Online Appendix for Resetting the Urban Network: 117-2012

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This is an online appendix for our paper "Resetting the Urban Network: 117-2012", and it contains three sections. First, Appendix A presents a simple model that explains how a town may become trapped in a bad location as result of historical accident. Second, Appendix B discusses in detail how we constructed our dataset. Finally, Appendix C examines a possible explanation for why France's towns survived in Roman era locations during the fifth and sixth centuries.

Appendix A. Model of Town Location

To frame our empirical analysis we construct a simple infinite-horizon discrete-time model of urban location. We assume that there is a population of measure one of identical, infinitely lived people. Each person maximizes the expected present discounted value of their consumption:

$$U_t = E\left[\sum_{s=0}^{\infty} \beta^t u\left(c_{t+s}\right)\right], \tag{1}$$

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where the period utility function $u(c_t)$ is strictly increasing in consumption, c_t, and $\beta \in (0,1)$ is the discount factor.

People may live in one of two locations, which are indexed by $i \in \{1,2\}$.[1] The contribution of locational fundamentals to productivity in location i is $\theta_i \in \{0, \theta_F\}$. We assume that the two locations differ in their productivity ($\theta_1 \neq \theta_2$), and that in the first period $\theta_1 = \theta_F$ and $\theta_2 = 0$. In each subsequent period there is a probability $p_F \geq 0$ that the locational advantage changes, because either the fundamentals themselves change, or their productivity changes, or both.[2]

We call a location where a positive mass of people work a town, and we assume that working in a town provides an (additive) productivity adjustment θ_T, over and above that of the locational fundamentals.[3] If agglomeration forces make towns more productive then we expect that $\theta_T > 0$, but our model also allows for cases where θ_T is zero or even negative, as long as $\theta_T + \theta_F \geq 0$.[4]

Since we are interested in cases where towns fail, we allow for an exogenous probability $p_T \in (0,1)$ that a town ceases to function for one period. During that period, worker productivity is determined solely by locational fundamentals, and in the subsequent period a town re-emerges in the location with more productive locational fundamentals.

We assume that the sequence of events within each period is as follows. First, each person costlessly chooses their location, taking current town location as given.[5] Second, each person inelastically supplies one unit of labour, receives the output that they produce, and consumes it. Third, nature

[1]Our model can be thought of as reflecting the choice of urban location within a given geographical region, which may be considerably smaller than a country. We assume only two locations for analytical tractability. In reality, of course, there may be many more, and the model can be extended to capture this, but without much gain in our economic intuition.

[2]In our model locational fundamentals affect only productivity, and do not affect utility directly. It would, however, be straightforward to add a difference in the utility of living in the two locations.

[3]Sunk investments may also increase productivity in an existing town location, and make path-dependence more likely. For a discussion of the consequences of durable housing in declining cities see Glaeser and Gyourko (2005). Modelling interdependence between towns in an urban network could similarly make path dependence more likely, since a town with poor first nature fundamentals may be complementary to an existent urban network. To keep the model simple and tractable, we do not include multiple towns or sunk costs in our model.

[4]Our formulation implicitly allows for increasing returns ($\theta_T > 0$), constant returns ($\theta_T = 0$), or decreasing returns ($\theta_T < 0$) in towns. If returns are strongly decreasing such that $\theta_T + \theta_F < 0$, however, the model has no equilibrium. We could write a more general model where in this case employment all concentrates in a non-urban sector, which is presently unmodeled. But this would complicate the framework without yielding additional interesting testable predictions, so we have opted to keep the model leaner.

[5]If people can coordinate then they can all relocate to a better location whenever an opportunity arises. But coordination is often difficult to achieve an in practice people often take the status quo locations as given.

determines locational advantage for the next period, with locational advantage changing with probability p_F. Finally, with probability p_T the town is disrupted for one period.

Equilibrium

In equilibrium, if a town is located in the more productive location, or if there is no town, the entire population flocks to the more productive location. If a town exists in the less productive location, each person still chooses to locate in the most productive location, which may be the location with more productive fundamentals if $\theta_F \geq \theta_T$ or the one with less productive fundamentals if $\theta_F < \theta_T$.[6]

This result allows us to characterize the model's equilibrium using three exhaustive and mutually exclusive scenarios, each of which corresponds to a set of parameter values. Scenario 1, which we call "Fixed locational advantage", corresponds to the case where $p_F = 0$. In this scenario location 1 is always more productive, and when a town is disrupted it always reemerges in that location. This scenario may be applicable to a rocky island with a limited area suitable for a town, or to an inhospitable desert bordering on a narrow coastal area which is more habitable.

Scenario 2, which we call "Changing locational advantage with stronger fundamentals", corresponds to the case where $p_F > 0$ and $\theta_F \geq \theta_T$. In this case, locational fundamentals (or their value) may change over time, and they are more important for productivity than being in a town. Therefore, the town always locates in the more productive location, which changes over time. When locational fundamentals (or their value) change, the town simply moves to the more productive location. This scenario may describe a situation where initially a town is more productive inland, where it can serve a larger agricultural hinterland; but later it is more productive on the coast, where trade costs are lower. In this scenario, the town relocates to the coast.

Finally, Scenario 3, which we call "Changing locational advantage with stronger towns", corresponds to the case where $p_F > 0$ and $\theta_F < \theta_T$. In this case locational fundamentals or their value

[6]We assume that in case of indifference people prefer the location with better fundamentals. Since people in the model are identical and move costlessly, they all co-locate in every period.

change, but the productivity advantage of being in a town is larger than that conferred by locational fundamentals. In this scenario, even if locational fundamentals change, the town will remain where it was. A town only relocates if it exogenously ceases to function, in which it reemerges the following period in the location that is then more productive.

In this scenario, a town may become "trapped" in a suboptimal location due to past decisions, which we refer to as "path dependence". Specifically, the utility from working in a town in the more productive location:

$$U_H = (\theta_F + \theta_T) + \beta \left\{ \begin{array}{c} (1 - p_F)(1 - p_T) U_H + (1 - p_F) p_T (\theta_F + \beta U_H) + \\ p_F (1 - p_T)(\theta_T + \beta U_L) + p_F p_T (\theta_F + \beta U_H) \end{array} \right\}$$

The utility from working in a town in the less productive location:

$$U_L = \theta_T + \beta \left\{ \begin{array}{c} (1 - p_F)(1 - p_T) U_L + (1 - p_F) p_T (\theta_F + \beta U_H) + \\ p_F (1 - p_T)(\theta_T + \theta_F + \beta U_H) + p_F p_T (\theta_F + \beta U_H) \end{array} \right\}$$

The difference in utility between locations is:

$$\Delta \equiv U_H - U_L = \theta_F + \beta \left\{ (1 - p_F)(1 - p_T)(U_H - U_L) - p_F (1 - p_T)(\theta_F + \beta (U_H - U_L)) \right\},$$

which simplifies to:

$$\Delta = \theta_F + \beta (1 - p_F)(1 - p_T) \Delta - \beta p_F (1 - p_T)(\theta_F + \beta \Delta),$$

which in turn simplifies to:

$$\Delta = \theta_F \left\{ 1 - \beta p_F (1 - p_T) \right\} / \left\{ 1 - \beta (1 - p_F)(1 - p_T) + \beta^2 p_F (1 - p_T) \right\} > 0.$$

This last expression implies that a central planner would have moved the town to the more productive location. Of course, this assumes that the (unmodeled) cost of moving a town is not too large.

We now distinguish between two variants of the third Scenario. In Scenario 3A, $\theta_F \approx 0$, so locational fundamentals barely affect productivity, and path dependence is inconsequential. In other words, a town may be "trapped" in an unfavourable location, but this location is so similar to the optimal location that this is of little consequence. One example of this scenario is a flat plain, in which every location is similar to the others. Another example is a flattish terrain with a slow-flowing river, where any locations along this river are similarly productive.

In Scenario 3B, $\theta_F \gtrnapprox 0$, so locational fundamentals significantly affect productivity, and path dependence is consequential. This means that towns can get trapped in suboptimal locations. For example, consider the situation described above in the second scenario, where the coast becomes more productive, but the existing town is located inland. In Scenario 3B, as long as the town remains intact, it will not move to the coast.

The framework we outline is intentionally simple, but we can still relate some of the existing evidence on the locations of towns over time to the scenarios above. For example, Davis and Weinstein (2002) find high persistence in the location of economic activity over time in Japan, which corresponds to Scenario 1. Acemoglu, Johnson, Robinson (2005) show that Atlantic ports grow faster after the discovery of the new world, which may be interpreted as consistent with Scenario 2. Redding, Sturm, and Wolf (2011) and Bleakley and Lin (2012) both find evidence for path dependence, but their work suggests that the locations in which economic activity ended up concentrating are not significantly inferior to others, which is broadly consistent with Scenario 3A. Evidence for consequential path dependence, as in Scenario 3B, is rare, and typically comes from settings involving technology selection, rather than from economic geography (see for example David 1985).

Testable implications

Appendix Table A13 summarizes the parameter value combinations, theoretical implications and empirical implications of the different scenarios outlined above. The model is deliberately simple and stylized, and parameter values may vary across towns within each country, but we can draw some distinctions between the predictions of the different scenarios. If Scenario 1 is empirically relevant, then we expect a high persistence of town locations relative to their Roman counterparts in both France and Britain, because locational fundamentals pin towns to a fixed set of locations. If Scenario 2 is relevant, then we expect a lower persistence of town locations in both countries, because the changing value of fundamentals from the Roman to the medieval eras makes towns relocate to more favourable sites, regardless of whether the urban network was hit by a calamity. If Scenario 3 is relevant, however, then we expect higher persistence of locations relative to their Roman counterparts in France than in Britain. This is because the calamity that wiped out Britain's urban network allowed it to move to more favourable sites, while France's urban network is largely fixed to its Roman locations.

Another empirical prediction shared by Scenarios 1, 2, and 3A is that the improvement in suitability of locations from the Roman to the medieval eras (as judged by medieval economic conditions) should have been similar in Britain and France, although for different reasons. In Scenario 1 this is because a fixed set of locations is optimal for both eras. In Scenario 2 it is because the set of optimal locations changes, but towns everywhere follow. And in Scenario 3A it is because the best locations and the next-best locations are similarly suitable. In contrast, in Scenario 3B, Britain's towns will have relocated to sites that are more favourable given the prevailing medieval conditions, while in France there would not be much change in the suitability of locations from the Roman to the medieval eras.

Appendix B. Data Description

This data appendix contains a detailed description of our data construction process. To ensure that it is self-contained, this appendix includes explanations that are provided in the main text as well as additional details.

We construct our dataset around a grid of points, which allows us to consider all potential locations for towns within the areas we analyse. The small size of the squares of our grid, each covering an area of one square kilometre, enables us to differentiate locations that are close by and yet differ in their fundamentals or in their urban histories. Further reducing the size of the grid would not have substantially improved accuracy, since town location cannot be meaningfully measured with higher precision. And from a practical standpoint, our chosen grid size is computationally manageable. In our empirical analysis, we typically allow for 5km bands around locations, to account for possible measurement error.

Using Geographic Information System (GIS), we begin with a grid that covers the entire land area of the Roman Empire at the time of its greatest extent, around the death of Emperor Trajan in 117CE.[7] At the time the Roman Empire had a land area of about 5 million square kilometres (Taagepera 1979). The Roman Empire spanned the area around the Mediterranean (North Africa, the Levant, and southern Europe) and stretched as far north as the Danube and the Rhine, and in some cases (as in present-day Romania and Britain) even further. We focus most of our analysis on Britain and France, which had similar histories during the Roman and Norman eras.[8] This leaves us with a dataset of 697,198 grid points. In some of our robustness checks we also use data on all the northwestern provinces of the Roman Empire, which presently lie within the United Kingdom,

[7]Data on the boundaries of the Roman Empire and its partition into provinces are from the Digital Atlas of Roman and Medieval Civilization (McCormick et al. 2013). The shapefiles with the location of the land and coastlines, and of present-day countries, are from the Economic and Social Research Institute (2010).

[8]We analyse Britain as far north as Hadrian's Wall, since Roman occupation north of that line was tenuous and did not lead to lasting urbanization. In both Britain and France we include proximate islands in Europe if they are either large enough (at least 1,000 square kilometres) or close enough (within 10km) to their respective mainlands. Thus in Britain we include two nearby islands (Isle of Wight and Anglesey) but not those further away (e.g. Isles of Scilly, Isle of Man, and the Channel Islands) or further north than Hadrian's Wall (e.g. Hebrides and the island groups of Orkney and Shetland). Although Corsica is further from France, we do include it in our data, since it is considerably larger than the other islands.

