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THE LONG SHADOW OF HISTORY ROMAN LEGACY AND ECONOMIC DEVELOPMENT — EVIDENCE FROM THE GERMAN LIMES

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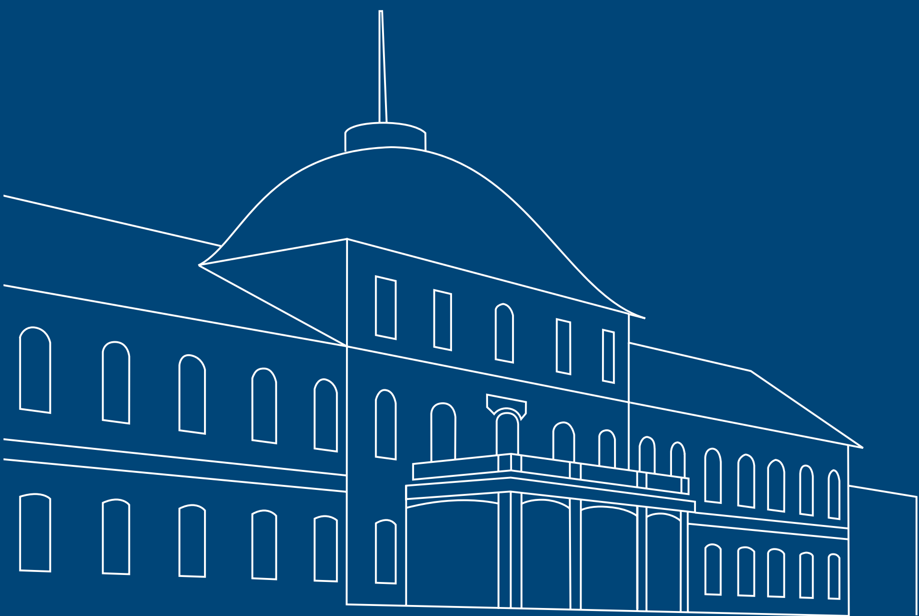

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– Evidence from the German Limes

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The Long Shadow of History

Roman Legacy and Economic Development—Evidence from the German Limes

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Abstract

This paper contributes to the understanding of the long-run consequences of Roman rule on economic development. In ancient times, the area of contemporary Germany was divided into a Roman and non-Roman part. The study uses this division to test whether the formerly Roman part of Germany show a higher night-light luminosity than the non-Roman part. This is done by using the Limes wall as geographical discontinuity in a regression discontinuity design framework. The results indicate that economic development—as measured by luminosity—is indeed significantly and robustly larger in the formerly Roman parts of Germany. The study identifies the persistence of the Roman road network until the present as an important factor causing this development advantage of the formerly Roman part of Germany both by fostering city growth and by allowing for a denser road network.

Keywords: Roman Empire, Economic Development, Germany, Boundary Discontinuity, Transport Infrastructure, Persistence

JEL Classification: N13, N73, O18, R12, R40

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1 Introduction

To what extent are contemporary economic development levels still imprinted by history? Answering this question is key for effectively designing political measures to reduce development differences and ensure the long-run sustainability of prosperity.

Many studies (Acemoglu et al. 2001, Ashraf and Galor 2013, Becker et al. 2014, Bleakly and Lin 2012, Dell 2010 Nunn 2014) suggest a high amount of persistence in development levels of countries or regions. Recent research has painted a more differentiated picture and identified the conditions under which certain phenomena have persistent or non-persistent effects (e.g. Grosfeld and Zhuravskaya 2014, Michaels and Rauch 2014, Musacchio et al. 2014, Voigtländer and Voth 2012 and Nunn 2014).

Simultaneously, the last few years have seen an increasing interest in studying the extent to which legacies of the Roman Empire influenced developments in the subsequent periods (e.g. Bosker et al. 2013, Buringh et al. 2012, Michaels and Rauch 2014, McCormick 2001). Historical and economic literature suggests several possible channels through which the Roman Empire could have influenced later developments (persistence of Roman bishop residences, urbanization patterns, road networks, the Roman market economy, law and legal systems etc.). Yet, these studies find that the Roman influence on city development vanished in some countries but remained persistent in others (Michaels and Rauch 2014) or conclude that, e.g. the spatial distribution of the Roman market economy was different from the distribution of markets in post-Roman Europe (Buringh et al. 2012).

This study aims at investigating whether there are significant differences in economic development (proxied by nighttime light intensity) between former Roman and non-Roman parts of today's Germany. The German Limes—the part of the Roman border through contemporary Germany that was a paved wall and that was not identical to the course of Rhine or Danube—is the part of the Roman border that is most suitable for identifying the effect of Roman legacy with a border discontinuity.[1] This is because the Roman border does not divide all European countries (France, Italy and Spain were completely within the Roman Empire) and if the border splits contemporary countries it most often follows the course of the Danube or other rivers, is located in mountainous areas like the Carpathians or coincides with other geographic discontinuities like the contemporary Scottish border.[2] In North Africa, the Roman area was most often a small strip along the coast of the Mediterranean—meaning that one can hardly distinguish between the effect of being on the coast and that of being part of the Roman Empire. Moreover, with the exception of Tunisia and Morocco, the Roman road network was not very dense in Northern Africa and in general, the course and existence of the roads is uncertain.[3] Hence, for the identification of a causal effect of Roman legacy with a border discontinuity, the Limes wall is the most promising segment of the Roman border. The Roman border through contemporary Germany, the course of Rhine and Danube as well as the Roman and non-Roman area of Germany are visualized in Figure 1.

[Figure 1 about here]

Furthermore, I want to test whether these differences can be traced back to the persistence of the Roman road network. This road network is that part of the Roman heritage that is most likely to have a persistent effect. Transport infrastructure (railways and roads) is often found to have long-lasting effects on economic development (e.g. Berger and Enflo 2014, Cogneau and Moradi 2014, Holl 2004, Jedwab et al. 2014) by giving an

[1] Actually, the Limes wall consisted of two different wall segments, the Upper Germanic Limes, from the Rhine area to the east of the Swabian Alb, and the Rhaetian Limes from the east of the Swabian Alb to Kehlheim on the Danube in today's Bavaria.

[2] In fact, Scotland is even more problematic as the Romans never gained full control of the border area and left Britain earlier than other parts of Europe (see also Michaels and Rauch 2014). Furthermore, the Romans actually built two border walls in Britain, Hadrian's wall and the more northern Antonine wall that was never paved and was used for less than 20 years before being abandoned as the Romans withdrew to Hadrian's wall. Nevertheless they had built roads in this area that after their withdrawal were potentially used by the Celts. This makes it hard to identify a clean treatment for Scotland.

[3] Complementary to this argument, the findings of Bosker et al. 2013 suggest that Roman roads played no or only a very limited role for the development of cities in North Africa and the Middle East.

advantage to those place that are connected to a railroad or that were connected earlier.[4] It has additionally been shown that many of the major Roman roads were also used and maintained in the centuries after the break-down of the Empire (e.g. Glick 1979). Moreover, previous studies (e.g. Bosker et al. 2013) found that location on Roman roads remains significantly positively related to city growth until the early modern period, although their results are not quite robust. Furthermore, Bosker and Buringh (2012) find that the probability of the existence of a city is significantly higher at locations nearby Roman roads. There are two major reasons for the persistence of the Roman road network and why it provides a long-lasting development advantage to the regions previously ruled by the Romans.

First, pre-existing roads represented a cost advantage as no new roads needed to be built by the rulers following the Romans. In particular, during the Middle Ages, most rulers lacked the resources, capabilities or money to build and maintain new road networks and thus, largely relied on the existing ones. In later periods, the rulers could use the saved resources for the building of additional roads. This led to a denser transport network in the Roman regions that is clearly favorable for trade and commerce.

