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Frontiers, Warfare and the Economic Geography of Countries: The Case of Spain

By *Daniel Oto-Peralías*

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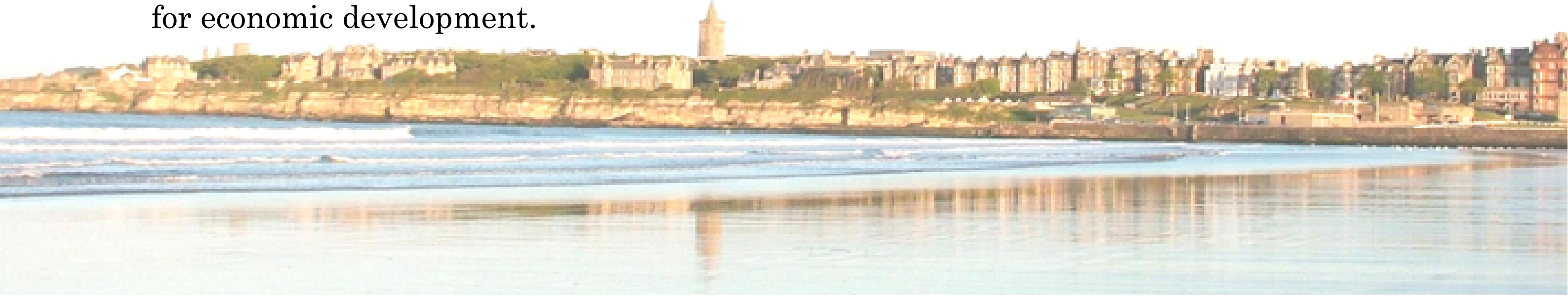

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Abstract

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Keywords: Frontiers, Warfare, Economic Geography, Spain, Europe, Spatial discontinuity.
JEL Classification: C14, N90, O1, R10.

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1 Introduction

This article shows that historical frontiers can decisively shape the economic geography of countries. Frontiers can explain why people live close together in cities in some regions but scattered across the space in others and why some areas are scarcely settled. This question is at the heart of one of the most central issues in economic geography and in economics in general: the determinants of the spatial distribution of the population and economic activity (Ottaviano and Thisse, 2004; Ahlfeldt et al., 2015; Redding, 2016). Its relevance lies in that geographic location matters a lot. How villages, towns and cities are distributed across the space significantly affects economic interactions and may influence economic development in the short- and long-run.[1] It can inform us not only about current economic outcomes, but also about factors related to the historical development path of countries –for instance, landownership, land use and main economic activities.

Focusing on historical Spain, I explore how extreme military insecurity in frontier regions can condition the political and economic occupation of the territory to such an extent to convert it into one of the most desert areas in Europe. The first part of the analysis documents that Spain has an anomalous settlement pattern characterized by a very low density in a large part of its territory, which goes hand in hand with a high spatial concentration of the population. Econometric evidence rules out geographic and climatic factors as relevant explanations for this. The second part investigates the historical origins of Spain's settlement and population patterns, with the findings pointing to the dynamics of a large and insecure frontier region in the Middle Ages, and the associated militarized and "ranching" style of colonization, as their main determinants. It is also shown that the area exposed to medieval frontier warfare is relatively poorer today.

The settlement and population structure of the territory constitutes a key element of a country's economic geography, heavily affecting economic interactions and development (World Bank, 2009). Figure 1 shows three indicators that capture different dimensions of this structure, namely, the extent of the settlement of the territory, population concentration and population density. Panel A represents an indicator of settlement density that measures the percentage of 10-km^2 grid cells that are inhabited in each pixel unit. Many European countries have values close to 100%, which means that it is rare to find uninhabited 10-km^2 cells. The picture is naturally different in high-latitude countries such as Iceland and the northern part of Scandinavia, where settlement density is low, but Spain stands out as a separate case. A large part of its territory, particularly its southern half, has a remarkably low density of settlements. Only 44% of 10-km^2 grid cells are populated in Spain, which is one of the lowest values in Europe.[2] Extreme geographic and climatic conditions do not seem to be the reason

[1] According to the general equilibrium framework developed by Allen and Arkolakis (2014), geographic location alone can explain at least 20% of the spatial variation in income across the United States.