France, Belgium, Luxembourg, Netherlands, Germany, and Switzerland.[9]

To this grid we add, using GIS, data on a number of locational fundamentals. These include a measure of elevation in meters using a 3x3km grid of elevation (ESRI 2010). We compute the elevation of each of our grid points using inverse distance weighted interpolation (IDW), a technique that computes local averages of elevation for points with unknown elevation using points with known elevation, giving smaller weight to input grid points further away. Thus every elevation point of the input map influences the local average that we compute, but the more distant points carry less weight in the computation. The power function that determines the weights is computed endogenously in GIS by minimizing the root mean square prediction error. This is the standard technique for solving this type of problem, and its application to estimate elevation for unknown points from known points is explicitly given in the GIS help files**.** In coastal areas our calculation sometimes results in negative elevation numbers, since the Global GIS datasets records the elevation of the ocean floor; in these cases we convert negative elevation values to zero elevation.

Using this measure of elevation and our grid points, we compute a measure of ruggedness, following Nunn and Puga (2012) and Riley et al. (1999). Let $e_{r,c}$ denote elevation at a grid point located in row r and column c of a grid of elevation points. Then the ruggedness is computed as $\sqrt{\sum_{i=r-1}^{r+1} \sum_{j=c-1}^{c+1} (e_{i,j} - e_{r,c})^2}$. This measure considers squared deviations of elevations for each point with respect to the eight points that immediately surround it.[10]

We also calculate the closest distance from each grid point to the coast (using ESRI 2010) and to the nearest navigable river (using Historical GIS for European Integration Studies 2013). We use two different definitions of navigable rivers: the first covers rivers classified as "Commercial International", "Commercial Regional or National", and those suitable for "Large Motor Yacht" or "Cabin Cruisers"; the second covers all navigable rivers, adding to those above rivers accessible only to

[9]We use modern country border shapefiles from Eurostat (2013). We do not analyse Italy, which lay at the heart of the Roman Empire and was therefore more heavily urbanized, and Spain and North Africa, whose subsequent histories differed due to the Muslim conquest.

[10]Where a grid point falls at the edge of a map and some of its neighbours are missing, we assume the elevations in these missing locations to be zero.

"Open Boats".[11] We also compute measures of distance to each of the two types of navigable rivers where we manually restrict the shapefiles of these rivers to those that flow into the ocean or a sea. The river maps we obtain are not GIS shapefiles, but images that we digitize. We georeference these images, and transform them into shapefiles using colour recognition features in GIS. This process has some limitations: (i) Rivers digitized that way from images tend to be wider than in reality. (ii) In a few instances the software misclassifies borders or names as rivers, and we corrected these mistakes manually. (iii) Georeferencing results in some imprecision, which we believe, however, to be minor. Based on these measures we use Stata to construct indicators for each grid point for whether it is within 5km of: (a) the coast or a (narrowly defined) navigable river, which flows into the ocean or a sea ("Coastal access I"); or (b) the coast or a navigable river (broadly defined), which flows into the ocean or a sea ("Coastal access II").

Having discussed the measurement of the terrain, we now move on to the human aspects of geography. Our main source of data on modern towns (including cities) is the World Gazetteer (2012), which compiles population data from official national statistical agencies.[12] Based on these official data the website provides an estimate of each town's 2012 population. We focus our analysis of modern towns on those with estimated populations of 10,000 or more in 2012. For the vast majority of towns, the World Gazetteer also provides the coordinates of each town, typically quite close to its centre.[13] We use these coordinates to assign each town to the grid point that is closest to it.[14] To avoid the inclusion of towns that lie outside the grid, we restrict the match to towns that are within a

[11] We acknowledge that the shapes of some rivers have changed since the Middle Ages (or the Roman era for that matter), but accounting for changes in navigability is difficult in practice. For example, see debates discussed in Blair (2007) regarding the extent of navigability of British rivers in the early and late Middle Ages. We therefore use present-day navigability to proxy for historical navigability.

[12] For example, the site contains 1,000 such units in the United Kingdom and 1,000 in France. The smallest of the towns in each of the countries we use (listed above) are estimated to have had fewer than 10,000 people in 2012.

[13] We cross-checked a sample of the coordinates against Google Maps website and typically the coordinates were within fewer than 5km of each other, although towns are clearly not points and some measurement error is unavoidable. In cases where coordinates were missing from the World Gazetteer, we added them in manually using additional sources listed below.

[14] In four cases a single grid point is matched to more than one town, in which case we select the largest matched town, as ranked by population. We thus lose Vosselaar due to its proximity to Beerse, Bourg-la-Reine because of Sceaux, Saint-Ouen-l'Aumone due to Pontoise and Voisins-le-Bretonneux due to Montigny-le-Bretonneux.

distance of 1km from the grid point that they are matched with. Because of minor mismeasurement problems in our data, some coastal towns appear to be further away than 1km from their nearest grid point. This problem pertains to 19 towns in Britain, 2 in Belgium and 15 in France. In these cases, we manually match these towns to the nearest grid point to ensure that our data spans all the modern towns in the area we analyse. Finally, in four cases, towns appeared just across national borders from their actual countries, and in these cases we corrected the country identifier of each town.

The resulting dataset with modern towns (and their names and locations) provides the basis for matching into the grid the locations of earlier towns and sites, most of which are only identified by name and locality (typically from maps). The combination of name and locality allows us to match most of our historical data. Where no matches were possible, we used other sources, including the Getty Thesaurus of Geographic Names (Getty 2013), a gazetteer that includes many antique and old spelling versions of many town names. For locations that we still cannot match, we turn to Bairoch et al. (1988), which includes coordinates of the towns it lists.[15] We also use the Ordnance Survey Historical Map Roman Britain (2011) and the Catholic Encyclopedia (1907), which contain useful information on old places in Europe. We track the few remaining units that do not show up in any of these sources using a general search on the internet. After obtaining coordinates for these towns we create a map for each of these data sources and merge that map with our 1km grid using GIS software.

In reconstructing the historical populations of towns we use (like many researchers before us) the estimates provided by Bairoch et al. (1988). Unfortunately, this source covers French towns from 800CE and Britain towns only from 1000CE, so to look further back in time we required other sources of data.[16] In tracing the origins of western European urbanization back into the first millennium, we tried to balance a number of criteria. First, we wanted measures that capture the spatial concentra-

[15]In a few cases we identified inaccuracies with some of the coordinates data in Bairoch et al. (1988), which is why we preferred to rely on the sources above where possible.

[16]Chandler (1987) provides earlier population estimates for some towns, but unfortunately too few in for statistical analysis in present-day Britain and France.

tions of economic activity, which typically characterize towns. Second, we sought where possible to obtain estimates made in recent years, reflecting knowledge that has been built up by historians and archaeologists. Third, we looked for town definitions that were as comparable as possible for the areas that make up present-day Britain and France. Fourth, when considering post-Roman urbanization in particular, we searched for measures of urbanization dating back as early as possible in the medieval era, even if in some cases the locations can only be thought of as proto-towns, rather than fully-fledged ones. Finally, wherever possible, we aimed for definitions that covered more than a handful of sites in both Britain and France, in order to facilitate a meaningful statistical analysis, starting with the pre-Roman era.

Some scholars (e.g. Wacher 1978 and Woolf 1998) conclude that pre-Roman northwestern Europe was largely a pre-urban world. Nevertheless, this world, which was largely populated by Celtic tribes, had some settlements with features that we might recognize as urban (or proto-urban), such as the use of coins. To identify the location of these pre-Roman settlements, we use data from Fichtl (2005) on Iron Age *oppida*.[17] This source lists 107 *oppida* in France, but only 11 *oppida* in Britain, so we also use map 3:3 from Jones and Mattingly (1990) to locate other important Iron Age settlements in Britain, which may be viewed as harbingers of British urbanization.[18]

When it comes to measuring Roman-era towns, we face the challenge that different authors define Roman towns differently, and arrive at different lists of towns. To mitigate this problem, we do not rely on just one particular definition a "Roman town", but instead use three different definitions. Our first (baseline) measure is an indicator for Roman towns using classical references: Wacher (1995) for the main towns of Britain, Burnham and Wacher (1990) for the "small towns" of Britain, and Bedon (2001), for Roman towns of various sizes in France.[19] Each of these sources describes every town in

[17] According to www.oppida.org, which contains a list of oppida similar to Fichtl (2005): "*Oppidum* (plural *oppida*) was the name used by Caesar to describe the Celtic towns that he discovered during his conquest of Gaul. In archaeology, the term is now used to describe all fortified Celtic sites covering a minimum area of 15ha and dating back to the second half of the 2nd and 1st centuries BC (the late La Tène period). These towns were both economic and political centres."

[18] In all but one of the cases, the oppida that Fichtl (2005) reports in Britain are also covered in Jones and Mattingly (1990).

[19] We are grateful to Greg Woolf and Penelope Goodman for advice on these data sources.

considerable detail, using both historical and archaeological records.[20] These sources reveal many similarities between the Roman towns in Britain and France, as one might expect from neighbouring areas within the empire. In particular, larger Roman towns in both Britain and France had civil, commercial, and residential buildings that served a broad range of economic functions, whereas smaller towns typically had a more limited range of buildings, mostly residential and commercial. As Appendix Table A1 shows, our baseline sample includes 74 Roman towns in Britain and 167 Roman towns in France. Panel C of the table also reports separately the number of Roman towns in northern France, defined using the two Trajan provinces of the Roman Empire (Belgica and Lugdunensis). The table also shows that the Roman towns in Britain were quite similar to their counterparts in France in their origins (pre-Roman or Roman) and their coastal access, although towns in France were generally located in higher elevations and in more rugged terrain.[21] Our empirical methodology allows us to control for pre-existing differences in locational fundamentals.

Our second measure of towns uses the size of defended (walled) area of towns. Since precise population estimates for towns are unavailable, there is a long tradition of using walled areas to construct estimates of population, and this methodology is still widely used.[22] We apply a specific cutoff - having at least 5 hectares of walled area - for selecting the larger Roman towns. One advantage of this approach is that it allows us to cover not on Britain and France, but also other parts of northwestern Europe, as we explain below. This approach also has limitations: some Romans lived outside the walls (see Goodman 2007); even within the walls population densities may have differed; and some important Roman towns, especially in France (e.g. Marseille) did not have town walls. Nonetheless, this approach provides a useful complement to our baseline definition of Roman towns. The data we use on the size of walled areas come from recent estimates for Britain (Mattingly 2006), France

[20] Other sources, such as Millet (1990) and Ordnance Survey (2011), contain even longer lists of towns for Roman Britain but with less detail on each than Wacher (1995) and Burnham and Wacher (1990). Tassaux (1994) and Petit et al. (1994) include longer lists of agglomerations in parts of France, but they do not cover the entire country, nor do they provide as much detail as Bedon (2001).

[21] For more details on the origins of the Roman towns, see below.

[22] For a recent discussion of this methodology and its applications, see Bowman and Wilson (2011).

(Bedon 2001), and the rest of northwestern Europe (Esmonde-Cleary 2003).[23] It is probable that each town with 5 hectares or more of defended area had at least of 500-1000 people (see for example Bowman and Wilson, eds., 2011) and at most tens of thousands of people.[24] The specific size cutoff we apply is due partly to data limitations (Mattingly 2006 does not list smaller towns), but also because coverage of walled areas for smaller towns might not be as complete (see for example Millet 1990 and Bowman and Wilson, eds., 2011). As Table A1 shows, Roman towns with walled areas of 5 hectares or more number 38 in Britain (with an average log walled area in hectares of 2.93) and 58 in France (with an average log walled area in hectares of 2.96), of which 30 are in northern France (with an average log walled area in hectares of 2.78). The similarity of these figures suggests that in terms of their population, the towns of Roman Britain were not too dissimilar from those of France. Moreover, a comparison of the walled areas of Roman towns in Britain and northern France suggests that it is highly improbable that urbanization survived in northern France and not in Britain because Britain's towns were vastly inferior.

Our third definition of Roman towns relies on administrative usage of the Romans themselves. Each Roman administrative towns was classified as either *colonia, municipium* or "*civitas* capital".[25] *Colonia* was originally the name for Roman towns for retired soldiers, and this term was later used for the highest rank of Roman cities in the provinces. *Municipium* was a Roman town with some administrative functions, which was in principal not as prestigious as a colonia. Lastly, a *civitas* capital was a regional administrative town, which often served a particular local tribe. While these definitions had some relevance, they became less important over time, as more people within the Roman Empire became Roman citizens. One drawback of using the administrative definitions, is the imperfect correlation between these definitions and towns' actual size and economic importance.

[23] We cross-checked a sample of the estimated size of defended areas against earlier estimates, for example by Millet (1990) for Britain and Lot (1945) for France, and found that they were quite similar.

[24] Fleming (2010) argues that the population of Roman London may have reached 30,000, and Bowman and Wilson (2011) estimate that a few Roman-era French towns exceeded 10,000 people.

[25] At the very bottom of the Roman administrative hierarchy were local centers known as *pagi*, but our evidence on the location of *pagi* in Britain is almost nonexistent, so we do not use the *pagi* classification in our analysis.