Furthermore, cities founded by the Romans (e.g. Cologne, Mainz etc.) often remained among the most important and populous ones in the subsequent centuries. Moreover, they had a central position in the post-Roman urban networks as they were connected by the Roman roads and were therefore easier to reach and leave making them e.g. favorable places for trade and giving them a better market access. Unlike their non-Roman counterparts, most Roman cities were connected by roads and also remained urban centers after the demise of the Empire. Thus, they probably have grown earlier and larger, i.e. they become largely agglomerated areas ("cores"). This again led to a higher degree of urbanization in the Roman parts of Germany. Strongly

[4]Furthermore, the course, building and characteristics of Roman roads have been extensively studied by historians and archaeologists (e.g. Laurence 1999). From such works the Roman road network can be reconstructed with some certainty.

agglomerated areas usually show more economic activity than less agglomerated areas and agglomeration tends to persist (e.g., Bleakly and Lin 2012, Bosker et al. 2013). Thus, there is a feedback from larger city growth and stronger agglomeration back to a denser transportation network that is both necessitated and allowed by economic prosperity and urbanization.

This study empirically tests these conjectures by exploiting the division of today's Germany in an area with and without Roman heritage as a natural experiment. Empirical identification of a positive effect of Roman heritage is based on a spatial regression discontinuity approach. In this boundary discontinuity design (BDD), the Limes acts as two-dimensional cutoff separating treated and non-treated areas. By adopting this strategy the paper adds to a growing literature that exploits geographical or political discontinuities in space to identify causal effects of certain variables on economic outcomes (e.g., Dell 2010, Grosfeld and Zhuravskaya 2015, Michalopolous and Papaioannou 2014, Schumann 2014)

The results indicate that indeed, economic development is significantly higher in the historically Roman parts of Germany. Furthermore, I can show that the Roman road network largely persisted until today, that the formerly Roman parts of Germany have a denser road network and that this denser road network is associated with better economic development. In addition, I am able to show that cities in the Roman area are on average larger and that this is particularly true for cities founded by the Romans and/or cities connected by Roman roads.

The remaineder of the paper is organized as follows: first, I explain the empirical setting and introduce the data used for the empirical analysis. Next, I conduct the empirical analysis, discuss relevant identification issues and interpret the results. Afterwards, I report the results of additional robustness checks and finally I conclude.

2 Data and Empirical Setting

2.1 Empirical Setting

The unit of analysis is a grid cell of 30*30 arc seconds (0.0083 degree size).[5] If not already available in this resolution all the data is aggregated to this grid cell size. All different shapefiles are projected to use the same spatial reference (UTM WGS 1984 Zone 32N). All distances are calculated as geodesic distances. All data was obtained using ArcGIS. The borders of contemporary Germany are extracted from a shapefile of European countries provided by the Eurostat GEOSTAT database.

2.2 Data

The dependent Variable is the natural logarithm of night light intensity (luminosity) of a grid cell. Luminosity is measured by a continuous scale ranging from 0 (unlit) to 63. Nightlight Data is available from the National Geophysical Data Center (NGDC) of the National Oceanic and Atmospheric Administration of the US. The data comes from satellite images taken for the Defense Meteorological Satellite Program (DMSP) of the US Department of Defense (the official data set is called DMSP-OLS).Here, I use the latest version of the data (4.0) and take the values of 2009. Figure 2 shows the distribution of nightlight luminosity across Germany as well as the Roman border.

[Figure 2 about here]

The course of the Border of the Roman Empire in 200 AD originates from a shapefile provided by Euratlas-Nüssli (Nüssli 2012). This border—which is identical to that in 100 AD— is chosen because it is the border that marks the Roman territory in Germany for a long period of time. Or, to put it another way, it represents the border of the largest territory in Germany that the Romans were able to hold for a long period of time.

[5]On the equator this is equivalent to a grid cell area of 0.86 square kilometers

The elevation data is taken from SRTM 90m Elevation data set in its newest version (4.0) and is available from the Consortium for Spatial Information (CGIAR-CSI). Data on terrain ruggedness is based on the above elevation data set by computing the grid level standard deviation of elevation. Data on agricultural suitability is computed from the data set of Zabel et al. (2014) and measures the suitability of a pixel's soil for the cultivation of 16 different kinds of crops. Data on the course of major rivers (Rhine, Danube, Elbe and Oder) are from the "WISE Large Rivers and Large Lakes" GIS map provided by the European Environment Agency.

Data on the course and coordinates of Roman roads is taken from the shapefile of McCormick et al. (2013) who digitized the information in the "Barrington Atlas of the Greek and Roman World". Finally, the data on major roads/ highways in Germany is from the "World Roads" shapefile included in ESRI Data & Maps (ArcGIS online).

Table 1 provides a descriptive overview of the data set and also gives a first impression about the different characteristics of the Roman and non-Roman part of contemporary Germany with respect to the considered variables.

[Table 1 about here]

3 Empirical Analysis

3.1 Roman Rule and Contemporary Economic Development

3.1.1 Identification Issues

To be able to identify a causal effect of a "Roman legacy" on contemporary outcomes from the BDD design, the standard assumptions of the RDD design have to hold (Lee and Lemieux 2010). However, in the context of a geographic discontinuity as assignment variable, there are additional challenges for identification (Dell 2010, Keele and Titiunik 2014). The standard RDD assumption is that in the absence of treatment all outcomes would vary smoothly at the border, i.e. there would be no discontinuity at the border in any outcome (Imbens and Lemieux 2008). With a geographic border as assignment variable this corresponds to the border being drawn in a non-systematic way. Testing the continuity of outcomes is possible by running a standard RD Design on relevant observables. As is evident from Table 1 there are significant differences in elevation, ruggedness and agricultural suitability between the historically Roman and non-Roman parts of Germany. Figure 3 visualizes the distribution of these three variables across Germany and also shows the course of the Roman border.

[Figure 3 about here]

A glance at these maps gives the impression that the differences between the Roman and the non-Roman areas are in general not caused by the Roman border but reflect differences between the mountainous southern part of Germany and the North German Plain.[6] This impression is confirmed by statistical evidence in Table 2.[7]

[Table 2 about here]

There I test for the continuity of elevation, ruggedness and agricultural suitability at the Roman border more formally by running a classical (one-dimensional) RDD with these variables as dependent variables. I estimate the RDD specification for different distance bands around the Roman border, beginning with a buffer area of less than 10km (column (1)) and ending with a buffer of less than 200m around the border in column (6). For all three variables, I found no discontinuity for a buffer area of less than 1km around the border and for all variables with the exception of ruggedness I cannot

[6] This is probably not true for a small area in today's Hesse (approximately at the point where the border has a turning point to north-south instead of east-west orientation. This area is the "Wetterau" an area with particularly high soil quality that the Romans wanted to secure for their own purposes. However, as I control for agricultural suitability this should be no concern. Furthermore, I show that the positive discontinuity in economic development also holds if I focus only on the segments of the border without the Wetterau area (see Table 8).

[7] As throughout the paper, the order of the distance polynomial used in the respective columns is chosen according to the AIC criterion.

reject their continuity for a buffer area smaller than 5km. This provides evidence that the Roman border can be used for a valid RDD analysis.

Furthermore, there could be relevant unobservable factors that cannot be tested. Thus, it is necessary to consider this point carefully. Here, one aspect seems to be especially important. It appears that the Romans were originally set on conquering a larger part of Germany establishing the Border of the Empire along the river Elbe and not the Rhine and Danube (the Elbe actually constituted the Border of the Empire for at least three times between 12 BC and 16 AD following the conquests of, Drusus, Tiberius and Domitius Ahenobarbus (Wolters 2011).[8] Thus, there is no reason to suppose that there were intrinsic detrimental characteristics of northern Germany that made it unattractive to the Romans (and likely were correlated with development). Rather it seems to be the case that there were other reasons why the cost of conquering larger parts of Germany exceeded the benefits (e.g. the failure in the battle of the Teutoburg forest).