[2] Only Iceland, Norway and Macedonia have lower values. The first two are close to the Arctic while the third one is a small Balkan country. Differences are also striking at the sub-national level: among the ten European NUTS 3-regions with the lowest settlement density, six are from southern Spain, while the other four are from Iceland, Norway, Sweden, and Finland. When one looks at the percentage

for this. I use the term 'Spanish anomaly' for this remarkably low density of settlements not explained by geography and climate.

The fact that a large part of the Spanish territory is unpopulated does not necessarily imply low population density. People may live concentrated in cities and towns, leaving a relatively empty countryside. This appears to be the case for most of the Spanish territory. Panels B and C show that the pattern of population density is not particularly different from the rest of Europe but the level of population concentration is much higher. Consistent with this, Spain ranks in an intermediate position in population density (22nd out of 37) but occupies a top position in population concentration (2nd/37).[3]

After ruling out geography and climate as main explanations for Spain's anomalous settlement and population patterns, the central part of the paper investigates its historical origins. The Spanish anomaly is not a recent phenomenon. Already in the 17th century, European travelers were impressed by the scarcity of settlements: "One can travel for days on end without passing a house or village, and the country is abandoned and uncultivated"; "Spain gives the impression of being a desert of Libya, so unpopulated it is".[4] I put forward the hypothesis that the Spanish anomaly has medieval frontier origins. It was the consequence of frontier warfare and insecurity during the central centuries of the Middle Ages. Intensive warfare determined a colonization strategy based on militarization, ranching and the concentration of the population in a few fortified settlements. To test this hypothesis, I exploit a geographic discontinuity in military insecurity during the 11th to 13th centuries in the context of the Spanish Reconquest.

"Historical accidents" made the colonization of the area south of the Tagus River very different from the colonization north of it. The invasions of the Almoravids and Almohads converted the territory south of the Tagus into a battlefield for one-and-a-half centuries (c. 1085-1230), this river being a natural defensive border. Continuous warfare and insecurity heavily conditioned the nature of the colonization process in this frontier region, which was characterized by the leading role of the military orders as colonizer agents, scarcity of population, and a livestock-oriented economy (González Jiménez, 1992). The implications were the prominence of great castles and the absence of villages and towns, and consequently, a spatial distribution of the population characterized by a very low density of settlements. Bishko (1963) referred to this style of colonization as a "medieval ranching frontier". As argued below, the interplay between initial militarization and ranching contributed to the persistence of the initial spatial population structure.

The empirical analysis supports the medieval frontier hypothesis by revealing a statistically significant jump in settlement density and population concentration across the River Tagus, whereas there are no geographic and climatic discontinuities across it nor pre-

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of 1-km^2 grid cells populated in each country, Spain ranks at the bottom (only above Iceland), with a value of 12.3%.

[3] 76.6% of the Spanish population live in the most populated one percent of the territory. Only Iceland has a higher concentration with an extreme value above 99%.

[4] From the Venetian ambassadors Federico Cornaro (1678-81) and Giovanni Cornaro (1681-82), quoted in Brenan (1950: 128).

existing differences in settlements and Roman roads. The results are robust to many specification tests and several falsification exercises. In addition, I collect census data on population entities in the 16th and 18th centuries to show that the discontinuity in settlement density already existed in those periods, and therefore is not the result of migration movements and urban developments taking place in the modern or contemporary eras. A confirmatory analysis for Portugal, which shares a common historical past, provides support for the findings. The results also indicate that the territory exposed to the medieval ranching frontier is relatively poorer today, suggesting that the way the territory is settled matters for development. Overall, my findings indicate that the anomalous spatial distribution of the population in Spain has, to a large extent, medieval frontier roots, and potential implications for development