Another limitation is that while a fairly comprehensive list of administrative towns in the late Roman Empire in France - the *Notitia Galliarum* - appears to have survived (see for example Harris 1978), we have no comparable list for Britain. The list of administrative towns that have been identified in Britain (even including towns with possible administrative roles) is shorter, and may be incomplete. In total our dataset includes 24 administrative Roman towns in Britain and 110 in France, of which 46 are in northern France, as defined above (we use Mattingly 2006 for Britain and Bedon 2001 for France).

We complement the data on the location of Roman towns using these three definitions with additional information. We use data from Bedon (2001) to identify Roman towns that had bishops in the fourth century.[26] To identify whether the Roman towns had pre-Roman origins, we use Millet (1990) for Britain and again Bedon (2001) for France.[27]

During its post-Roman period, from 450-600CE, Britain had no functional towns (as discussed in Ward-Perkins 2001, Palliser 2001, Fleming 2010, Mattingly 2006, and Nicholas 1997), while in France many towns survived. From the seventh century onwards, trading settlements known as emporia (or "wics") began to emerge in Britain (Fleming 2010). These emporia had some urban features (and are sometimes described as "proto-urban"), but only few such sites have been identified in Britain, and they have almost no counterpart in France (Quentovic being a rare exception), making a quantitative analysis impractical.

Our first measure of post-Roman urbanization identifies the seats of bishops (including archbishops), known as bishoprics, from 700-900 (Reynolds 1995). From these locations bishops exercised power at a time when the church was central for many aspects of life. The bishops and their followers also produced and consumed various products and services, sustaining a spatial concentration

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[26]We include towns where Bedon specifies that the existence of a fourth-century bishop is uncertain. There is, however, much greater uncertainty on the location of Roman-era bishops in Britain, so we use the Roman bishop identifier for France only.

[27]Note that this measure of pre-Roman origins may include relatively minor settlements, and is therefore different from the measures of main Iron Age settlements described above (which also include Iron Age settlements that did not develop into Roman towns).

of economic activity (Fleming 2010 and Nicholas 1997). The bishoprics thus provide a window into early post-Roman (proto) urbanization.

Our next measure of (proto) urbanization is more directly related to the location of economic activity in early medieval Europe, namely the minting of coins. While the size and importance of early mints varied considerably, their presence suggests a concentration of local economic activity for a period where good measures of economic activity in both Britain and France are difficult to come by. We use data from Spufford (1988), who describes the location of mints in Carolingian and post-Carolingian France and in pre-Norman Britain (from 768-1066).

The main advantage of using bishoprics and mints is that they allow us to track the early stages of urbanization in Britain and France. For later years, however, we have more direct and conventional measures of urban activity in the form of population estimates. As discussed above, Bairoch et al. (1988), which is a standard reference, reports town population estimates for Britain only from 1000 onwards, and in the first few centuries of the second millennium the number of British towns it covers is very low - only 14 in 1000 and 5 in 1100. In contrast, Holt (2000), when discussing Britain's urban population in 1086, writes that "Estimates of the size of individual towns based on the recorded number of houses or of tenants (as presented in Appendix 2) must of necessity be cautious, producing minimal figures; even by that reckoning, however, some thirty-six towns had a population greater than 1,000." Given our focus on the location of towns, albeit small, we construct an indicator for towns with 1,000 people or more in Britain or France, using any town with estimated population in this range from Bairoch et al. (1988) for 1000-1200 or Dyer (2000) - the above mentioned appendix, which is based on the Domesday Book.[28] While this approach has its drawbacks (it may for example miss small towns in France if they are excluded from Bairoch et al. 1988) it permits a quantitative analysis of the location of early towns in both Britain and France.

[28]In Britain we include all towns listed by Dyer (2000) as towns of categories I, II, III and IV. These include 36 towns mentioned in the Domesday Book, plus London and Bristol, which are included in Dyer (2000) despite their omission from the Domesday Book.

Despite its limitations, Bairoch et al. (1988) is our main source for the population of towns for each century from 1200-1800. Because of the selection problems related to smaller towns, we focus on towns with at least 5,000 inhabitants. Since town populations grew rapidly during the industrial revolution, we use an additional population threshold of 10,000 inhabitants or more for towns in 1800.

Because the medieval era is important for our analysis, we also use Russell (1972) as alternative estimate of town populations circa 1300, before the onset of the Black Death. From Russel's estimates we again construct an indicator for towns with 5,000 people or more, as we do using the estimates of Bairoch et al. (1988) for that period.

For the period following the Black Death we construct an indicator for the 50 most populous towns in Britain and France. This measure takes the largest 50 towns as reported by Bairoch for 1400, and adds the 50 largest town in Britain as measured by the number of taxpayers based on the poll taxes of 1377-1381, as reported in Dyer (2000).[29] While the size of towns included in this measure most likely differs between Britain and France, this measure helps us understand the location of towns up to a fixed threshold in the town size hierarchy.

Finally, to examine individual towns that are locally important, irrespective of their absolute or relative size within a country, we compute arbitrary grid cells of 100 kilometres by 100 kilometres using an equal area projection in GIS. We then compute indicators for the largest towns within each of these cells for each century from 1200-1800 (using Bairoch et al. 1988) and for 2012 (using the World Gazetteer 2012). We also use these same cells to cluster the standard errors in our empirical analysis.

[29]Bairoch et al. (1988) list only 21 towns in Britain for that year, including 10 of 5,000 people or more. For France it lists 60 towns, including 38 with 5,000 people or more.

Appendix C. Why France's Urban Network Stayed

We have found that many French towns remained in Roman-era town sites that were suboptimal in terms of their (first nature) locational fundamentals. This result is perhaps unsurprising in periods when towns are highly productive ($\theta_T \gg 0$). But this description is probably ill-suited for the towns in France following the fall of the Western Roman Empire, in the fifth and sixth centuries. To complete the picture and explain why many French towns' location persisted through this difficult period, we examine the possible role of bishops. As Nicholas (1997) and Wickham (2009) discuss, bishops played important roles in town life in France after the fall of the Western Roman Empire. In addition to their religious duties, bishops often also had administrative and political roles. The bishops and their followers also provided services for the surrounding countryside, so towns remained important focal points. Finally, the goods and services consumed by the bishops and their followers meant that towns in France continued to concentrate economic activity even when urbanization reached a nadir after the fall of Rome.

Nicholas (1997), quoted above, suggests that bishops may have instrumental in the survival of towns in France after the fall of the Roman Empire. While the location choice of bishops in the late Roman Empire was potentially endogenous, we examine, at least descriptively, the hypothesis that Roman towns in France with bishops survived better than others. To examine this hypothesis, we estimate regressions as in specification (**??**), but this time adding as a control an indicator for fourth-century bishoprics in France. The results in Table A14 suggest that Roman-era towns with fourth-century bishops were significantly more likely to have survived throughout the Middle Ages and up until the present-day.

What is perhaps even more interesting, however, is that Roman-era towns in France without fourth-century bishops were quite similar to their counterparts in Britain in terms of their survival rate, at least until the dawn of the Industrial Revolution. In Appendix Tables A15 and A16 we present a set of robustness checks for this result, using different definitions of proximity, Roman towns, areas in continental Europe, and geographic controls. The general picture that emerges is that in the post-Roman era towns in France without a late-Roman bishop displayed fairly low survival rates, which were typically comparable to those in Britain.

Appendix Table A1. Descriptive statistics for Roman and later towns

	(1) Number of towns	(2) Coastal access I	(3) Coastal access II	(4) Coast	(5) Eleva-tion in meters	(6) Rugg-edness	(7) Pre-Roman origin	(8) Iron Age settle-ment	(9) Roman towns with walled area ≥ 5ha	(10) Ln(walled area) in towns with walled area ≥ 5ha
A. Britain										
Roman baseline town	74	0.41	0.50	0.09	77	117	0.38	0.11	38	2.93
Town with 1k+ people, 1086-1200	48	0.67	0.78	0.29	50	96	0.17	0.10	-	-
Town with 5k+ people in 1200	15	0.80	0.80	0.33	41	99	0.20	0.13	-	-
Town with 5k+ people in 1700	44	0.66	0.77	0.27	64	126	0.11	0.05	-	-
B. France										
Roman baseline town	167	0.33	0.51	0.13	251	564	0.37	0.10	58	2.96
Town with 1k+ people, 1086-1200	85	0.35	0.55	0.12	193	566	0.32	0.14	-	-
Town with 5k+ people in 1200	62	0.37	0.58	0.10	185	481	0.35	0.16	-	-
Town with 5k+ people in 1700	169	0.36	0.53	0.13	183	463	0.17	0.09	-	-
C. Northern France: Belgica and Lugdunensis only										
Roman baseline town	63	0.40	0.57	0.10	136	268	0.32	0.16	30	2.78
Town with 1k+ people, 1086-1200	32	0.47	0.69	0.06	103	280	0.31	0.22	-	-
Town with 5k+ people in 1200	26	0.42	0.65	0.04	100	230	0.27	0.19	-	-
Town with 5k+ people in 1700	87	0.43	0.60	0.11	108	220	0.13	0.11	-	-

Notes: Columns (1) and (9) report counts, columns (2), (3), (4), (5), (6), (7), (8), and (10) report means. Coastal access measure I: within 5km of the coast or of a major navigable river which leads to the coast. Coastal access measure II: within 5km of the coast or of any navigable river which leads to the coast. See the text for a description of the dataset and the sources for each of the other variables.

Appendix Table A2. Largest 20 cities in Britain, France and Northern France

Britain		France		Northern France		Britain		France		Northern France	
Ranked by Bairoch 1700 population	5km of Roman town	Ranked by Bairoch 1700 population	5km of Roman town	Ranked by Bairoch 1700 population	5km of Roman town	Ranked by 2012 population	5km of Roman town	Ranked by 2012 population	5km of Roman town	Ranked by 2012 population	5km of Roman town
London	1	Paris	1	Paris	1	London	1	Paris	1	Paris	1
Bristol	0	Lyon	1	Rouen	1	Birmingham	0	Marseille	1	Nantes	1
Norwich	0	Marseille	1	Lille	0	Liverpool	0	Lyon	1	Lille	0
Newcastle	0	Rouen	1	Nantes	1	Leeds	0	Toulouse	1	Rennes	1
Birmingham	0	Lille	0	Versailles	0	Sheffield	0	Nice	1	Reims	1
Liverpool	0	Bordeaux	1	Orleans	1	Manchester	0	Nantes	1	Angers	1
Manchester	0	Nantes	1	Amiens	1	Bristol	0	Strasbourg	1	Le Havre	0
Exeter	1	Versailles	0	Caen	0	Cardiff	0	Lille	0	Amiens	1
Leeds	0	Toulouse	1	Dijon	1	Leicester	1	Montpellier	0	Tours	1
Plymouth	0	Strasbourg	1	Rennes	1	Bradford	0	Bordeaux	1	Dijon	1
Chester	0	Orleans	1	Metz	1	Kingston	0	Rennes	1	Le Mans	1
Coventry	0	Amiens	1	Brest	1	Coventry	0	Reims	1	Brest	1
Nottingham	0	Caen	0	Angers	1	Plymouth	0	Angers	1	Orleans	1
Sheffield	0	Montpellier	0	Reims	1	Derby	0	Le Havre	0	Metz	1
York	1	Dijon	1	Nancy	0	Stoke-On-Trent	0	Toulon	1	Rouen	1
Great Yarmouth	0	Rennes	1	Douai	0	Nottingham	0	Saint-Etienne	0	Boulogne	0
Worcester	1	Metz	1	Troyes	1	Wolverhampton	0	Grenoble	1	Argenteuil	0
Sunderland	0	Brest	1	Valenciennes	0	Southampton	0	Aix-Provence	1	Saint-Denis	0
Bath	1	Nîmes	1	Abbeville	0	Portsmouth	0	Nîmes	1	Nancy	0
Portsmouth	0	Avignon	1	Arras	1	Dudley	0	Limoges	1	Caen	0

Notes: Top 20 most populated cities ranked by 1700 (left half) and 2012 (right half) populations. Northern France consists of the Roman provinces of Lugdunensis and Belgica. To rank towns with identical 1700 population we use 1600 population. No towns with equal populations to those displayed in a given year are excluded.