Furthermore there should be no "compound treatment" or it should be irrelevant. Compound treatment would mean that the Roman border would not only be analogous to the border of the Roman Empire but completely or partly corresponds to other political/ administrative borders or geographical features that potentially matter for economic development. Here, the fact that the actual border of the Roman Empire through Germany—as it was in the 2nd century after the installment of the Limes—followed the Rhine in its westernmost part and the Danube in its easternmost part (see Figure 1) is important. The rest of the border (i.e., the Limes) seems not to have a systematic course as, e.g., it too does not follow contemporary administrative borders of

[8]During the rule of Augustus, the Romans started several attempts to conquer the area right of the Rhine, starting with the campaign of Drusus in 12 BC and followed by several other campaigns of Tiberius, Domitius Ahenobarbus and Germanicus. However, in 16 AD, among others, as consequence of the defeat in the battle of the Teutoburg forest, the Romans returned to their older positions left of the Rhine and south of the Danube. Nevertheless, the successors of Tiberius repeatedly tried to reconquer parts of Germania right of the Rhine (Riemer 2006, Wolters 2011). In fact, if the border of the Roman Empire would have been the Elbe then the Roman Area would have been more different to the non-Roman area with respect to elevation, ruggedness and agricultural suitability.

states or counties and is a straight line for more than 70km.[9] Thus, I decided to restrict the analysis to those parts of the border that are not identical to the course of Danube or Rhine, i.e. the Limes.[10]

A last condition for the validity of an RDD is the absence of selective sorting, i.e. the observed units should not be able to (completely) control the assignment variable and hence their treatment status. However, it does not appear that people (or cities) could systematically choose to be located in the Roman area or not. Furthermore, migration between the Roman and non-Roman parts of today's Germany was limited during the existence of the Roman Empire. This should be no valid concern here.

To further diminish heterogeneity and to account for the fact that the treatment effect might vary along different border segments (Keele and Titiunik 2014) I include border segment fixed effects in the RDD specification. Finally, I also include covariates (i.e. elevation, terrain ruggedness, agricultural suitability and distance to river) in some of the regressions to be sure that these factors do not cause the estimates to be biased.

3.1.2 Empirical Approach

A BDD is a special case of an RDD with a two-dimensional (or multiple) forcing variable (Keele and Titiunik 2014). As there is no consensus about how to estimate such a spatial RDD I implement all approaches applied by previous studies. First, I treat the border as a one-dimensional threshold and estimate a classical RDD with Euclidean distance to the Roman border as forcing variable. More precisely, I estimate variants of the following equation:

$$ln(Luminosity_{s,i}) = \alpha + \beta Roman_{s,i} + f(D_i) + \gamma' \mathbf{X_{s,i}} + \delta_s + \epsilon_{s,i} \quad (1)$$

[9] Apart from the Wetterau area as discussed in the previous footnote.

[10] Descriptive statistics of the actual estimation sample for the BDD regressions can be found in the Appendix Table A.1.

With $f(D_i)$ being a flexible function of each grid's geodesic distance to the closest border point. "Flexible" means that I allow the distance polynomial to differ in the treated and non-treated area (i.e., I interact the distance terms with the treatment variable). $ln(Luminosity_{s,i})$ is the nighttime light intensity of each grid in border segment s in 2009. $Roman_{s,i}$ is a dummy variable indicating whether a pixel was located within the territory of the Roman Empire in 200 AD. $\mathbf{X_{s,i}}$ is a vector of control variables, namely distance to the closest river and grid cell $i's$ elevation, ruggedness and agricultural suitability. Finally, δ_s represents border segment fixed effects (where the border is split into five equally large segments).[11]

Second, I treat the border as a two-dimensional threshold and estimate a BDD, i.e. I flexibly control for the exact geographic location of a pixel (its longitude and latitude):

$$ln(Luminosity_{s,i}) = \alpha + \beta Roman_{s,i} + f(x_i, y_i) + \gamma' \mathbf{X_{s,i}} + \delta_s + \epsilon_{s,i} \tag{2}$$

With $f(x_i, y_i)$ I have a flexible function of a grids' longitudinal and latitudinal coordinates (x_i and y_i). I will use $2^n d$ or $3^r d$ order coordinates polynomial of the following form: $f(x, y) = x + y + xy + x^2 + y^2 + x^2 * y + y^2 * x(+x^3 + y^3)$.

Third, following Seidel and von Ehrlich (2015) I combine both approaches and estimate an equation including both type of forcing variables.

Furthermore, I follow Dell (2010) in also using the distance to other geographical features or locations that are possibly relevant for economic development as forcing variable. That is, I will estimate equation (1) with $f(D_i)$ being a flexible function of each pixels' distance to the closest major river.

I implement the RDD in a parametric (or semiparamteric) and non parametric way. For the parametric specifications I only consider observations less than 100km away from the border. To come closer to the theoretically ideal RDD and to show robustness

[11] As the segments that are identical to Rhine and Danube are excluded I consider only the border segments 2–4 in the RDD estimation sample.

of the results I also estimate the RDD for 15km, 10km and 5km buffers around the Limes.

Hence, the actual area for which the BDD is estimated is (at most) a 100km distance band around the Limes. The distribution of nightlight luminosity in this area and the Limes is reported in Figure 4.

[Figure 4 about here]

3.1.3 BDD Results

To get a first impression about the presence of a discontinuity in luminosity at the Roman border in Germany it is useful to plot nightlight luminosity against distance to the Roman border as is done in Figure 5 for different bandwidths and using different methodologies. In Figure 5(a) I plot nightlight luminosity against distance to border using a bandwidth (buffer area) of 100km to the north and south of the border. The relationship between luminosity and distance to border is approximated by an 8^th order polynomial chosen according to the AIC criterion. Figure 5(b) depicts the relationship for a 10km bandwidth and models luminosity as a linear function of distance to border (again implied by the AIC criterion). Finally, in Figure 5(c) I visualize the result of a non-parametric RDD estimation using local linear regression (LLR) and choosing the bandwidth according to the method of Imbens and Kalyanaraman (2012).[12] All figures show a significant positive discontinuity in nightlight luminosity at the Roman border providing some initial evidence for a persistent positive effect of Roman legacy on economic development.

[Figure 5 about here]

In Table 3 I report the results of estimating non-parametric and parametric RDD specifications. In column (1) the results of the non-parametric RDD applying the LLR

[12] In all figures the bins are chosen according to the IMSE-optimal evenly-spaced method using polynomial regression.

method are reported. The coefficient indicates that in the historically Roman area, luminosity is on average around 5% higher than in the non-Roman area. This is virtually unchanged if I estimate the RDD using the method introduced by Calonico et al. (2014a) with bias-corrected robust standard errors (see Calonico et al. 2014b) correcting for too large bandwidth choices (second row of column (1)). In the case of the parametric RDD I first report the results using the coordinates polynomial, then using the distance polynomial and finally combining both in column (3). In column (4) I add border segment fixed effects and finally in column (6) I add four control variables (agricultural suitability, distance to a major river, elevation and ruggedness). The results of the parametric estimation imply an even larger effect of Roman legacy of around 10% higher luminosity in the historically Roman area.[13] Furthermore, standard errors clustered on latitude and longitude are reported in brackets to account most flexibly for the possibility of spatial clustering. These standard errors are estimated by applying the multiway-clustering method of Cameron et al. (2011). Although the standard errors are notably larger the coefficients remain significant in all but one case (column (2) without controls and the distance to border polynomial).

[Table 3 about here]

In Table 4 I repeat the parametric RDD estimations for smaller buffer areas of 15, 10 and 5km around the border. I start in the upper half of Table 4 by first including the coordinates polynomial (columns (1) to (3)) and then the distance polynomial (columns (4) to (6)) together with border fixed effects. In the upper half of the table I include both distance and coordinates polynomials jointly and add control variables in the last three columns. In general, these estimations again show a significant positive effect that is in the range of the initial non-parametric result implying an effect of Roman

[13]Again, the order of the polynomials is chosen according to the AIC criterion.

legacy of around 4 to 5%–although the effect is larger if one only includes coordinates polynomials.

[Table 4 about here]

Finally, Table 5 additionally considers polynomials in distance to a major river as a third forcing variable. Again the results hold, even if—as in the lower half of the Table in columns (4) to (6)—all three types of polynomials are added jointly together with border segment fixed effects and controls (again agricultural suitability, elevation and ruggedness). In fact, the results are even larger when the distance to river is included as additional forcing variable. They now imply that nightlight luminosity in the historically Roman part of Germany is at least (column (4) in the lower half of the table) 20% larger than in the historically non-Roman part of Germany. This indicates that the presence of rivers which is positively correlated with both being in the Roman area and economic development has masked some of the effects of Roman legacy.