The analysis of the Spanish case makes an interesting general point by showing that historical frontier warfare can shape a country's economic geography by generating an occupation of the territory characterized by high population concentration and scarcity of settlements. The exposure to warfare and insecurity creates incentives for a militarized colonization based on a few fortified settlements and a livestock-oriented economy. This mechanism can operate in similar historical contexts, such as the Chinese northern frontier with the nomadic peoples of Central Asia and the Russian steppe frontier. It can also be applied to other contested frontiers in Europe, for instance with the Ottoman Empire, although the remarkably low settlement density and high population concentration in Spain's southern plateau is the legacy of remarkably high frontier violence and insecurity.[5]

This article's focus on settlement patterns and population concentration provides new insights into a central topic in economic geography, namely the spatial distribution of the population and economic activity (Ottaviano and Thisse, 2004). The results of the analysis reveal an important role of frontiers in shaping the settlement structure of the territory and how persistent this structure may become, which contributes to the extant literature that shows that cities and the urban network are very persistent and to the debate regarding the role played by location fundamentals (Bleakley and Lin, 2012; Michaels and Rauch, 2017; Bosker and Buringh, 2017).

This paper also relates to a new empirical literature on frontier societies which has studied the consequences of frontiers in North and South America and Spain (García-Jimeno and Robinson, 2011; Oto-Peralías and Romero-Ávila, 2016, 2017; Droller, 2017; Bazzi et al., 2017).[6] Compared to previous work, this article focuses on the effect of frontiers on the spatial

[5] In this regard, it is worth stressing that Castile and Leon "experienced events between the 11th and 13th centuries that make it a particularly interesting and exceptional subject of study for the analysis of war" (García Fitz, 2016: 26). Thus, medieval Iberian societies suffered, on top of a level of conflict between Christian kingdoms comparable to that of the rest of Europe, the war against Islam, against rich Muslim estates and powerful North African empires.

[6] García-Jimeno and Robinson (2011) analyze the divergent frontier experiences in the New World and argue that the outcome of frontier expansions depends on the initial political equilibrium. Oto-Peralías and Romero-Ávila (2016) focus on the Spanish Reconquest and propose that the political equilibrium and the outcome of the colonization process may be endogenous to the pace of the frontier expansion. Oto-Peralías and Romero-Ávila (2017) exploit the former frontier of Granada to study the link between militarily insecurity in frontier regions and inequality. Droller (2017) focuses on the

distribution of the population, which is the basic layer on which all economic activities are built. In addition, this paper adds to the literature on the effect of military conflicts on urban growth, state capacity and economic development. In contrast to previous works finding long-term positive effects of conflicts (e.g., Voigtländer and Voth, 2013; Dincecco and Onorato, 2016), the analysis shows that historical warfare may have negative consequences in certain contexts. Thus, in consolidated states or kingdoms it may foster urban growth and fiscal capacity, but in frontier regions it may lead to negative outcomes.[7] As discussed below, under the conditions of frontier expansion, intense militarization and a ranching-oriented economy, a large region can get trapped in a vicious circle of low settlement density, with negative implications for development.[8]

Finally, this study is also related to a body of research on the interplay between history and geography, more specifically, on the contingent role of geographic factors in development (e.g., Dell 2012, Nunn and Puga 2012, Belloc *et al.* 2017). As argued below, the River Tagus created a discontinuity in settlement patterns and development due to a contingent factor such as high military insecurity, which in turn was the consequence of the Almoravid and Almohad invasions during the 11th and 12th centuries. It was the interaction between history and geography that left its lasting imprint on Spain's economic geography.

The rest of the paper is organized as follows. Section 2 documents a Spanish anomaly in settlement and population patterns in Europe and investigates whether geography can explain this. Section 3 provides a brief historical discussion about the medieval frontier origins of Spain's low settlement density and high population concentration. Sections 4 and 5 conduct an econometric analysis to shed light on this issue. Section 6 discusses the main findings of the investigation. Finally, Section 7 puts forward some implications and concludes.