Appendix Table A3. Robustness checks for the probability of towns (700-1500) within 5km of Roman towns

	Bishopric or Arch-bishopric 700-900	Coin Mint 768-1066	Town with 1k+ people 1086-1200	Town with 5k+ people in 1200	Town with 5k+ people c.1300 (Russell)	Town with 5k+ people in 1300	Largest 50 towns 1377-1400	Town with 5k+ people in 1400	Town with 5k+ people in 1500
Panel A: Same as baseline, but using 10km radius instead of 5km radius									
Ratio Britain	4.46	2.52	3.27	3.58	2.99	2.63	2.95	3.72	3.13
Ratio France	10.06	8.30	8.14	8.55	10.47	8.28	8.06	7.69	7.43
Ratio Britain / France	0.44	0.30	0.40	0.42	0.29	0.32	0.37	0.48	0.42
p-value[1]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.001
Panel B: Same as baseline, but using 0km radius instead of 5km radius									
Ratio Britain	1,403	465	744	1,336	1,145	859	633	1,432	1,169
Ratio France	19,712	8,761	7,455	8,696	31,210	8,064	6,377	5,706	4,380
Ratio Britain / France	0.07	0.05	0.10	0.15	0.04	0.11	0.10	0.25	0.27
p-value[1]	0.003	0.000	0.000	0.008	0.043	0.017	0.015	0.054	0.018
Panel C: Same as baseline, but using only Trajan provinces of Britannia, Belgica, and Lugdunensis									
Ratio Britain	13.12	6.52	9.79	10.93	9.78	8.08	8.62	10.93	9.91
Ratio France	42.91	30.73	33.87	30.45	39.92	29.46	28.26	27.27	24.58
Ratio Britain / France	0.31	0.21	0.30	0.36	0.25	0.27	0.31	0.40	0.40
p-value[1]	0.000	0.000	0.000	0.013	0.000	0.008	0.008	0.044	0.014
Panel D: Same as baseline, but using only Roman towns with defended areas of 5ha or more									
Ratio Britain	19.14	10.79	15.68	21.29	19.04	15.74	12.58	21.29	13.77
Ratio France	59.59	61.58	55.05	61.63	76.47	58.58	68.50	65.80	50.39
Ratio Britain / France	0.32	0.18	0.29	0.35	0.25	0.27	0.18	0.32	0.27
p-value[1]	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Panel E: Same as baseline, but using only Roman towns with defended areas of 5ha or more in all Northwest Europe									
Ratio Britain	19.14	10.79	15.68	21.29	19.04	15.74	12.58	21.29	13.77
Ratio France	62.72	59.71	41.82	49.49	60.15	35.23	79.88	38.69	32.62
Ratio Britain / France	0.31	0.18	0.38	0.43	0.32	0.45	0.16	0.55	0.42
p-value[1]	0.000	0.000	0.000	0.003	0.001	0.069	0.000	0.112	0.040
Panel F: Same as baseline, but using only Roman administrative towns									
Ratio Britain	25.23	12.05	17.72	28.07	30.16	24.93	16.59	33.71	21.80
Ratio France	52.59	43.67	42.12	45.18	55.99	44.74	44.21	42.47	35.13
Ratio Britain / France	0.48	0.28	0.42	0.62	0.54	0.56	0.38	0.79	0.62
p-value[1]	0.009	0.000	0.001	0.186	0.075	0.127	0.001	0.530	0.266
Panel G: Same as baseline, but using only Roman towns with pre-Roman origins									
Ratio Britain	21.63	8.60	13.66	14.41	6.44	0.000	9.95	11.52	14.94
Ratio France	43.66	40.86	39.25	44.57	54.92	42.57	42.62	40.94	39.56
Ratio Britain / France	0.50	0.21	0.35	0.32	0.12	0.00	0.23	0.28	0.38
p-value[1]	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005
Panel H: Same as baseline, but with geographic controls and their Britain interactions									
Ratio Britain	9.57	5.27	8.66	11.20	10.49	9.09	8.38	9.50	10.35
Ratio France	56.11	43.46	40.46	44.02	59.56	38.59	30.45	28.47	28.86
Ratio Britain / France	0.17	0.12	0.21	0.25	0.18	0.24	0.28	0.33	0.36
p-value[1]	0.000	0.000	0.000	0.001	0.000	0.011	0.001	0.011	0.010

Notes: The number of observations is 697,198, except in Panel C in which it is 396,228 and in Panel E in which it is 906,076. Robust standard errors are clustered to account for spatial correlation.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France $\neq$ 0

Appendix Table A4. Robustness checks for the probability of towns (1600-2012) within 5km of Roman towns

	Town with 5k+ people in 1600	Town with 5k+ people in 1700	Town with 10k+ people in 1700	Town with 5k+ people in 1800	Town with 10k+ people in 1800	Town with 10k+ people in 2012	Town with 20k+ people in 2012	Town with 50k+ people in 2012	Town with 100k+ people in 2012
Panel A: Same as baseline, but using 10km radius instead of 5km radius									
Ratio Britain	2.45	2.72	2.79	1.96	2.32	1.39	1.51	1.83	1.74
Ratio France	5.79	5.23	7.60	4.19	7.38	3.20	4.63	7.32	8.99
Ratio Britain / France	0.42	0.52	0.37	0.47	0.31	0.44	0.33	0.25	0.19
p-value[1]	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panel B: Same as baseline, but using 0km radius instead of 5km radius									
Ratio Britain	668	590	668	268	321	74	97	184	297
Ratio France	2,738	2,380	5,256	1,529	4,487	364	688	2,160	7,392
Ratio Britain / France	0.24	0.25	0.13	0.18	0.07	0.20	0.14	0.09	0.04
p-value[1]	0.000	0.000	0.001	0.000	0.000	0.007	0.033	0.057	0.024
Panel C: Same as baseline, but using only Trajan provinces of Britannia, Belgica, and Lugdunensis									
Ratio Britain	7.54	7.42	7.01	4.55	5.62	2.07	2.54	3.44	4.15
Ratio France	18.85	18.83	25.83	14.27	27.22	7.20	11.96	21.04	30.34
Ratio Britain / France	0.40	0.39	0.27	0.32	0.21	0.29	0.21	0.16	0.14
p-value[1]	0.007	0.001	0.001	0.000	0.000	0.001	0.004	0.013	0.000
Panel D: Same as baseline, but using only Roman towns with defended areas of 5ha or more									
Ratio Britain	11.73	10.83	10.91	6.07	6.96	2.30	2.70	4.36	6.28
Ratio France	34.20	34.99	57.08	22.19	48.86	12.02	20.77	43.44	70.36
Ratio Britain / France	0.34	0.31	0.19	0.27	0.14	0.19	0.13	0.10	0.09
p-value[1]	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panel E: Same as baseline, but using only Roman towns with defended areas of 5ha or more in all Northwest Europe									
Ratio Britain	11.73	10.83	10.91	6.07	6.96	2.30	2.70	4.36	6.28
Ratio France	28.95	28.46	42.45	18.33	38.58	6.46	10.02	21.39	34.75
Ratio Britain / France	0.41	0.38	0.26	0.33	0.18	0.36	0.27	0.20	0.18
p-value[1]	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panel F: Same as baseline, but using only Roman administrative towns									
Ratio Britain	16.25	13.33	12.95	8.13	7.87	2.58	2.85	4.77	8.52
Ratio France	27.09	24.76	39.51	18.02	36.28	9.39	16.33	31.98	44.22
Ratio Britain / France	0.60	0.54	0.33	0.45	0.22	0.27	0.17	0.15	0.19
p-value[1]	0.115	0.026	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Panel G: Same as baseline, but using only Roman towns with pre-Roman origins									
Ratio Britain	11.93	9.79	7.40	5.70	8.10	2.47	3.67	4.09	3.65
Ratio France	28.42	22.96	44.14	16.36	37.02	9.30	15.86	31.99	46.91
Ratio Britain / France	0.42	0.43	0.17	0.35	0.22	0.27	0.23	0.13	0.08
p-value[1]	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panel H: Same as baseline, but with geographic controls and their Britain interactions									
Ratio Britain	8.08	9.27	8.92	4.11	5.91	1.73	2.06	2.73	3.60
Ratio France	21.64	21.12	37.40	15.70	36.86	8.28	15.08	29.51	48.76
Ratio Britain / France	0.37	0.44	0.24	0.26	0.16	0.21	0.14	0.09	0.07
p-value[1]	0.002	0.005	0.003	0.000	0.000	0.000	0.000	0.000	0.002

Notes: The number of observations is 697,198, except in Panel C in which it is 396,228 and in Panel E in which it is 906,076. Robust standard errors are clustered to account for spatial correlation.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France ≠ 0

Appendix Table A5. Robustness checks for the probability of towns (1200-2012) within 5km of Roman towns, using the largest town in each cluster

	Largest town in cluster in 1200	Largest town in cluster in 1300	Largest town in cluster in 1400	Largest town in cluster in 1500	Largest town in cluster in 1600	Largest town in cluster in 1700	Largest town in cluster in 1800	Largest town in cluster in 2012
Panel A. Using all of Britain and France								
Ratio Britain	8.59	7.20	8.57	8.05	6.51	7.29	5.92	4.74
Ratio France	35.07	31.64	35.46	30.29	29.71	27.45	29.68	27.39
Ratio Britain / France	0.25	0.23	0.24	0.27	0.22	0.27	0.20	0.17
p-value[1]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panel B. Using only Trajan provinces of Britannia, Belgica, and Lugdunensis								
Ratio Britain	8.59	7.20	8.55	8.05	6.51	7.29	5.92	4.74
Ratio France	37.97	29.60	32.05	27.23	28.25	27.07	29.83	28.24
Ratio Britain / France	0.23	0.24	0.27	0.30	0.23	0.27	0.20	0.17
p-value[1]	0.000	0.003	0.001	0.004	0.000	0.002	0.000	0.000

Notes: This table is similar to the lower part of Table 4, except for the left hand side variable.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France ≠ 0

Appendix Table A6. First stage regressions

Sample:	France	Britain	Britain	Britain
Iron Age settlement (Fichtl 2005)	0.159	0.272		-0.049
	(0.036)	(0.134)		(0.164)
Iron Age settlement (Jones and Mattingly 1990)			0.333	0.353
			(0.106)	(0.110)

Notes: These first stage regressions complement Table A7. The dependent variable is Roman town (baseline). “Iron Age settlement (Fichtl 2005)” is an indicator for Iron Age *oppida* from Fichtl (2005). “Iron Age settlement (Jones and Mattingly 1990)” is an indicator for major Iron-Age settlements in Britain from Jones and Mattingly (1990). Robust standard errors are clustered to account for spatial correlation.

Appendix Table A7. IV: Probability of towns (700-2012) within 5km of Roman towns

	Bishopric or Arch-bishopric 700-900	Coin Mint 768-1066	Town with 1k+ people 1086-1200	Town with 5k+ people in 1200	Town with 5k+ people c.1300 (Russell)	Town with 5k+ people in 1300	Largest 50 towns 1377-1400	Town with 5k+ people in 1400	Town with 5k+ people in 1500
Roman town	0.996	1.011	0.850	0.725	0.647	0.437	0.470	0.558	0.468
	(0.191)	(0.178)	(0.193)	(0.174)	(0.170)	(0.148)	(0.129)	(0.139)	(0.143)
Britain	-0.006	0.031	0.012	-0.001	-0.000	-0.000	0.018	-0.001	0.001
	(0.002)	(0.008)	(0.003)	(0.002)	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)
Roman town	-0.520	-0.259	-0.170	-0.497	-0.539	-0.452	0.206	-0.327	-0.121
x Britain	(0.246)	(0.270)	(0.267)	(0.176)	(0.177)	(0.148)	(0.224)	(0.141)	(0.311)
Intercept	0.015	0.010	0.012	0.009	0.006	0.005	0.007	0.007	0.008
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Ratio Britain	60.10	19.24	30.27	32.06	20.73	-2.00	28.19	39.00	37.82
Ratio France	69.47	98.18	73.58	86.22	114.30	85.15	71.08	81.32	56.31
Ratio Britain/France	0.87	0.20	0.41	0.37	0.18	-0.02	0.40	0.48	0.67
p-value[1]	0.678	0.001	0.036	0.029	0.004	0.003	0.062	0.100	0.570
First stage F	9.936	9.936	9.936	9.936	9.936	9.936	9.936	9.936	9.936
Underid. test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Town with 5k+ people in 1600	Town with 5k+ people in 1700	Town with 10k+ people in 1700	Town with 5k+ people in 1800	Town with 10k+ people in 1800	Town with 10k+ people in 2012	Town with 20k+ people in 2012	Town with 50k+ people in 2012	Town with 100k+ people in 2012
Roman town	0.855	1.258	0.709	1.270	0.850	1.538	1.188	0.387	0.369
	(0.215)	(0.233)	(0.181)	(0.223)	(0.159)	(0.357)	(0.240)	(0.143)	(0.141)
Britain	-0.000	-0.001	0.001	0.016	0.014	0.200	0.135	0.065	0.024
	(0.003)	(0.003)	(0.002)	(0.007)	(0.005)	(0.026)	(0.023)	(0.012)	(0.004)
Roman town	-0.409	-0.948	-0.739	-0.439	-0.554	-0.235	-0.339	0.003	-0.082
x Britain	(0.342)	(0.309)	(0.182)	(0.353)	(0.254)	(0.683)	(0.385)	(0.286)	(0.246)
Intercept	0.018	0.023	0.009	0.040	0.013	0.074	0.040	0.013	0.005
	(0.002)	(0.002)	(0.001)	(0.003)	(0.001)	(0.009)	(0.006)	(0.002)	(0.001)
Ratio Britain	26.14	15.23	-2.00	15.84	12.23	5.75	5.85	5.97	10.83
Ratio France	48.65	56.03	83.54	32.68	67.06	21.73	30.42	30.66	73.77
Ratio Britain/France	0.54	0.27	-0.02	0.48	0.18	0.26	0.19	0.19	0.15
p-value[1]	0.242	0.006	0.000	0.027	0.001	0.012	0.005	0.052	0.026
First stage F	9.936	9.936	9.936	9.936	9.936	9.936	9.936	9.936	9.936
Underid. test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: This table is the same as Table 3, except that the estimates use limited information maximum likelihood (LIML) instead of OLS. First stage estimates are reported in Table A6. The reported first stage F-statistic is the Kleibergen-Paap statistic. The underidentification test reports the p-value from the Kleibergen-Paap LM test. The number of observations is 697,198. Robust standard errors are clustered to account for spatial correlation.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France ≠ 0