[Table 5 about here]

3.2 Channels of Persistence

3.2.1 The Persistence of the Roman Road Network

For my argument about the importance of the Roman road network for the understanding of the persistent effect of Roman legacy is crucial.[14] In Figure 6 I present visual evidence confirming the persistence of the Roman road network in Germany. Figures 6(a)–7(c) show that large parts of today's highways (Autobahnen) and also major roads (Autobahnen and Bundesstraßen (federal highways)) follow the course of Roman Roads (i.e., are located in the same grid). The areas for which this is not true

[14]Among historians, one can find different opinions about the long-run importance of Roman roads. Bairoch (1988) or Lopez (1956) for example, are skeptical about the importance of Roman roads for medieval trade. They doubt that many of the important Roman roads were maintained or represented the most cost-saving path to the trade centers.

primarily connect more rural areas in the south of today's Baden-Württemberg and in the south-east of Bavaria with the large agglomerations of the state capitals Stuttgart and Munich and were also built to connect Switzerland and Austria to the major German road network. Furthermore, the dense road network connecting Frankfurt am Main and the Rhine-Neckar area with Saarbrücken (in the mid-west of the map) probably also follows historical Roman roads as Saarbrücken and Frankfurt originated from Roman settlements. However, McCormick et al. (2013) classified these roads (or their course) as uncertain and thus I do not consider them in the analysis, leading me to underestimate the possible persistence of the road network. Figure 6(d) shows the small amount of contemporary highways that do not follow a Roman road.

This persistence is likely due to the fact that many of the Roman cities and settlements remained important urban centers (Pirenne 1944, McCormick 2001) (e.g., due to the surviving ecclesiastical administration in the Roman bishoprics) and furthermore new cities developed along the roads connecting the Roman settlements taking advantage of the location on a road (Bosker and Buringh 2012). In light of the fact that the Romans choose the course of their roads to come as close as possible to the straight line often accepting large slopes and crossing mountainous area, this is a classical case of path-dependency (e.g. Margary 1973, Lopez 1956).

[Figure 6 about here]

Table 6 provides a more rigorous empirical test of the persistence of the Roman road network.[15] In columns (1)–(2) I show that there is a highly significant positive correlation between distance of a grid to a major contemporary road or highway and its distance to a Roman road. This correlation is robust to the inclusion of border segment fixed effects and agricultural suitability, distance to a major river, elevation and rugged-

[15]For these regressions, I use all observations, that is, I do include the critical areas—where the Roman border was identical to the course of the Rhine and Danube—that were previously excluded from the sample.

ness as additional controls. In column (3) I show that a grid with a Roman road is also more likely to have a contemporary highway intersecting its area.

The results in column (4) indicate that nightlight luminosity is significantly higher in grid cells intersecting Roman roads than in grid cells that do not intersect Roman roads (when considering the whole sample). Finally, column (5) tells us that in general, distance to a highway is significantly negatively associated with economic development.[16] Figure 7 visualizes these relationships. From both subfigures it is evident that the centers of economic activity (corresponding to the largest agglomerations/ cities) are all connected by both highways and Roman roads. This suggest that the most important centers of economic activity today were already connected with roads during the Roman era.

[Figure 7 about here]

3.2.2 Roman Legacy and a Denser Road Network

Now I test the first of the proposed transmission channels, namely that the persistence of the Roman road network allowed for a denser road network. To do so, I re-run the parametric BDD specification used in the lower half of Table 5 column (5), i.e. I include both the distance to the Roman border and to a major river as well as the coordinates polynomial and I only consider the area 10km around the historical Roman border. The result in column (6) suggests that, indeed, there is a significant negative discontinuity in distance to a highway at the historical Roman border.[17] This is suggestive evidence for the idea that the persistence of the Roman road network allowed for a denser transportation network.

[16]This would also work with a dummy variable indicating grids that intersect a highway. Regression not shown but available upon request.

[17]This result also holds if one were to control for luminosity to account for the fact that the higher road density could also be the result of higher economic development that in turn could have been the result of higher levels of urbanization and agglomeration caused by Roman heritage. The inclusion of luminosity would reduce the coefficient to -0.5033 which would still be significant at 1% level.

[Table 6 about here]

3.2.3 Roman Legacy and Long-run City Development

The second channel I consider to be responsible for the persistence of the Roman road network and the effect of Roman legacy on contemporary economic prosperity is city growth. After the decline of the Roman empire most of the cities/ settlements of the Romans remained important urban centers, e.g. due to their function as bishop seats but also due to the fact that almost all of them were connected by Roman roads (e.g. Hohenberg and Lees 1995, Planitz 1966). Therefore, those cities were easier to reach, giving them the advantage of a better market access and making them centers of trade and commerce. These advantages allowed them to grow earlier and faster than the non-Roman cities. This in turn led them to become larger and additionally resulted in a higher degree of agglomeration and urbanization in general. This was because over time new cities were founded along the existing roads that took advantage of the location on a road and managed to become notable centers of trade. Moreover, this persistence of the urban Roman network is also an additional factor explaining the persistence of the Roman road network as it is clear that the important urban centers are always connected by major roads and if these centers stay the same, then the roads connecting them stay the same.

To test the significance of this channel I create a city-level panel data set for including the population of cities 100km to the left and the right of the Limes in the years 1500, 1800 and 2000.[18] The city population data for 1500 and 1800 originates from Bairoch et al. (1984) and for the year 2000 I took the values from the Clio-infra database on urban settlements.[19] For the studied area these sources provide city populations for 54 cities (36 on the Roman side of the Limes and 18 on the non-Roman side). Altogether the

[18]For the years earlier than 1500 the number of cities with population figures would become too small to conduct a reasonable regression analysis. Thus, I limit myself to these three periods.

[19]The data can be downloaded here: `http://www.cgeh.nl/sites/default/files/def%20europe.xls`; accessed on July, 10th 2015.

data set consists of 154 city-year pairs. As city population figures are not available for each of the city-year pairs the actual number of city-year pairs on which I conduct the empirical analysis is 130. I supplement the city population data with the coordinates of the cities and the same variables as used in the previous grid level analysis. That is, I include the elevation at a city's coordinates, the standard deviation of elevation (ruggedness) and agricultural suitability in an area 5km around the city, as well as a city's distance to the closest major river and the closest Roman road. Furthermore, I collected information on Roman cities/ settlements and whether these were located on a Roman road.[20] A descriptive overview of this data set is given in the Appendix, Table A.2. Figure 8 shows the locations of the cities (cities on the Roman side of the border in red and cities on the non-Roman side of the border in blue), their size in 1800 (Figure 8(a)) and 2000 (Figure 8(b)) indicated by the size of the dots, as well as the Roman road network. The visual impression suggests that cities on the Roman side of the border seem to be larger on average than their counterparts in the non-Roman area.

[Figure 8 about here]

To empirically test the persistent impact of Roman legacy on city development I estimate the following regression specification:

$$ln(Population_{isc}) = \alpha + \beta Roman_{si} + \gamma' \mathbf{X_{si}} + \delta_s + \lambda_c + \epsilon_{isc} \quad (3)$$

Where $ln(Population_{isc})$ is the natural logarithm of the population of city i in border segment s in year c with $c = 1500, 1800, 2000$. $Roman_{si}$ is one of five measures of Roman treatment of city i in border segment s. $\mathbf{X_{si}}$ is a vector of control variables including agricultural suitability, ruggedness, elevation and distance to a major river. Finally, δ_s are border segment fixed effects, λ_c are year fixed effects and ϵ_{isc} is the error term.

[20] Information about Roman settlements is taken from the shapefile"Europe in 200 AD" provided by Euratlas Nüssli (Nüssli 2012).