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frontier expansion in the Argentinean Pampas to analyze the impact of population composition on economic development. Bazzi *et al.* (2017) test the Turner's Frontier Thesis finding confirmatory evidence that the US frontier fostered individualism. Related from a methodological point of view, there are also several studies that analyze former historical borders between countries or empires to exploit discontinuities in culture or institutions (e.g., Grosjean, 2011; Becker *et al.*, 2016; Wahl, 2017). For a review on frontiers in historical perspective and how modern economic theory can be used to explain territorial expansions, see Findlay and Lundahl (2017).

[7] There are also other recent papers arguing that the consequences of warfare on state development depend on the historical context. Gennaioli and Voth (2015) build a model in which military conflicts are positive for state capacity when fiscal resources become crucial for winning wars, which happened after the "military revolution" of the 16th-17th centuries. Dincecco *et al.* (2016) find that historical warfare in Sub-Saharan Africa is associated with "special-interest states", characterized by high fiscal capacity and *high* social conflict, while in the rest of the Old World it is associated with "common-interest states" (i.e., high fiscal capacity and *low* social conflict).

[8] In his analysis of the border upland regions of Southeast Asia, Scott (2010) suggests that those who migrate to border regions may have incentives to keep the economy under-developed, in order to protect themselves from state incursion. One may wonder whether this argument is applicable to the Iberian medieval frontier. It is however highly unlikely that settlers and jurisdictional authorities seek to maintain the economy under-developed to reduce the state interference and control. The relative underdevelopment south of the Tagus is rather the unintended consequence of the initial pattern of colonization. Scarcity of settlements, low population density and ranching favored an economy characterized by an extensive use of land and scarcity of labor, which did not favor urban growth nor set in motion forces of agglomeration.

2 The Spanish anomaly in population and settlement patterns in Europe

This section aims to analyze population and settlement patterns in Europe and to provide evidence on the existence of a Spanish anomaly, which is not satisfactorily explained by geographic and climatic factors. I first describe the data and then conduct an econometric analysis at the grid cell level.

2.1 Data

The main data source employed to create indicators of population and settlement patterns is the GEOSTAT 2011 population grid (Eurostat 2016a). The GEOSTAT population grid is a convenient tool to measure the spatial distribution of the population because it provides data at a very high 1-km^2 resolution. The sample consists of the territory covered by GEOSTAT 2011 after excluding the overseas regions (see Figure 1), an area slightly larger than 5 million km^2 with approximately 2.08 million populated 1-km^2 grid cells. The analysis is conducted using a grid whose cells have a surface area of 250-km^2. The total number of cells (*pixel units*) in the sample is 23,498.[9]

I create three indicators capturing different dimensions of the spatial population structure of countries. First, an indicator called *settlement density* that measures the extent of the settlement of the territory. More specifically, it measures the percentage of 10-km^2 grid cells that are inhabited in each pixel unit. A 10-km^2 grid cell is considered to be populated if it contains at least one 1-km^2 populated cell within it.[10] I choose 10-km^2 as cell area because it is a meaningful size from an economic point of view. In a balance occupation of the territory, we would expect every 10-km^2 to have at least one settlement. For instance, the average size of a commune in France is 15-km^2 and, typically, each commune has more than one settlement. It is worth noting that, according to this indicator, settlements are identified through the presence of populated 1-km^2 cells. An important advantage of this way of identifying settlements is its homogeneity across countries. Other alternatives such as data on municipalities or on local administrative units cannot be used for comparative purposes since they are heterogeneous and depend on the legal and political system of each country. Panel A of Figure 1 represents the values of this indicator at the pixel level for the European sample

[9] The word *pixel* is (improperly) used to refer to the 250-km^2 grid cells, which are the units of analysis, with the purpose of avoiding ambiguity.

