larger for inland waterways than turnpike roads. Also as expected we find that having coal and being coastal are both positively related to the probability of adopting at least one engine and the number of engines adopted between 1771 and 1800. The findings shed new light on how transport improvements affected technology adoption during the industrial revolution.

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