Equation (3) is estimated using OLS with standard errors clustered on city level. Results of the estimations are reported in Table 7. In column (1) I regress city population on a dummy for cities located in the historically Roman area. I find a large and positive effect indicating that cities on the Roman side of the border are on average around 50 % larger. If I limit myself to the cross-section of city population in 2000, the estimated effect would be even larger.[21] In column (3) I include a dummy variable for cities actually founded by the Romans, i.e. cities that developed from a Roman settlement (like e.g., Mainz or Trier) and find a comparable positive effect. I uncover a smaller, yet still economically and statistically significant effect if I limit myself only to cities located on a Roman road (column (4)).[22] However, the most direct test of my argument is to look at cities founded by the Romans that were located on a Roman road. If I include a dummy variable identifying those cities in the regression, the estimates (column (5)) again suggest that those cities were on average around 50 % larger than the other cities.

Finally, to directly test the hypothesis that the advantage of Roman cities is to a large extent due to their location on a Roman road I limit the analysis to the Roman area and show that within the Roman area, Roman cities had a growth advantage compared to non-Roman cities (column (6)) and that this advantage disappears when I additionally include the distance to the next Roman road (column (7)).

All in all, the estimates in Table 7 indicate that city growth was larger in the formerly Roman area of Germany and that this higher city growth probably resulted from the amenities of the Roman road network. Compared to the previous findings of Bosker et al. (2013) my empirical results suggest a more robust and larger effect of Roman roads on city development than they found in their, larger European sample. Even more, their observation period ends in 1800 AD, while I could show that the effect survived

[21] In general, results using a cross-section for the population estimates in 2000 would yield comparable results. However, I do not report all of them due to space restrictions. They are available upon request.

[22] I code a city as being located on a Roman road if it is located within a 5km buffer around the road.

the fundamental changes connected to the Industrial Revolution and is visible even today.

[Table 7 about here]

4 Robustness Checks

How can I make sure that the robust border effect I found is not due to a statistical coincidence? Often, researchers conduct tests with placebo borders (shifting the border to the south or the north of the actual border) to see if they can find an effect then. However, unlike when one conducts such a placebo test for an enormous amount of placebo borders, one might still find a "placebo border effect" due to coincidence. Thus, a more satisfying way of conducting such a placebo-like test is to run a Zivot-Andrews test. This test allows to identify the most likely structural break (in the intercept) in the luminosity series from the data itself. I run the Zivot-Andrews test on luminosity.[23] The results are shown in Figure 9. The test identified the most likely breakpoint at a distance of 2km to the north of the Roman border. However, given the spatial resolution of the data, the remaining uncertainty about the exact location of the border and the fact that the test only allows distance to be measured with integer values, this is evidence for the distinctive nature of the Roman border and thus suggests that I do not find a border effect due to simple coincidence.

[Figure 9 about here]

A last robustness check is to look at whether the results of the BDD change if I consider each segment of the border separately. This is done in Table 8 where I re-estimate the specification of Table 5 column (4)–(6) in the lower half of the table that basically includes the three different types of forcing variables (distance to border, distance to

[23]The number of lags considered by the test are chosen according to the AIC criterion.

major river and coordinates) as well as all controls. The only difference is that, this time, I run the regressions for each of the border segments separately. For the second border segment (columns (7)–(9)) the results are almost identical to the results obtained with all segments of the border. However, the results for the third and fourth border segment are huge, particularly for the 3rd border segment. If one looks at the spatial distribution of luminosity in these border segments, it is evident that large agglomerations on the Roman side (Frankfurt am Main and Stuttgart) are located close to the border while on the non-Roman side of the border there are rural areas that can explain these huge results. Nevertheless, one should not take the size of these coefficients for granted—however, it is reassuring that there is still a significant and positive effect. This is especially true for the 2^nd and 4^th border segments that do not include the Wetterau area, which it is known to have had favorable characteristics and was intentionally conquered by the Romans.

[Table 8 about here]

5 Concluding Remarks

The present study has shown that the Roman Limes border wall across contemporary Germany constitutes a positive discontinuity in economic development. Those parts of contemporary Germany that once were part of the Roman Empire show higher economic development than the non-Roman parts. I was also able to show that this positive and long-lasting Roman legacy is likely due to the persistence of the Roman Road network. This persistence meant that settlements in the former Roman Empire have had developmental advantages in several ways as it has allowed for a denser transportation network and a faster city growth resulting in higher levels of urbanization, agglomeration and economic activity.

These results are in line with other studies, e.g. documenting the persistence of the

Roman urbanization patterns in Europe as well as the persistence of the Roman ecclesiastical structure (e.g. the bishop seats). However, it is contrary to other studies that, considering e.g. the centers of the Roman market economy, do not find persistence from the Roman era to the Middle Ages. Thus, it also contributes to the understanding of the conditions necessary for the existence of persistence itself.

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Figures and Tables

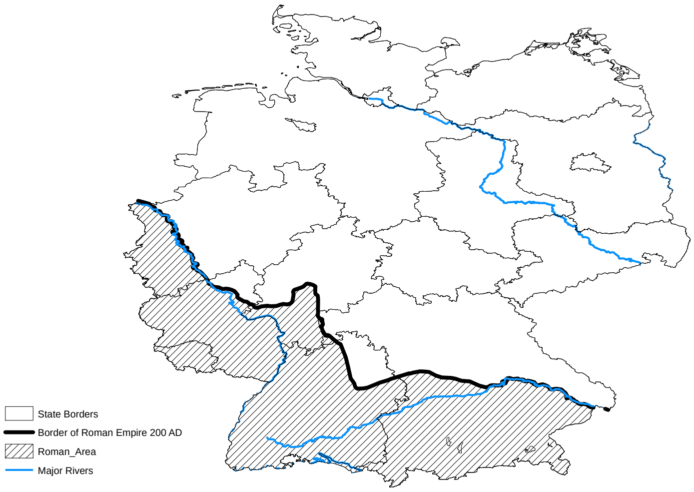


Figure 1: Border of the Roman Empire in 200 CE and Contemporary Germany

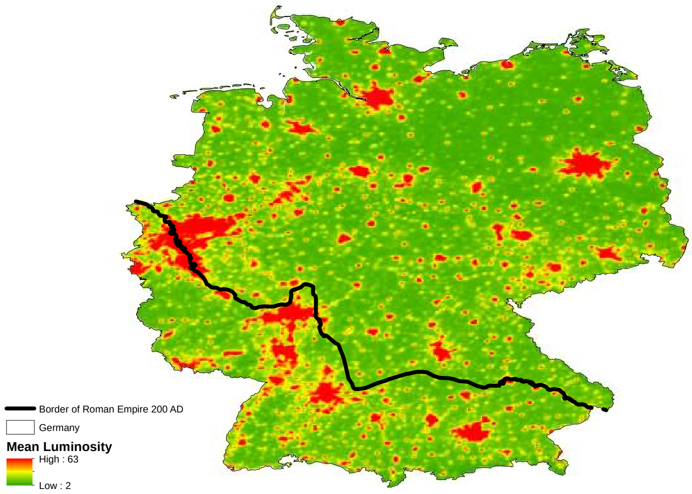
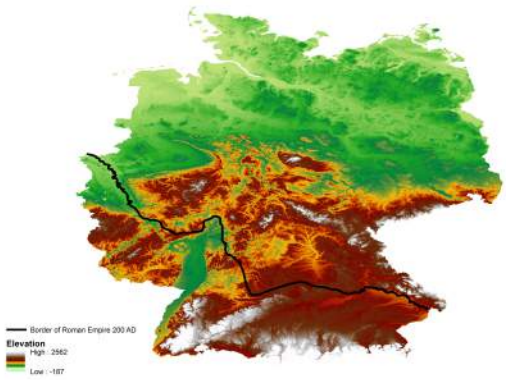
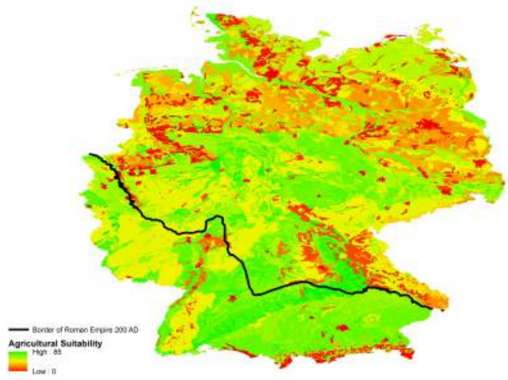