[10] More formally, an indicator of settlement density (*SD*) of cell-size *s* in pixel *i* is constructed as follows:

$$SD_i^S = \frac{\sum_1^N PC_{n,i}^S}{\sum_1^N C_{n,i}^S} \times 100$$

where $\sum_1^N PC_{n,i}^S$ is the number of populated grid cells of size *s* in pixel *i*, and $\sum_1^N C_{n,i}^S$ is the total number of grid cells of size *s* in pixel *i*. Therefore, SD_i^S represents the percentage of populated cells of size *s* over the total number of cells of that size in pixel *i*. Grid cell *n* in pixel *i* is considered to be populated if it contains at least one 1-km^2 populated cell. I set *s* equal to 10-km^2. As the indicator does not take into account how many people live in each grid cell *n*, its correlation with population density is far from perfect. Indeed, the higher the cell size *s*, the lower the correlation.

while Figure 2 illustrates the construction of the indicator.

Second, I compute an indicator of population concentration that measures the percentage of the population living in the most populated one percent of the territory. It is worth stressing that the level of spatial aggregation used is important to this indicator. Population concentration may be high at the country level but moderate or low at the sub-national level. However, there is in practice a strong correlation (0.86) between the country level value and the average of pixel level values.[11] Third, I also calculate an indicator of population density. Panels B and C of Figure 1 depict the spatial distribution of both indicators. Regarding the correlation among these indicators, settlement density is negatively correlated with population concentration (-0.75) and positively with the logarithm of population density (0.77), while population concentration and population density are negatively correlated (-0.58).

I construct many geographic and climatic variables, including temperature, rainfall, average altitude, ruggedness, distance from the coast, etc. To save space, the definitions and sources of all the variables as well as the descriptive statistics are reported in Appendix 2 in the Supplementary Material.

2.2 Empirical analysis

The descriptive evidence provided in Figure 1 shows that Spain stands out in Europe with an anomalous settlement and population pattern characterized by a low density of settlements and a high concentration of the population. In addition, the figure reveals that there exists substantial heterogeneity within Spain, and it is particularly in its southern half where these features are most strongly manifested.

Are southern Spain's anomalous settlement and population patterns explained by geographic and climatic factors? After all, geography plays a crucial role in development (Gallup *et al.* 1999), and many observers and scholars have traditionally pointed to the adverse geography of Spain (particularly, its central plateau) as a reason for its economic backwardness.[12] However, on careful consideration, this does not seem very convincing. The extreme levels of settlement density and population concentration in southern Spain are only surpassed in exceptionally adverse geographies (e.g., areas close to the Arctic). Arguably, climatic and geographic conditions in southern Spain are not so extreme as to account for this phenomenon. Therefore, an econometric study of this question is conducted. The empirical strategy is simple: to analyze the differences in settlement and population patterns between southern Spain and the rest of Europe through a regression model that controls for geographic and climatic factors. If after controlling for these factors there is still a sizable difference, then it can be inferred that historical factors –rather than geographic ones– are

[11] Population concentration at the sub-national level tends to be lower. See Appendix 1 in the Supplementary Material.

[12] An example of the traditional view of adverse geographic conditions is the book *Los Males de la Patria* (i.e, "the evils of the country") by Lucas Mallada (1890), where it is argued that only 10% of Spanish land "leads us to suppose that we have been born in a privileged country" (quoted in Simpson, 1995, p. 34).

behind the Spanish anomaly.

Table 1 explores the geographic determinants of settlement density and population concentration. I focus on these two indicators as these are the dimensions in which the Spanish pattern is anomalous. Throughout the analysis, I correct for spatial dependence by clustering standard errors at the country level. I start in column 1 of Panel A by regressing settlement density on a quadratic polynomial in temperature, which turns out to be a powerful predictor (with R^2 equal to 40%).[13] Next, I include rainfall, which also shows a nonlinear relationship, although with a much lower explanatory power. Column 3 adds average elevation, which enters with a large negative coefficient increasing R^2 by 9 points. Column 4 further includes additional geographic indicators, namely ruggedness, soil quality, distance to the coast (linear and squared) and an island dummy, which add little explanatory power and are mostly statistically insignificant. Column 5 finally includes the quadratic polynomial in latitude and longitude, which increases R^2 by 10 points. Panel B uses population concentration as the dependent variable. The sign of the coefficients is the opposite in this case, which is hardly surprising given the negative correlation between both dependent variables. Beyond this, the most noticeable difference is that the explanatory power of the geographic and climatic variables is slightly lower.