Appendix Table A8. Probability of towns (1300-2012) within 5km of towns with 5,000+ people in 1200

	Town with 5k+ people c.1300 (Russell)	Town with 5k+ people in 1300	Largest 50 towns, 1377-1400	Town with 5k+ people in 1400	Town with 5k+ people in 1500	Town with 5k+ people in 1600	Town with 5k+ people in 1700
Town with 5k+ people in 1200	0.655	0.479	0.638	0.638	0.556	0.837	0.880
	(0.068)	(0.066)	(0.065)	(0.065)	(0.067)	(0.049)	(0.037)
Britain	-0.000	-0.000	0.018	-0.001	0.0010	-0.000	-0.001
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.003)	(0.004)
1200 town x	0.072	0.183	0.203	-0.111	0.101	-0.188	-0.035
Britain	(0.126)	(0.123)	(0.102)	(0.151)	(0.146)	(0.138)	(0.093)
Intercept	0.006	0.005	0.007	0.007	0.009	0.018	0.023
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Ratio Britain	133.8	134.2	34.54	86.6	70.0	37.2	39.7
Ratio France	113.3	91.7	95.27	91.5	66.1	47.2	39.0
Ratio Britain / France	1.18	1.46	0.36	0.95	1.06	0.79	1.02
p-value[1]	0.573	0.235	0.000	0.830	0.785	0.172	0.918

	Town with 10k+ People in 1700	Town with 5k+ People in 1800	Town with 10k+ People in 1800	Town with 10k+ People in 2012	Town with 20k+ People in 2012	Town with 50k+ People in 2012	Town with 100k+ people in 2012
Town with 5k+ people in 1200	0.717	0.943	0.777	0.877	0.863	0.664	0.414
	(0.056)	(0.016)	(0.052)	(0.028)	(0.036)	(0.068)	(0.058)
Britain	0.001	0.016	0.013	0.200	0.135	0.066	0.024
	(0.002)	(0.007)	(0.005)	(0.026)	(0.023)	(0.012)	(0.004)
1200 town x	-0.127	0.000	-0.070	-0.152	-0.038	-0.010	0.156
Britain	(0.131)	(0.018)	(0.13)	(0.037)	(0.043)	(0.116)	(0.151)
Intercept	0.009	0.040	0.013	0.075	0.041	0.013	0.005
	(0.001)	(0.003)	(0.001)	(0.009)	(0.006)	(0.002)	(0.001)
Ratio Britain	62.4	17.7	27.8	3.6	5.7	9.3	20.5
Ratio France	83.1	24.4	60.6	12.8	22.2	51.8	81.6
Ratio Britain / France	0.75	0.73	0.46	0.28	0.26	0.18	0.25
p-value[1]	0.133	0.013	0.000	0.000	0.000	0.000	0.000

Notes: This table is similar to Table 3, except that it analyzes locational persistence relative to 1200 towns instead of Roman towns. The number of observations is 697,198. Robust standard errors are clustered to account for spatial correlation.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France ≠ 0

Appendix Table A9. Coastal access and the location of Roman and later towns using only Trajan provinces of Britannia, Belgica, and Lugdunensis

	Later town:							
Dependent variable: Roman town (baseline) or later town	Town with 1k+ people in 1086-1200		Town with 5k+ people in 1200		One of largest 50 towns in 1377-1400		Town with 5k+ people in 1700	
Coastal access measure:	I	II	I	II	I	II	I	II
Roman period	0.00020	0.00016	0.00020	0.00016	0.00020	0.00016	0.00020	0.00016
	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)
Roman period x Britain	0.00019	0.00022	0.00019	0.00022	0.00019	0.00022	0.00019	0.00022
	(0.00008)	(0.00009)	(0.00008)	(0.00009)	(0.00008)	(0.00009)	(0.00008)	(0.00009)
Roman period x Coastal access	0.00054	0.00046	0.00054	0.00046	0.00054	0.00046	0.00054	0.00046
	(0.00011)	(0.00008)	(0.00011)	(0.00008)	(0.00011)	(0.00008)	(0.00011)	(0.00008)
Roman period x Britain x Coastal access	-0.00012	-0.00013	-0.00012	-0.00013	-0.00012	-0.00013	-0.00012	-0.00013
	(0.00017)	(0.00012)	(0.00017)	(0.00012)	(0.00017)	(0.00012)	(0.00017)	(0.00012)
Later period	0.00009	0.00006	0.00008	0.00005	0.00007	0.00005	0.00027	0.00021
	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00004)	(0.00003)
Later period x Britain	0.00005	0.00005	-0.00005	-0.00002	0.00009	0.00006	-0.00013	-0.00011
	(0.00004)	(0.00004)	(0.00002)	(0.00002)	(0.00004)	(0.00004)	(0.00006)	(0.00005)
Later period x Coastal access	0.00036	0.00032	0.00025	0.00024	0.00037	0.00046	0.00083	0.00069
	(0.00010)	(0.00007)	(0.00008)	(0.00005)	(0.00009)	(0.00008)	(0.00017)	(0.00012)
Later period x Britain x Coastal access	0.00037	0.00028	0.00005	-0.00004	0.00033	0.00035	-0.00018	-0.00013
	(0.00016)	(0.00012)	(0.00011)	(0.00008)	(0.00016)	(0.00012)	(0.00021)	(0.00016)
Coastal access effects in Britain:								
on Roman towns (=C1)	2.08	1.87	2.08	1.87	2.08	1.87	2.08	1.87
on later towns (=C2)	6.09	6.30	12.18	7.49	5.41	6.64	5.89	6.37
Change in effect: C2/C1-1	1.93	2.36	4.87	3.00	1.61	2.55	1.84	2.40
Test H0:C2/C1≤1 vs. H1:C2/C1>1, p-value:	0.012	0.027	0.061	0.078	0.003	0.003	0.028	0.043
Coastal access effects in France:								
on Roman towns (=C3)	3.68	3.79	3.68	3.79	3.68	3.79	3.68	3.79
on later towns (=C4)	4.93	6.25	4.10	5.37	5.99	6.31	4.14	4.22
Change in effect: C4/C3-1	0.34	0.65	0.12	0.42	0.63	0.67	0.13	0.11
Test H0:C4/C3≤1 vs. H1:C4/C3>1, p-value:	0.222	0.124	0.389	0.177	0.120	0.134	0.348	0.356
Differential change, Britain minus France: (C2/C1)-(C4/C3)	1.59	1.71	4.75	2.58	0.98	1.88	1.71	2.29
Test H0:(C2/C1)-(C4/C3)≤0 vs. H1:(C2/C1)-(C4/C3)>0, p-value:	0.061	0.087	0.058	0.103	0.137	0.036	0.073	0.067

Notes: This table is the same as Table 4, except that the sample is restricted to the Roman provinces of Britannia, Belgica and Lugdunensis. Robust standard errors are clustered to account for spatial correlation.

Appendix Table A10. Coastal access and the location of Roman and later towns, Roman towns with defended area of 5ha or more

	Later town:							
Dependent variable: Roman town with defended area of 5ha+, or later town	Town with 1k+ people in 1086-1200		Town with 5k+ people in 1200		One of largest 50 towns in 1377-1400		Town with 5k+ people in 1700	
Coastal access measure:	I	II	I	II	I	II	I	II
Roman period	0.00008	0.00006	0.00008	0.00006	0.00008	0.00006	0.00008	0.00006
	(0.00002)	(0.00001)	(0.00002)	(0.00001)	(0.00002)	(0.00001)	(0.00002)	(0.00001)
Roman period x Britain	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008
	(0.00004)	(0.00004)	(0.00004)	(0.00004)	(0.00004)	(0.00004)	(0.00004)	(0.00004)
Roman period x Coastal access	0.00037	0.00029	0.00037	0.00029	0.00037	0.00029	0.00037	0.00029
	(0.00010)	(0.00006)	(0.00010)	(0.00006)	(0.00010)	(0.00006)	(0.00010)	(0.00006)
Roman period x Britain x Coastal access	-0.00002	0.00003	-0.00002	0.00003	-0.00002	0.00003	-0.00002	0.00003
	(0.00014)	(0.00010)	(0.00014)	(0.00010)	(0.00014)	(0.00010)	(0.00014)	(0.00010)
Later period	0.00009	0.00006	0.00008	0.00005	0.00007	0.00005	0.00027	0.00021
	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00004)	(0.00004)
Later period x Britain	0.00005	0.00005	-0.00005	-0.00002	0.00009	0.00006	-0.00013	-0.00011
	(0.00004)	(0.00005)	(0.00002)	(0.00002)	(0.00004)	(0.00004)	(0.00006)	(0.00005)
Later period x Coastal access	0.00036	0.00032	0.00025	0.00024	0.00037	0.00029	0.00083	0.00069
	(0.00010)	(0.00007)	(0.00008)	(0.00005)	(0.00009)	(0.00006)	(0.00017)	(0.00012)
Later period x Britain x Coastal access	0.00037	0.00028	0.00005	-0.00004	0.00034	0.00035	-0.00018	-0.00013
	(0.00016)	(0.00012)	(0.00011)	(0.00008)	(0.00016)	(0.00012)	(0.00021)	(0.00016)
Coastal access effects in Britain:								
on Roman towns (=C1)	3.04	3.21	3.04	3.21	3.04	3.21	3.04	3.21
on later towns (=C2)	6.09	6.30	12.18	7.49	5.41	6.64	5.89	6.37
Change in effect: C2/C1-1	1.00	0.96	3.00	1.33	0.78	1.07	0.93	0.98
Test H0:C2/C1≤1 vs. H1:C2/C1>1, p-value:	0.046	0.062	0.072	0.109	0.011	0.005	0.080	0.102
Coastal access effects in France:								
on Roman towns (=C3)	5.59	5.68	5.59	5.68	5.59	5.68	5.59	5.68
on later towns (=C4)	4.93	6.25	4.10	5.37	5.99	6.31	4.14	4.22
Change in effect: C4/C3-1	-0.12	0.10	-0.27	-0.06	0.07	0.11	-0.26	-0.26
Test H0:C4/C3≤1 vs. H1:C4/C3>1, p-value:	0.657	0.383	0.787	0.568	0.422	0.387	0.778	0.798
Differential change, Britain minus France: (C2/C1)-(C4/C3)	1.12	0.86	3.27	1.39	0.71	0.96	1.19	1.24
Test H0:(C2/C1)-(C4/C3)≤0 vs. H1:(C2/C1)-(C4/C3)>0, p-value:	0.063	0.110	0.038	0.079	0.102	0.051	0.074	0.080

Notes: This table is the same as Table 4,, except that it uses a different definition of Roman towns, which only considers Roman-era towns with walled area of 5 hectares or more. Robust standard errors are clustered to account for spatial correlation.

Appendix Table A11. Access to canals and the growth of towns with 5,000 people or more in 1200, for towns with reduced market access (Coastal Access Type I measure = 0)

Sample:	Britain and France	Britain and France	Britain and France	Britain and France	Britain and France	Britain and France, only areas ≤25km of coast or navigable river	Britain and France, only Britannia, Belgica, and Lugdunensis	Northwestern Europe, all Roman provinces	Britain and France
Dependent variable is population growth from:	1200-1800	1200-1800	1200-1800	1200-1700	1200-2012	1200-1800	1200-1800	1200-1800	1200-1800
Canal access	0.302	0.458	0.461	0.446	0.660	0.461	0.693	0.407	0.433
	(0.170)	(0.191)	(0.192)	(0.202)	(0.227)	(0.380)	(0.276)	(0.165)	(0.208)
Log population in 1200		-0.404	-0.401	-0.355	-0.368	-0.414	-0.676	-0.429	-0.396
		(0.159)	(0.160)	(0.187)	(0.207)	(0.310)	(0.255)	(0.113)	(0.163)
Britain			-0.471	-0.235	0.0821	-0.868	-0.543	-0.516	-0.586
			(0.212)	(0.197)	(0.340)	(0.311)	(0.233)	(0.204)	(0.283)
Canal access x Britain									0.349
									(0.323)
Observations	42	42	42	38	39	15	18	80	42

Notes: Coastal access measure I: within 5km of the coast or of a major navigable river which leads to the coast. Canal access: within 5km of a canal.

Robust standard errors are clustered to account for spatial correlation.