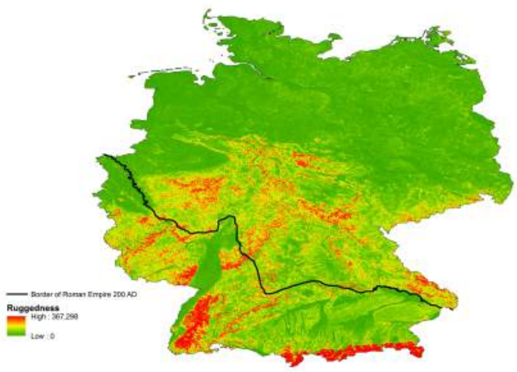
Figure 2: Night Light Intensity and the Roman Border



(a) Elevation and the Roman Border



(b) Agricultural Suitability and the Roman Border



(c) Ruggedness and the Roman Border

Figure 3: Spatial Distribution of Relevant Covariates Across Germany

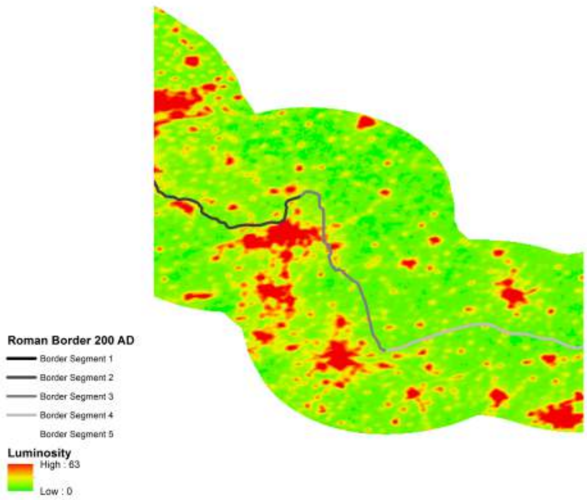
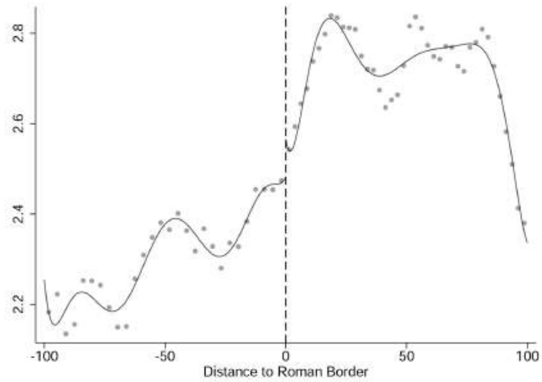
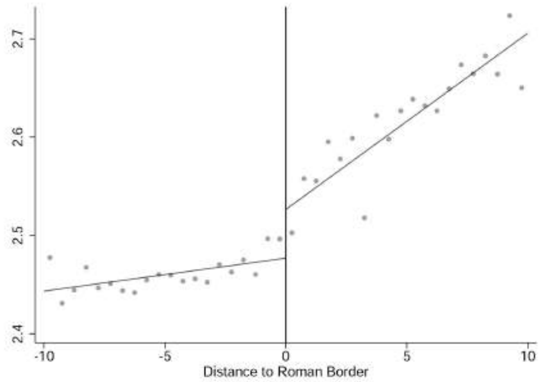


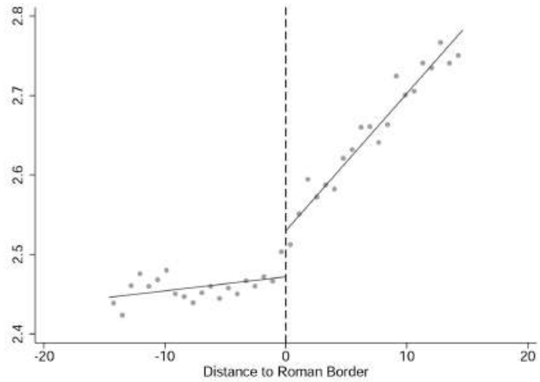
Figure 4: Luminosity within 100km Around the Roman Border (Without Critical Border Segments)



(a) 100km Buffer

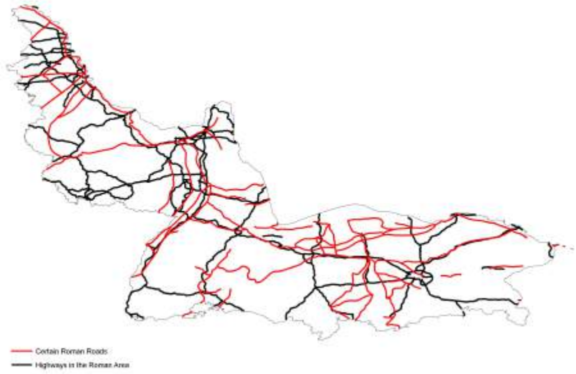


(b) 10km Buffer

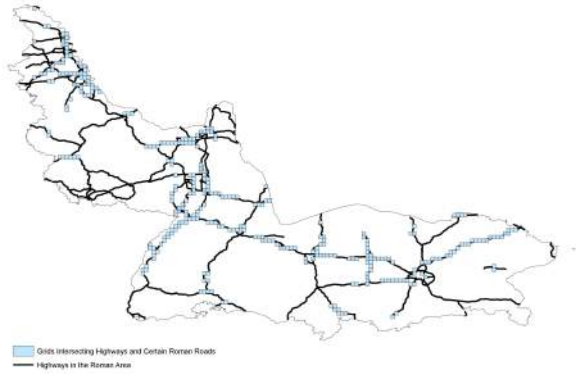


(c) Non-parametric RDD (Local Linear Regression)

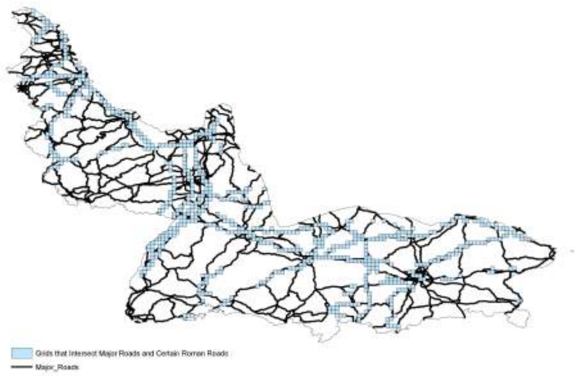
Figure 5: Baseline RDD Estimates



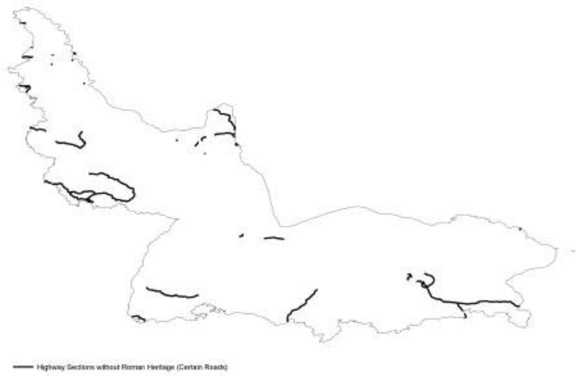
(a) Roman Roads and Contemporary Highways