Next, I run regressions of settlement density and population concentration on a full set of country dummies. Spain appears split into two parts, northern and southern Spain (see Figure 3A).[14] Figure 4 graphically represents the coefficients on the country dummies for six models. Model 0 does not include any control variable –therefore, the reported coefficients simply reflect the mean differences with respect to the reference category, which is France.[15] Remarkably, southern Spain has lower settlement density and higher population concentration than the Scandinavian countries, being only surpassed by Iceland. The gap compared to other countries is very large. For instance, the average settlement density in France is three times higher than in southern Spain. The contrast with the rest of Spain is also remarkable: the northern half of Spain –along with the Balearic Islands– has almost twice as much density as the southern half. In terms of population concentration, differences are also large: in southern Spain it is almost three times higher than in France and one third higher than in the rest of Spain.

To analyze whether this difference can be explained by geography and climate, models 1 to 5 include the control variables used in columns 1 to 5 of Table 1. Figure 4-Panel A shows that southern Spain becomes the territory with the lowest settlement density. Climatic and geographic factors can account for the settlement patterns of Norway, Finland, Sweden, and Iceland. In all these cases, the coefficient experiences a dramatic increase. In contrast, the negative coefficient on southern Spain is barely affected. This suggests that climate and

[13] There is a (nonlinear) inverted U-shaped relationship between temperature and settlement density, with its peak being at approximately 9.8 degrees Celsius. I follow Burke *et al.* (2015) in using quadratic polynomials in temperature and precipitation.

[14] Southern Spain refers to the 17 mainland provinces located south of Madrid (i.e., the eight Andalusian provinces, Badajoz, Cáceres, Murcia, Albacete, Ciudad Real, Toledo, Cuenca, Alicante and Valencia).

[15] Appendix 3 contains the full list of coefficients.

geography are not the keys to explaining the Spanish anomaly. Panel B tells a similar story for the case of population concentration, although the average difference with the rest of Europe is slightly less pronounced. Overall, the figure shows that southern Spain stands out with an anomalous spatial distribution of the population characterized by a remarkably low density of settlements and a high concentration of the population.[16],[17]

Finally, I conduct robustness checks to the previous results. First, I remove two countries that can be considered as outliers, Iceland and Malta. Second, I use a more flexible specification in which the geographic and climatic variables are interacted with four macro-region dummies. Third, I create 1,000 "virtual regions" with a surface area similar to southern Spain and then run 1,000 regressions in which I compare southern Spain to these virtual regions (included one by one). Fourth, I use alternative definitions of the territory characterized by an anomalous settlement and population pattern, which are depicted in Panels B to D of Figure 3. The results of these exercises, reported in Appendix 6, confirm the previous findings: a region that approximately corresponds to southern Spain has a remarkably low density of settlements (high population concentration), even lower (higher) than Scandinavian countries. Geographic and climatic factors fail to account for this anomaly, which suggests that the peculiarities of Spanish history are behind this.

3 On the medieval frontier origins of settlement patterns in Spain: Historical background

This section introduces the hypothesis that the above features of southern Spain's economic geography are linked to its character as an insecure military frontier region during the Middle Ages. First, I conduct a brief historical overview of the key period in which southern Spain was conquered and resettled by Castile and Leon in the Middle Ages. Second, I focus on the geographic discontinuity created by the River Tagus as a meaningful defensive barrier. Finally, I discuss the persistence of settlement and population patterns over time.

3.1 The Spanish Reconquest and the Christian colonization of southern Spain

The Reconquest is the formative process of modern Spain. During a period of almost 800 years, the northern Christian kingdoms were gradually conquering the territory under Muslim

[16] Appendix 4 provides the results of an analogous analysis for population density. While population density is low in southern Spain, differences with the rest of Europe are much smaller and its level is similar to some other countries.