Appendix Table A12. `Locally Suboptimal' Coastal Access and the location of Roman and later towns

	Later town:							
Dependent variable: Roman town (baseline) or later town	Town with 1k+ people in 1086-1200		Town with 5k+ people in 1200		One of largest 50 towns in 1377-1400		Town with 5k+ people in 1700	
Coastal access measure:	I	II	I	II	I	II	I	II
Roman period	0.00033	0.00041	0.00033	0.00041	0.00033	0.00041	0.00033	0.00041
	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)
Roman period x Britain	0.00021	0.00020	0.00021	0.00020	0.00021	0.00020	0.00021	0.00020
	(0.00010)	(0.00011)	(0.00010)	(0.00011)	(0.00010)	(0.00011)	(0.00010)	(0.00011)
Roman period x Suboptimal location	-0.00011	-0.00024	-0.00011	-0.00024	-0.00011	-0.00024	-0.00011	-0.00024
	(0.00006)	(0.00004)	(0.00006)	(0.00004)	(0.00006)	(0.00004)	(0.00006)	(0.00004)
Roman period x Britain x suboptimal location	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	(0.00011)	(0.00012)	(0.00011)	(0.00012)	(0.00011)	(0.00012)	(0.00011)	(0.00012)
Later period	0.00017	0.00020	0.00012	0.00015	0.00009	0.00012	0.00034	0.00041
	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00004)	(0.00005)
Later period x Britain	0.00032	0.00038	0.00006	0.00004	0.00039	0.00049	0.00013	0.00013
	(0.00008)	(0.00009)	(0.00006)	(0.00006)	(0.00008)	(0.00011)	(0.00007)	(0.00008)
Later period x Suboptimal location	-0.00005	-0.00012	-0.00003	-0.00009	-0.00000	-0.00006	-0.00013	-0.00024
	(0.00004)	(0.00003)	(0.00003)	(0.00002)	(0.00003)	(0.00003)	(0.00006)	(0.00005)
Later period x Britain x Suboptimal location	-0.00029	-0.00036	-0.00015	-0.00008	-0.00030	-0.00044	-0.02376	-0.00020
	(0.00010)	(0.00010)	(0.00007)	(0.00007)	(0.00009)	(0.00011)	(0.00010)	(0.00009)
Coastal access effects in Britain:								
on Roman towns (=C1)	0.85	0.66	0.85	0.66	0.85	0.66	0.85	0.66
on later towns (=C2)	0.31	0.19	0.08	0.13	0.37	0.18	0.23	0.18
Change in effect: C2/C1-1	-0.63	-0.71	-0.91	-0.81	-0.56	-0.73	-0.72	-0.72
Test H0:C2/C1≥1 vs. H1:C2/C1<1, p-value:	0.004	0.000	0.000	0.000	0.004	0.000	0.001	0.001
Coastal access effects in France:								
on Roman towns (=C3)	0.67	0.42	0.67	0.42	0.67	0.42	0.67	0.42
on later towns (=C4)	0.73	0.44	0.79	0.40	0.95	0.49	0.63	0.43
Change in effect: C4/C3-1	0.09	0.04	0.18	-0.05	0.43	0.16	-0.05	0.016
Test H0:C4/C3≥1 vs. H1:C4/C3<1, p-value:	0.621	0.563	0.681	0.424	0.808	0.664	0.401	0.532
Differential change, Britain minus France: (C2/C1)-(C4/C3)	-0.72	-0.75	-1.10	-0.76	-0.99	-0.89	-0.67	-0.74
Test H0:(C2/C1)-(C4/C3) ≥0 vs. H1:(C2/C1)-(C4/C3)<0, p-value:	0.015	0.003	0.005	0.005	0.032	0.011	0.003	0.001

Notes: This table is the same as Table 4 except that it considers measures of suboptimal location instead of the coastal access measures. These measures of suboptimality indicate locations that are within more than 5 kilometers but fewer than 25 kilometers from locations with corresponding coastal access (according to definitions I and II). Robust standard errors are clustered to account for spatial correlation.

Appendix Table A13. Model overview

Scenario	1. Fixed locational advantage	2. Changing locational advantage with stronger fundamentals	3A. Changing locational advantage with stronger towns and inconsequential fundamentals	3B. Changing locational advantage with strong towns and consequential fundamentals
Parameter values				
• Probability that value of fundamentals changes	$p_F=0$	$p_F>0$	$p_F>0$	$p_F>0$
• Productivity parameters	$\theta_F>0$	$\theta_F>\theta_T$	$\theta_T>\theta_F\approx 0$	$\theta_T>\theta_F\not\approx 0$ ($\theta_F>0$)
Theoretical implications				
• Do town locations change over time?	No	Yes	Yes	Yes
• Are town locations path-dependent (affected by history)?	No	No	Yes	Yes
• Are some town badly located?	No	No	No	Yes
Empirical predictions				
• Persistence of town locations relative to Roman period in France	High	Low	High	High
• Persistence of town locations relative to Roman period in Britain	High	Low	Low	Low
• Improved suitability to medieval economy of town locations from Roman to Medieval period in France	Low	High	Low	Low
• Improved suitability to medieval economy of town locations from Roman to Medieval period in Britain	Low	High	Low	High

Notes: Summary of parameter values, theoretical implications and empirical predictions of the different scenarios in the model.

Appendix Table A14. Probability of towns (700-1600) within 5km of Roman towns with and without 4th century bishoprics

	Bishopric or Arch-bishopric in 700-900	Coin Mint in 768-1066	Town with 1k+ people in 1086-1200	Town with 5k+ people in 1200	Town with 5k+ people c.1300 (Russell)	Town with 5k+ people in 1300	Largest 50 towns 1377-1400	Town with 5k+ people in 1400	Town with 5k+ people in 1500
Roman_town	0.238	0.167	0.165	0.093	0.070	0.058	0.057	0.056	0.067
	(0.050)	(0.043)	(0.042)	(0.033)	(0.028)	(0.025)	(0.026)	(0.026)	(0.027)
Britain	-0.006	0.031	0.012	-0.001	-0.000	-0.000	0.018	-0.001	0.001
	(0.002)	(0.008)	(0.003)	(0.002)	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)
Roman_town x Britain	-0.139	0.062	0.041	-0.019	-0.022	-0.022	0.135	0.005	0.018
	(0.062)	(0.063)	(0.058)	(0.043)	(0.040)	(0.033)	(0.048)	(0.039)	(0.048)
Roman Bishopric in the 4th	0.622	0.334	0.380	0.353	0.310	0.198	0.278	0.278	0.299
century	(0.065)	(0.087)	(0.075)	(0.059)	(0.052)	(0.052)	(0.061)	(0.061)	(0.059)
Intercept	0.015	0.011	0.012	0.009	0.006	0.005	0.007	0.007	0.009
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Ratio Britain	13.12	6.52	9.76	10.93	9.78	8.08	8.62	10.93	9.91
Ratio France (non-bishopric)	17.25	16.71	14.94	11.72	13.01	11.99	9.33	8.96	8.900
Ratio Britain / France (non-bishopric)	0.76	0.39	0.66	0.93	0.75	0.67	0.92	1.22	1.11
p-value[1]	0.361	0.020	0.201	0.873	0.606	0.505	0.862	0.728	0.831

	Town With 5k+ people in 1600	Town With 5k+ people in 1700	Town With 10k+ people in 1700	Town with 5k+ people in 1800	Town with 10k+ people in 1800	Town with 10k+ people in 2012	Town with 20k+ people in 2012	Town with 50k+ people in 2012	Town with 100k+ people in 2012
Roman_town	0.172	0.268	0.118	0.365	0.227	0.381	0.326	0.139	0.083
	(0.046)	(0.051)	(0.034)	(0.048)	(0.045)	(0.055)	(0.047)	(0.041)	(0.030)
Britain	-0.000	-0.001	0.001	0.016	0.013	0.200	0.135	0.065	0.024
	(0.003)	(0.004)	(0.002)	(0.007)	(0.005)	(0.026)	(0.023)	(0.012)	(0.004)
Roman_town x Britain	-0.055	-0.128	-0.060	-0.164	-0.105	-0.088	-0.056	0.053	0.009
	(0.068)	(0.063)	(0.043)	(0.063)	(0.056)	(0.081)	(0.079)	(0.062)	(0.048)
Roman Bishopric in the 4th	0.367	0.311	0.248	0.379	0.237	0.306	0.337	0.303	0.161
century	(0.077)	(0.079)	(0.064)	(0.076)	(0.075)	(0.080)	(0.072)	(0.068)	(0.053)
Intercept	0.018	0.023	0.009	0.040	0.013	0.074	0.041	0.013	0.005
	(0.002)	(0.002)	(0.001)	(0.003)	(0.001)	(0.009)	(0.006)	(0.002)	(0.001)
Ratio Britain	7.53	7.42	7.01	4.55	5.62	2.07	2.54	3.44	4.15
Ratio France (non-bishopric)	10.49	12.60	14.49	10.05	18.48	6.12	9.04	11.63	17.26
Ratio Britain / France (non-bishopric)	0.72	0.59	0.48	0.45	0.30	0.34	0.28	0.30	0.24
p-value[1]	0.409	0.060	0.122	0.000	0.001	0.000	0.000	0.029	0.027

Notes: This table is that same as Table 2, except that the estimated specification includes an additional right hand side indicator for 4th century bishoprics in France.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France ≠ 0

Appendix Table A15. Robustness checks for the probability of towns (700-1500) within 5km of Roman towns with and without 4th century bishoprics

	Bishopric or Arch-bishopric in 700-900	Coin Mint in 768-1066	Town with 1k+ people in 1086-1200	Town with 5k+ people in 1200	Town with 5k+ people c.1300 (Russell)	Town with 5k+ people in 1300	One of largest 50 towns in 1377-1400	Town with 5k+ people in 1400	Town with 5k+ people in 1500
Panel A: Same as baseline, but using 10km radius instead of 5km radius									
Ratio Britain	4.46	2.52	3.27	3.58	2.99	2.63	2.95	3.72	3.13
Ratio France	4.51	4.16	4.23	3.62	3.78	4.09	3.22	3.08	3.65
Ratio Britain / France	0.99	0.61	0.77	0.99	0.79	0.64	0.92	1.21	0.86
p-value[1]	0.972	0.153	0.379	0.978	0.641	0.418	0.824	0.683	0.716
Panel B: Same as baseline, but using 0km radius instead of 5km radius									
Ratio Britain	1,403	465	744	1,336	1,145	859	633	1,432	1,169
Ratio France	7,408	3,638	2,938	2,451	8,681	3,157	1,226	1,097	1,286
Ratio Britain / France	0.19	0.13	0.25	0.55	0.13	0.27	0.52	1.31	0.91
p-value[1]	0.015	0.024	0.029	0.419	0.165	0.161	0.461	0.774	0.890
Panel C: Same as baseline, but using only Trajan provinces of Britannia, Belgica, and Lugdunensis									
Ratio Britain	13.12	6.52	9.79	10.93	9.78	8.08	8.62	10.93	9.91
Ratio France	18.77	13.66	14.50	3.53	6.55	8.92	6.55	6.32	7.64
Ratio Britain / France	0.70	0.48	0.68	3.10	1.49	0.91	1.32	1.73	1.30
p-value[1]	0.374	0.127	0.430	0.132	0.681	0.895	0.663	0.448	0.652
Panel D: Same as baseline, but using only Roman towns with defended areas of 5ha or more									
Ratio Britain	19.14	10.79	15.68	21.29	19.04	15.74	12.58	21.29	13.77
Ratio France	22.18	40.80	31.37	35.00	42.12	33.96	49.79	47.85	27.39
Ratio Britain / France	0.86	0.26	0.50	0.61	0.45	0.46	0.25	0.45	0.50
p-value[1]	0.749	0.002	0.06	0.177	0.101	0.198	0.002	0.050	0.191
Panel E: Same as baseline, but using only Roman towns with defended areas of 5ha or more in all Northwest Europe									
Ratio Britain	19.14	10.79	15.68	21.29	19.04	15.74	12.58	21.29	13.77
Ratio France	28.85	19.15	49.71	36.20	64.47	31.52	40.72	39.31	19.11
Ratio Britain / France	0.66	0.56	0.32	0.59	0.30	0.50	0.31	0.54	0.72
p-value[1]	0.510	0.399	0.008	0.283	0.027	0.374	0.05	0.232	0.662
Panel F: Same as baseline, but using only Roman administrative towns									
Ratio Britain	25.23	12.05	17.72	28.07	30.16	24.93	16.59	33.71	21.80
Ratio France	26.71	25.57	23.48	19.37	21.37	25.86	22.02	21.15	7.073
Ratio Britain / France	0.95	0.47	0.75	1.45	1.41	0.96	0.75	1.59	3.08
p-value[1]	0.886	0.061	0.537	0.542	0.608	0.951	0.562	0.384	0.238
Panel G: Same as baseline, but using only Roman towns with pre-Roman origins									
Ratio Britain	21.63	8.60	13.66	14.41	6.44	0.00	9.95	11.52	14.94
Ratio France	11.63	16.84	15.69	18.34	21.48	18.10	17.55	16.88	18.44
Ratio Britain / France	1.86	0.51	0.87	0.79	0.30	0.00	0.57	0.68	0.81
p-value[1]	0.092	0.146	0.752	0.631	0.120	0.090	0.432	0.604	0.697
Panel H: Same as baseline, but with geographic controls and their Britain interactions									
Ratio Britain	18.14	9.82	15.92	29.94	34.66	30.71	16.71	30.07	23.86
Ratio France	37.35	32.63	29.51	24.93	30.08	31.00	21.43	20.05	6.88
Ratio Britain / France	0.49	0.30	0.54	1.20	1.15	0.99	0.78	1.50	3.47
p-value[1]	0.088	0.025	0.301	0.786	0.866	0.991	0.633	0.479	0.192