(b) Grids Intersection Roman Roads and Highways

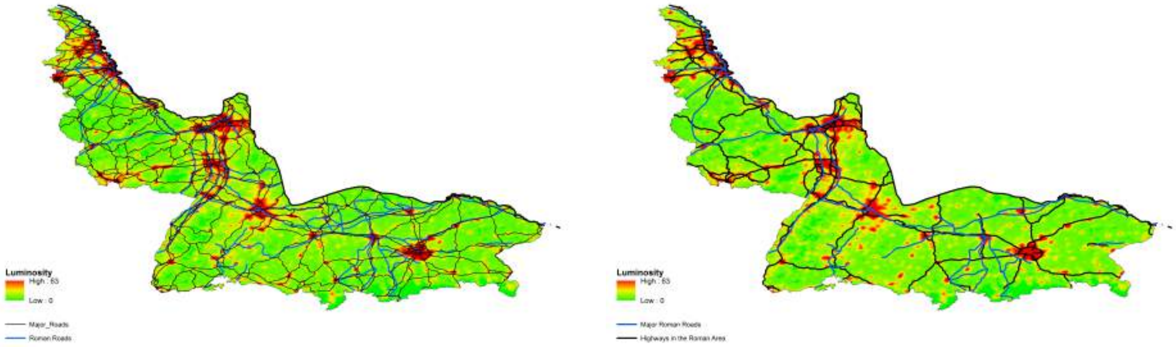


(c) Grids Intersection Roman Roads and Major Contemporary Roads



(d) Highway Sections without Roman Counterpart

Figure 6: Persistence of the Roman Road Network



(a) Roman Roads and Contemporary Major Roads **(b)** Major Roman Roads and Contemporary Highways

Figure 7: Persistence of the Roman Road Network and Luminosity

(a) City Size in Roman and Non-Roman Germany in 1800 **(b)** City Size in Roman and Non-Roman Germany in 2000

Figure 8: City Population in the Roman and Non-Roman Area of Germany (within a 100km Buffer)

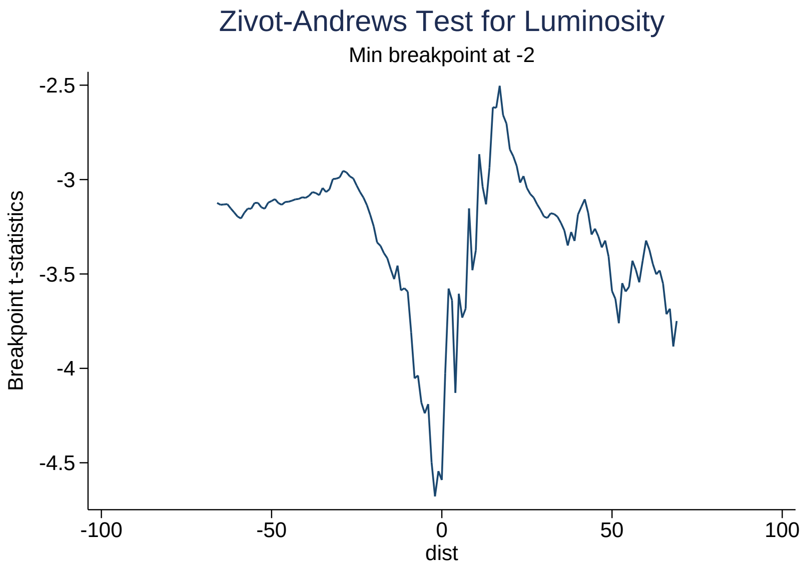


Figure 9: Zivot-Andrews Breakpoint Test of Luminosity

Table 1: Descriptive Statistics of Outcomes and Controls

Mean					Observations	
Roman	Non-Roman	All	S.E	Sign.	Roman	Non-Roman
Luminosity						
15.676	10.811	11.978	0.035	***	177870	483332
Agricultural Suitability						
52.172	37.583	41.51	0.059	***	177366	481673
Distance to Highway						
9.53	11.711	11.121	0.025	***	178347	481014
Distance to River						
38.073	74.984	65	0.098	***	178347	481014
Elevation						
450.324	182.91	254.856	0.671	***	177870	483248
Ruggedness						
17.218	9.007	11.216	0.05	***	177870	483248

Notes. Coefficient is statistically different from zero at the ***1 % level. The unit of observation is a pixel of 0.86 square kilometers size. The standard errors reported are from a t-test of equality of means assuming unequal variances.

Table 2: Testing for Discontinuities in Covariates at the Roman Border

	(1)	(2)	(3)	(4)	(5)	(6)
Buffer Area	<10km	<5km	<2km	<1km	<500m	<200m
			Panel A: Elevation			
Roman Area	-6.639*	-3.571	-3.916	-3.991	-5.225	-6.884
	(3.406)	(4.473)	(5.925)	(6.905)	(7.585)	(8.102)
Distance Polynomial			Linear			
Obs.	33,783	18,018	8,368	5,054	3,340	2,319
R^2	0.020	0.006	0.001	0.000	0.000	0.001
AIC	440831	235700	109752	66347	43867	30492
			Panel B: Ruggedness			
Roman Area	-0.966***	-0.724**	-1.083**	-0.943	-0.730	-0.813
	(0.243)	(0.321)	(0.430)	(0.579)	(0.541)	(0.573)
Distance Polynomial		Linear		Quartic	Linear	
Obs.	33,783	18,018	8,368	5,054	3,340	2,319
R^2	0.021	0.008	0.002	0.005	0.004	0.002
AIC	262734	140578	65907	39900	26333	18230
			Panel C: Agricultural Suitability			
Roman Area	1.864**	0.991	1.284	0.749	-0.435	-0.380
	(0.743)	(0.882)	(0.799)	(0.927)	(1.110)	(1.089)
Distance Polynomial	Cubic		Linear		Cubic	Linear
Obs.	33,765	18,006	8,361	5,048	3,334	2,314
R^2	0.046	0.040	0.020	0.007	0.005	0.008
AIC	302381	162541	76097	46035	30437	21113

Notes. Robust Standard errors are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a pixel of 0.86 square kilometers size. Flexible distance polynomials are applied, i.e. it is assumed that the distance polynomial in the treated area is different from that of the not treated area.

Table 3: Parametric and Non-Parametric RDD

Dep. Var.	ln(Luminosity)					
	(1)	(2)	(3)	(4)	(5)	(6)
Method	Nonparametric RDD	Parametric RDD				
Roman Area	0.0488***	0.2666***	0.0986***	0.0988***	0.109***	0.102***
	(0.0143)	(0.0061)	(0.0219)	(0.0206)	(0.0187)	(0.0169)
		[0.0406]	[0.0608]	[0.0581]	[0.0553]	[0.0472]
Roman Area (B. Corr. & Robust)	0.0535***					
	(0.0143)					
Order of Coordinates Polynomial		3rd		3rd	3rd	3rd
Order of Distance Polynomial			8th	8th	8th	8th
Segment Dummies	No	No	No	No	Yes	Yes
Controls	No	No	No	No	No	Yes
Obs.	29,766	181,950	181,950	181,950	181,950	181,947
Bandwidth Estimator	IK					
Bandwidth	14.618					
R^2		0.161	0.081	0.173	0.185	0.359
AIC		397329	413963	394868	392118	348426

Notes. In columns (2)–(6) robust Standard errors are reported in parentheses and standard errors adjusted for multiway clustering along latitude and longitude are shown in brackets. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a pixel of 0.86 square kilometers size. Flexible distance polynomials are applied, i.e. it is assumed that the distance polynomial in the treated area is different from that of the not treated area. Nonparamteric RDD means estimates in column (1) are estimated using local linear regression according to the method introduced in Calonico et al. (2014a) with standard and bias-correct robust confidence intervals (see Calonico et al. 2014b).Bandwidth is select according to the the selection criteria of Imbens and Kalyanaraman (2011). The included control variables in column (7) are agricultural suitability, ruggedness, elevation and distance to a major river.