[17] Macedonia (FYR) occupies the second position, following southern Spain, in the rankings of low settlement density and high population concentration. I briefly discuss in Appendix 5 some geographic and historical factors that might account for this, although it can be argued that, as a small country, Macedonia's distribution of the population is not particularly anomalous. There are many other areas of similar size in Europe with a more extreme distribution.

rule. The conquest was followed by a process of repopulation or resettlement of the territory. This process of territorial expansion made Spain a frontier society over a long period of time. The frontier conditions prevalent in each period and the subsequent way the territory was colonized had lasting consequences for the country's future development. This is a well-known hypothesis in Spanish historiography, first developed by Sánchez-Albornoz (1962) and recently tested by Oto-Peralías and Romero-Ávila (2016, 2017). Several factors affected the type of colonization conducted in each region. One was the size of the area that had to be colonized. A larger area made it difficult for the Monarchs to repopulate and defend the territory, thereby requiring the active involvement of the nobility and military orders, which led to the concentration of land and political power in their hands. Another important factor was military insecurity, which also led to the prominence of the military elite in the colonization.

When considering whether this process of medieval colonization is important to account for what I have called the Spanish anomaly, it is very revealing that the low settlement density area in Spain approximately matches a historically well-defined territory: the area conquered in the centuries that followed the conquest of Toledo (Figure 3B). This area suffered the intense warfare and insecurity brought about by the invasions of the Almoravid and Almohad armies during the 11^{th} to 13^{th} centuries. During this period, the Christian kingdoms struggled to conquer and defend key frontier positions.[18] Within this large territory, where military insecurity was particularly intensive was in the area conquered by Castile and Leon approximately during the 12^{th} and 13^{th} centuries, which is delimited by the Tagus to the north, the former Aragonese border to the east, Portugal to the west, and the former Granada frontier to the south (Figure 3C).[19]

The northern half of this territory (Figure 3D) suffered extreme frontier warfare during the one-and-a-half centuries that came after the conquest of Toledo in 1085, which brought the frontier down to the River Tagus. Almoravids and Almohads put great effort into trying to reconquer Toledo, converting the territory into a battlefield. This prolonged warfare largely conditioned the way the territory was colonized. Historians have long identified militarization as the main feature of medieval frontiers (Berend, 1999), and militarization reached a peak

[18] To mention just a few cases, Saragossa, in the Ebro Valley, was conquered in 1118 after a long period of 20 years of raids and a six-month siege (García Fitz, 2015). Valencia was conquered by the Cid in 1094 after a long siege of two years but was subsequently retaken by the Almoravids in 1102, being finally conquered in 1238 after a heavy siege (Bishko, 1975). Caceres was occupied in 1166 but returned to Muslim rule in 1174 to be finally conquered by the Leonese King in 1229 (Porrinas González, 2011). Cuenca was conquered by King Alfonso in 1106 but shortly after lost, being retaken again by Castile in 1177 after a siege of several months (Powers, 1988).

[19] It is worth noting that the borders of this territory capture reasonably well the area of low settlement density. One manifestation of the anomalous way this territory was settled was the existence of "agro-towns", which were the consequence of the concentration of the rural population in a few urban centers. "Agro-towns" were distributed across the southern part of Spain and represented large concentrations of farmers and landless peasants in urban centers which lacked the usual features of medieval towns and had a low level of economic activity associated with the non-agricultural sector (Reher 1990). They arose because "[t]owns provided security and lower transaction costs in a frontier economy during the repopulation process that followed the Reconquest" and due to the accumulation of land in a few hands (Álvarez-Nogal and Prados-de-la-Escosura, 2013, p. 13).

in the southern plateau, with no better example than the rise of the military orders as the best alternative to defend the dangerous frontier positions (Forey, 1984).[20] I focus on this territory to explore how frontier warfare affected population and settlement patterns. The advantages of focusing on this area are the extreme frontier violence that suffered and the possibility of exploiting the discontinuity in military insecurity created by the River Tagus, which marks the transition to the area of low settlement density and high population concentration.