Notes: The number of observations is 697,198, except in Panel C in which it is 396,228 and in Panel E in which it is 906,076. Robust standard errors are clustered to account for spatial correlation.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France ≠ 0

Appendix Table A16. Robustness checks for the probability of towns (1600-2012) within 5km of Roman towns with and without 4th century bishoprics

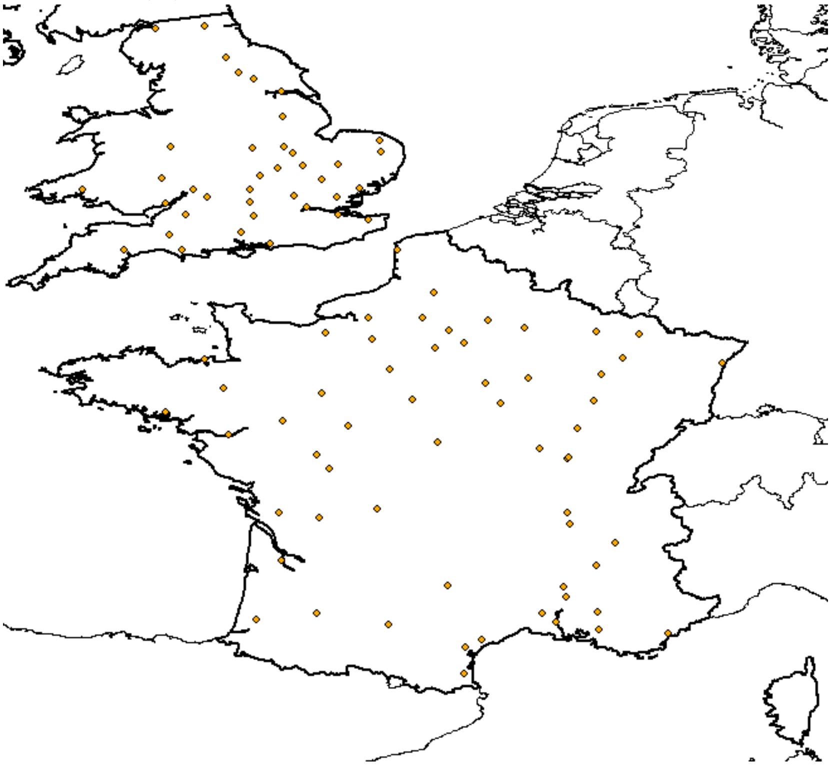
	Town with 5k+ people in 1600	Town with 5k+ people in 1700	Town with 10k+ people in 1700	Town with 5k+ people in 1800	Town with 10k+ people in 1800	Town with 10k+ people in 2012	Town with 20k+ people in 2012	Town with 50k+ people in 2012	Town with 100k+ people in 2012
Panel A: Same as baseline, but using 10km radius instead of 5km radius									
Ratio Britain	2.45	2.72	2.79	1.96	2.32	1.39	1.51	1.83	1.74
Ratio France	3.15	3.60	4.29	3.01	5.12	2.66	3.43	3.87	5.07
Ratio Britain / France	0.78	0.76	0.65	0.65	0.45	0.53	0.44	0.47	0.34
p-value[1]	0.500	0.325	0.315	0.015	0.010	0.000	0.000	0.033	0.046
Panel B: Same as baseline but using 0km radius instead of 5km radius									
Ratio Britain	668	590	668	268	320	74	97	184	297
Ratio France	1,254	1,417	2,500	963	2,710	232	433	951	3,472
Ratio Britain / France	0.53	0.42	0.27	0.28	0.12	0.32	0.23	0.19	0.09
p-value[1]	0.210	0.030	0.055	0.000	0.001	0.034	0.064	0.171	0.095
Panel C: Same as baseline, but using only Trajan provinces of Britannia, Belgica, and Lugdunensis									
Ratio Britain	7.54	7.42	7.01	4.55	5.62	2.07	2.54	3.44	4.15
Ratio France	9.62	10.90	10.71	9.15	16.63	5.06	8.28	9.86	13.78
Ratio Britain / France	0.78	0.68	0.66	0.50	0.34	0.41	0.31	0.35	0.30
p-value[1]	0.626	0.276	0.444	0.012	0.009	0.017	0.020	0.220	0.178
Panel D: Same as baseline, but using only Roman towns with defended areas of 5ha or more									
Ratio Britain	11.73	10.83	10.91	6.07	6.96	2.30	2.70	4.36	6.28
Ratio France	17.53	25.21	40.22	12.27	34.63	7.36	12.67	27.88	55.09
Ratio Britain / France	0.67	0.43	0.27	0.49	0.20	0.31	0.21	0.16	0.11
p-value[1]	0.376	0.004	0.002	0.012	0.000	0.000	0.001	0.003	0.001
Panel E: Same as baseline, but using only Roman towns with defended areas of 5ha or more in all Northwest Europe									
Ratio Britain	11.73	10.83	10.91	6.07	6.96	2.30	2.70	4.36	6.28
Ratio France	17.86	23.12	33.36	14.29	34.17	9.07	17.27	25.96	55.28
Ratio Britain / France	0.66	0.47	0.33	0.42	0.20	0.25	0.16	0.17	0.11
p-value[1]	0.438	0.038	0.053	0.016	0.010	0.001	0.004	0.047	0.004
Panel F: Same as baseline, but using only Roman administrative towns									
Ratio Britain	16.25	13.33	12.95	8.13	7.87	2.58	2.85	4.77	8.52
Ratio France	13.70	17.88	24.94	11.81	30.12	5.99	11.42	20.10	26.23
Ratio Britain / France	1.19	0.75	0.52	0.69	0.26	0.43	0.25	0.24	0.33
p-value[1]	0.740	0.445	0.268	0.221	0.003	0.011	0.002	0.016	0.136
Panel G: Same as baseline, but using only Roman towns with pre-Roman origins									
Ratio Britain	11.93	9.79	7.40	5.70	8.10	2.47	3.67	4.09	3.65
Ratio France	14.01	10.43	25.40	6.86	20.84	4.75	7.84	15.58	24.55
Ratio Britain / France	0.85	0.94	0.29	0.83	0.39	0.52	0.47	0.26	0.15
p-value[1]	0.704	0.862	0.045	0.539	0.023	0.032	0.019	0.046	0.032
Panel H: Same as baseline, but with geographic controls and their Britain interactions									
Ratio Britain	18.11	17.37	17.41	7.38	8.34	2.06	2.20	3.68	7.47
Ratio France	13.74	19.06	31.46	12.19	39.75	5.86	12.79	24.81	37.35
Ratio Britain / France	1.32	0.91	0.55	0.61	0.21	0.35	0.17	0.15	0.20
p-value[1]	0.597	0.828	0.407	0.142	0.004	0.008	0.002	0.009	0.090

Notes: The number of observations is 697,198, except in Panel C in which it is 396,228 and in Panel E in which it is 906,076. Robust standard errors are clustered to account for spatial correlation.

[1] Test H0: Ratio Britain - Ratio France = 0 vs. H1: Ratio Britain - Ratio France ≠ 0

Appendix Figure A1. Towns in Roman and Medieval Times

Panel A: Roman Baseline Towns (●)



Panel B: Roman Baseline Towns (●) and Medieval Bishoprics and Archbishoprics, (8th and 9th century, ○)

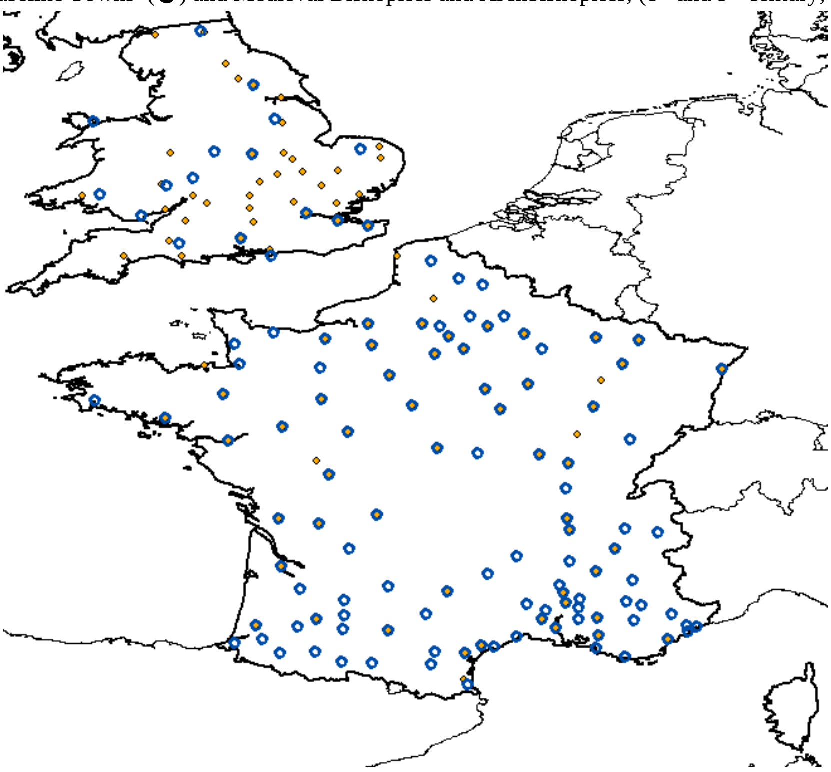
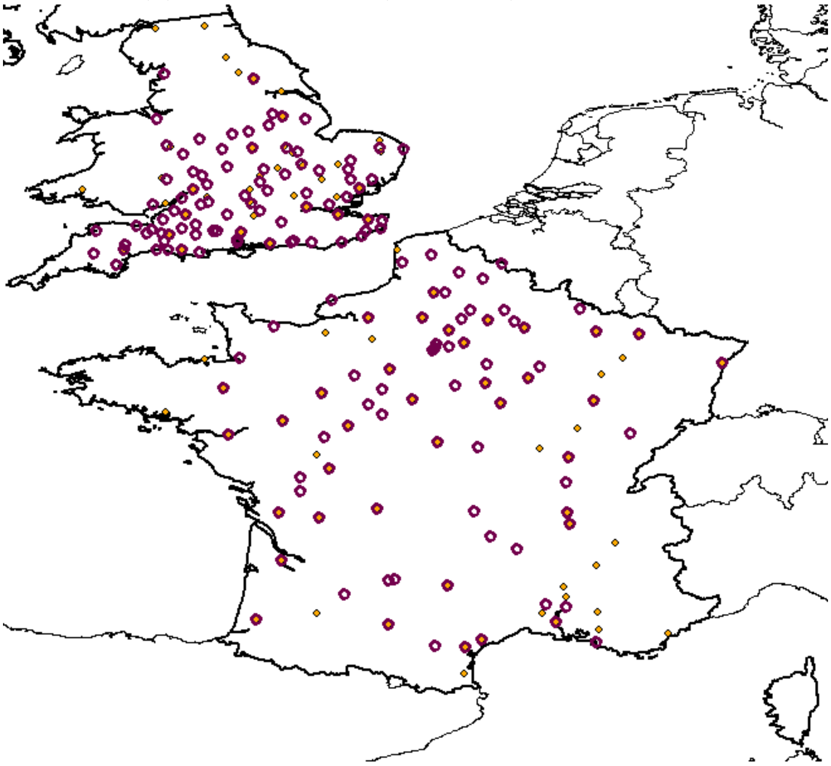