Table 4: Semiparamteric RDD Estimates I

Dep. Var.	ln(Luminosity)					
	(1)	(2)	(3)	(4)	(5)	(6)
Buffer Area	<15km	<10km	<5km	<15km	<10km	<5km
Type of Polynomial	Latitude & Longitude			Distance to Roman Border		
Order of Coordinates Polynomial	2nd					
Order of Distance Polynomial				1st		
Roman Area	0.248***	0.207***	0.115***	0.0472***	0.0476***	0.0299
	(0.00784)	(0.00855)	(0.0105)	(0.0126)	(0.0146)	(0.0189)
Controls	No	No	No	No	No	No
Obs.	30,524	20,767	10,929	30,524	20,767	10,929
R^2	0.214	0.239	0.280	0.169	0.184	0.182
AIC	55490	35453	16893	57158	36892	18294
Type of Polynomial	Distance to Border & Latitude and Longitude					
Order of Coordinates Polynomial	2nd					
Order of Distance Polynomial	1st					
Roman Area	0.0543***	0.0552***	0.0328*	-0.00109	0.0354***	0.0368**
	(0.0121)	(0.0139)	(0.0176)	(0.0102)	(0.0115)	(0.0147)
Controls	No	No	No	Yes	Yes	Yes
Obs.	30,524	20,767	10,929	30,524	20,767	10,929
R^2	0.226	0.246	0.282	0.482	0.503	0.505
AIC	55015	35266	16867	42765	26611	12808

Notes. Robust Standard errors are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a pixel of 0.86 square kilometers size. Flexible distance polynomials are applied, i.e. it is assumed that the distance polynomial in the treated area is different from that of the not treated area. All regression include border segment fixed effects. The included control variables are agricultural suitability, ruggedness, elevation and distance to a major river.

Table 5: Semiparamteric RDD Estimates II

Dep. Var.	ln(Luminosity)					
	(1)	(2)	(3)	(4)	(5)	(6)
Buffer Area	<15km	<10km	<5km	<15km	<10km	<5km
Type of Polynomial	Distance to River			Distance to River & Lat. And Long.		
Order of Distance River Polynomial	7th			7th		
Order of Coordinates Polynomial				2nd		
Roman Area	0.422***	0.684***	0.387***	0.174***	0.514***	0.421***
	(0.0509)	(0.0514)	(0.0550)	(0.0488)	(0.0481)	(0.0502)
Controls	No	No	No	No	No	No
Obs.	30,524	20,767	10,929	30,524	20,767	10,929
R^2	0.307	0.377	0.414	0.494	0.527	0.538
AIC	51639	31322	14663	42032	25616	12054
Type of Polynomial	Distance to River			Distance to River & Lat. And Long. & Distance to Border		
Order of Distance River Polynomial	7th			7th		
Order of Coordinates Polynomial	2nd			2nd		
Order of Distance Border Polynomial				3rd	2nd	6th
Roman Area	0.335***	0.481***	0.0854	0.217***	0.558***	0.397***
	(0.0571)	(0.0572)	(0.0573)	(0.0516)	(0.0502)	(0.0536)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	30,524	20,767	10,929	30,524	20,767	10,929
R^2	0.252	0.314	0.346	0.497	0.529	0.539
AIC	53976	33306	15853	41853	25536	12045

Notes. Robust Standard errors are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a pixel of 0.86 square kilometers size. Flexible distance polynomials are applied, i.e. it is assumed that the distance polynomial in the treated area is different from that of the not treated area.All regression include border segment fixed effects. The included control variables are agricultural suitability, ruggedness and elevation.

Table 6: Roman Heritage, Transport Infrastructure and Luminosity

Dep. Var.	ln(Distance to Highway)	ln(Distance Major Road)	Highway Grid	ln(Luminosity)	ln(Luminosity)	ln(Distance to Highway)
	(1)	(2)	(3)	(4)	(5)	(6)
Buffer Area						<10km
Type of Polynomial						Dist. to River/ Lat. & Long. / Dist. to Border
Order of Distance River Polynomial						7th
Order of Coordinates Polynomial						2nd
Order of Distance Border Polynomial						7th
ln(Distance to Roman Road)	0.116***	0.124***				
	(0.002)	(0.002)				
Roman Road Grid (Roman Area)			0.0139***			
			(0.003)			
Roman Road Grid (Whole Sample)				0.5661***		
				(0.01)		
ln(Distance to Highway)					-0.415***	
					(0.001)	
Roman Area						-0.749***
						(0.074)
Segment Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	177,366	177,366	177,366	658976	20,767	20,767
R^2	0.193	0.162	0.016	0.095	0.244	0.414
AIC						44455

Notes. Robust Standard errors are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a pixel of 0.86 square kilometers size. Flexible distance polynomials are applied, i.e. it is assumed that the distance polynomial in the treated area is different from that of the not treated area. The included control variables are agricultural suitability, ruggedness, elevation and distance to a major river. In column (5) the ln of luminosity is additionally included as control variable.

Table 7: Roman Legacy and City Development

Dep. Var.	ln(City Population)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Roman Area	0.475**	0.843**					
	(0.237)	(0.348)					
Roman City			0.407**			0.360**	0.236
			(0.174)			(0.177)	(0.166)
City on Roman Road				0.299*			
				(0.169)			
Roman City on Roman Road					0.424**		
					(0.179)		
Distance to Roman Road							-0.0196*
							(0.01)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	130	54	130	130	130	88	88
Adj. R^2	0.814	0.590	0.816	0.812	0.817	0.828	0.832

Notes. Standard errors clustered on city level are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a pixel of 0.86 square kilometers size. The included control variables are agricultural suitability, ruggedness, elevation, distance to a major river and segment and century fixed effects.

Table 8: Roman Legacy and Economic Development—Considering Individual Border Segments

Dep. Var.	ln(Luminosity)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Buffer Area	<15km	<10km	<5km	<15km	<10km	<5km	<15km	<10km	<5km
	4th Border Segment			3rd Border Segment			2nd Border Segment		
Order of Distance Border Polynomial	4th		2nd	7th	3rd	1st	7th	4th	2nd
Order of Coordinates Polynomial					1st				
Order of Distance River Polynomial		7th		7th	5th	6th		7th	
Roman	2.355***	1.805***	0.556	1,221***	161.0***	397.7***	0.154***	0.155***	0.241***
	(0.41)	(0.393)	(0.374)	(195.7)	(51.71)	(75.34)	(0.048)	(0.045)	(0.047)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	9,193	6,288	3,311	12,147	8,213	4,294	9,024	6,250	3,324
R^2	0.361	0.361	0.314	0.562	0.593	0.636	0.681	0.694	0.691
AIC	12602	7946	4244	13531	7595	3205	7572	4241	1546

Notes. Robust Standard errors are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a pixel of 0.86 square kilometers size. Flexible distance polynomials are applied, i.e. it is assumed that the distance polynomial in the treated area is different from that of the not treated area. The included control variables are agricultural suitability, ruggedness, elevation and distance to a major river.

Appendix

Table A.1: Descriptive Overview of the Estimation Sample for the BDD Estimates

Variable	Obs	Mean	Std. Dev.	Min	Max
Agricultural Suitability	181947	49.317	21.498	0	85
Elevation	181950	363.557	161.985	22.49	984.24
Highway Grid(Roman Area)	83224	0.045	0.206	0	1
Latitude	181950	49.802	1.031	47.958	52.541
ln(Distance to Highway)	181950	1.934	0.937	0	3.928
ln(Distance to Major Road)	181950	1.19	0.79	0	3.114
ln(Distance to River)	181950	3.746	1.015	0	5.141
ln(Distance to Roman Road)	83224	1.877	0.943	0	4.053
ln(Luminosity	181950	2.493	0.787	0	4.159
Longitude	181950	9.315	1.248	7.204	11.796
Roman	181950	0.457	0.498	0	1
Roman Road Grid	83224	0.045	0.206	0	1
Ruggedness	181950	15.427	12.321	0	104.939

Table A.2: Descriptive Overview of the City Level Data Set

Variable	Obs	Mean	Std. Dev.	Min	Max
Agricultural Suitability	162	38.278	27.518	0	85
Distance to River	162	48.759	39.749	0.277	165.987
Distance to Roman Road	108	6.284	8.129	0.105	33.569
Elevation	162	249.722	126.242	69	521
Latitude	162	49.497	0.751	48.137	51.309
ln(City Population)	130	9.925	1.495	6.908	14.006
Longitude	162	9.354	1.142	7.466	11.744
Roman Area	162	0.667	0.473	0	1
Roman City	162	0.185	0.39	0	1
Roman City on Roman Road	162	0.167	.374	0	1
Ruggedness	162	36.084	23.699	2.796	133.018

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