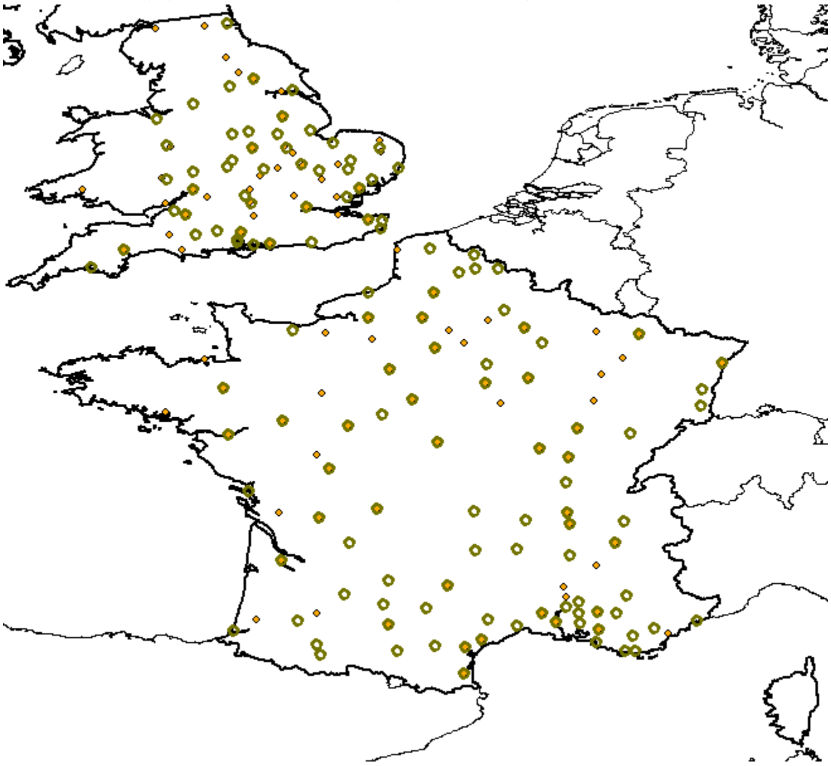
Figure continues overleaf

Appendix Figure A1 continued

Panel C: Roman Baseline Towns (●) and Medieval Mints (768-1066,○)



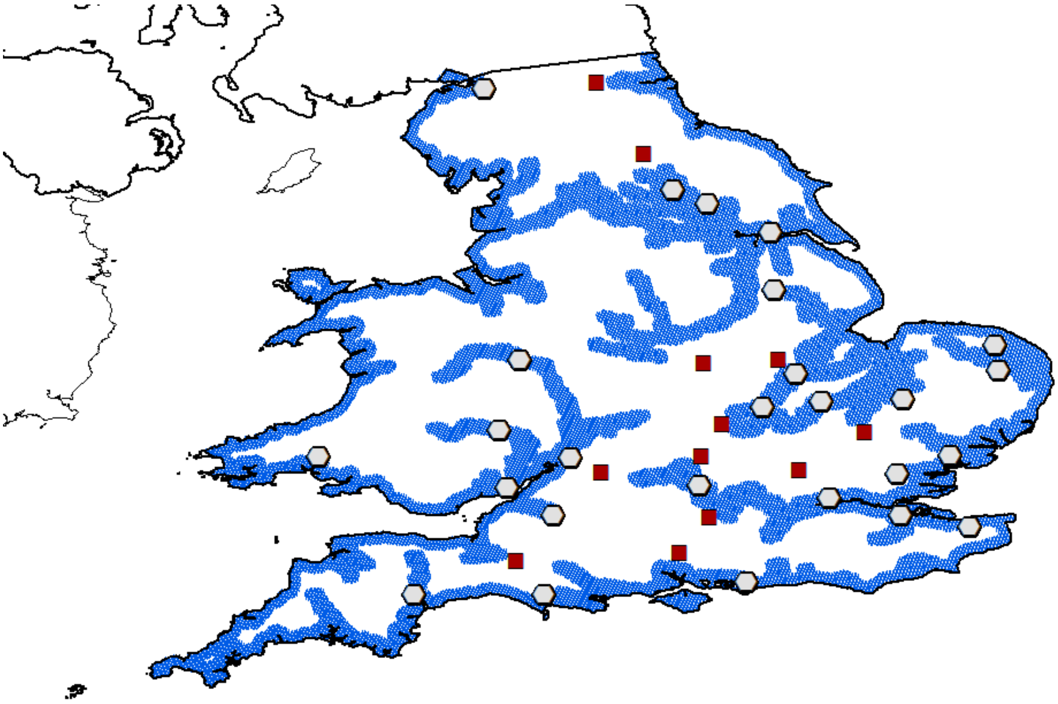
Panel D: Roman Baseline Towns (●) and Medieval Towns (1086-1200○)



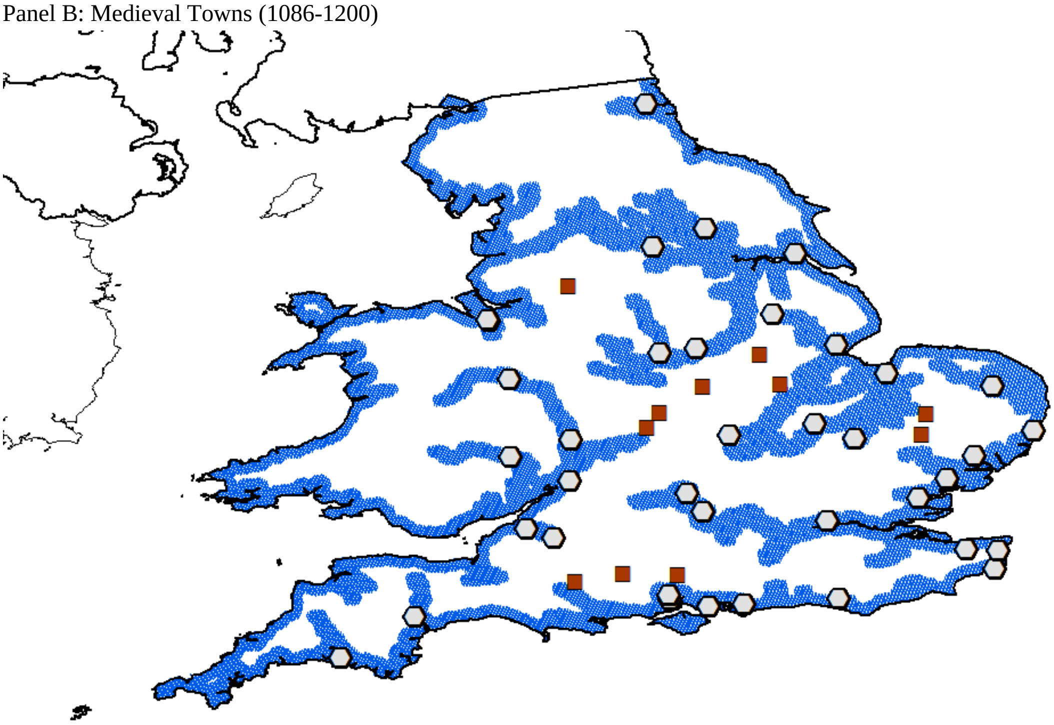
Notes: The maps show the location of all the Roman towns with walled areas of at least 5 hectares and the location of later towns as specified in each panel for the Roman parts of Britain and France. See the data section for sources and definitions of towns.

__Appendix Figure A2. Towns within and without 5km of navigable rivers and coasts in Britain__

Panel A: Roman Baseline Towns, 5ha of defended area or more



Panel B: Medieval Towns (1086-1200)



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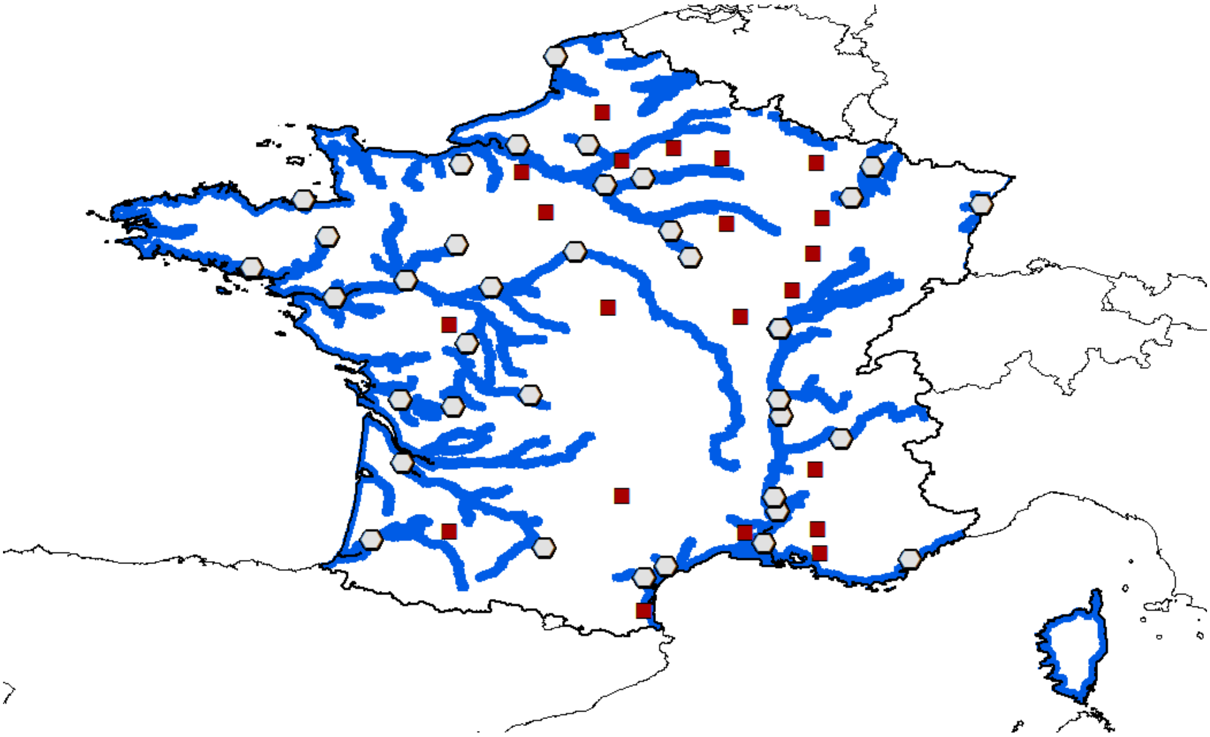
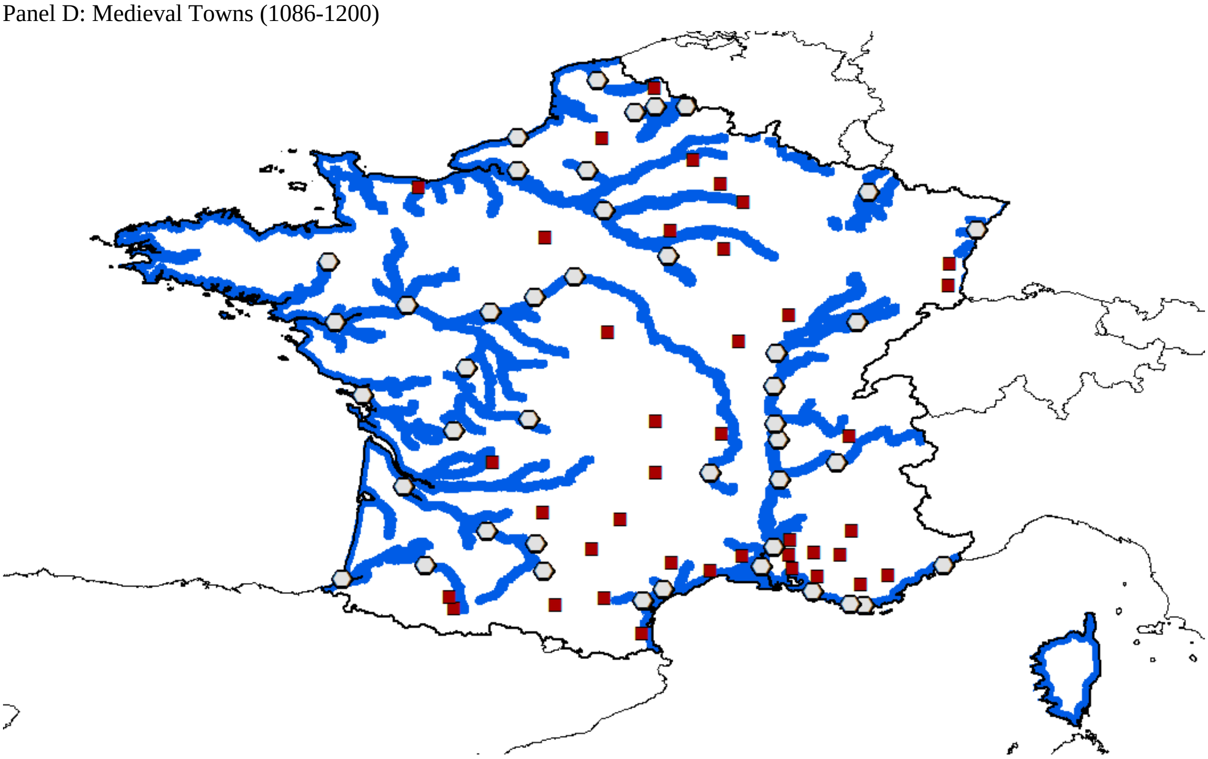
Appendix Figure A2 continued

Panel C: Roman Baseline Towns, 5ha of defended area or more



Panel D: Medieval Towns (1086-1200)



Notes: The figures show towns that are or are not within 5km of the coast or navigable rivers (by the “Coastal access II” measure) for the Roman part of Britain and France for different years as indicated in the panel titles. The areas with navigable access are highlighted in blue.