3.2 Extreme military insecurity in the southern plateau and the barrier of the River Tagus

What makes the period after the conquest of Toledo special is the extreme military insecurity that affected all the southern plateau, modern-day Extremadura and Castilla-la-Mancha. The territory south of the Tagus was a battlefield in the conflict between Christian and Muslim armies for almost one-and-a-half centuries (Bishko, 1963). This period of intensive warfare was due to an arguably exogenous factor: the invasions of the Almoravid and Almohad armies from North Africa. The fact that the Tagus was a natural defensive barrier that delimited the area subject to insecurity provides a way to identify the effect of medieval frontier conditions on settlement and population patterns, and consequently to study whether this region's frontier history is responsible for Spain's anomalous population patterns.[21] Put differently, the Tagus was a natural military barrier that created a discontinuity in the intensity of warfare suffered by the territory, which determined how it was colonized and settled.[22]

Historical references indicate that the Tagus was indeed a frontier landmark and a natural defensive border. For instance, González Jiménez (1992) mentions that "the reconquest of Toledo had [...] created a new frontier line based on the Tagus, against which all the Muslim attacks foundered" (p. 60). Rodríguez-Picavea (1999) points out that the Tagus was a landmark in that period which separated the rearguard (to the north) from the vanguard (to the south): "Obvious danger, incipient territorial articulation and sparse settlement awaited those who dared to cross this natural 'frontier'" (p. 33, author's translation). Toledo itself

[20] The 12th century witnessed the birth of the Castilian-Leonese religious military orders of Calatrava, Santiago and Alcantara, which –like Templars and Hospitallers– had the goal of fighting the "infidel" and protecting the frontier. "The military orders were invaluable in resisting the onslaught of the Almohads and in wresting and holdings lands on the frontier" (Mackay, 1977, p. 32). In the words of Vann (1999, p. 28), "[t]he knights of the orders provided professionally trained and well-supplied forces for a wide range of offensive or defensive undertakings". In addition to this military function, the orders also fulfilled a colonizing and political function (Ayala Martínez, 2006).

[21] As argued below, a key point in this identification strategy is that, while the Tagus was important from a military perspective under medieval war technology, it is not a major geographic obstacle for social and economic interactions.

[22] South of the Tagus there was a large frontier region that extended towards the mountains "Sierra Morena" (on the border with modern-day Andalusia) without precise boundaries. The only precise line was the Tagus, and north of it was the rearguard. This is why I focus on the Tagus as the delimitation between a vanguard frontier region to the south of it (affected by high military insecurity) and a relatively safer territory to the north.

was well protected by the Tagus, forming a great natural moat surrounding more than two-thirds of the city (Ladero Quesada, 1984). Vann (1999) also states that, in the defensive strategy of 12th-century Castile, "[t]he geography of the area played an important role in the positional fighting that took place along the Tagus River" (p. 25), and "Castilians took, settled, held (and periodically lost) strategic areas along the Tagus River, as if engaged in a giant game of chess" (p. 24).[23]

Military insecurity heavily conditioned the nature of the colonization process south of the Tagus. Castilian-Leonese conquests were extremely precarious and territory was often lost. For instance, most of the lands occupied and populated by Alfonso VII were relinquished as a result of the Almohad invasion (Sánchez-Albornoz, 1962). The resettlement of the area was based on castles and fortresses as strategic centers (Vann, 1999).[24] González Jiménez (1992), after emphasizing the ferocious violence brought to this region by the North African armies, states that "it was precisely this permanent insecurity which helps to explain the main features of New Castile and other regions" (p. 60). According to this author, central features of this region were shortage of population, a ranching-oriented economy, and the prominence of the military orders as colonizer agents. Military orders' lordships were indeed overwhelmingly located south of the Tagus and exposed to an almost permanent frontier friction (Ayala Martínez, 1996).[25]

In contrast, north of the Tagus, the territory was colonized under the king's control. This area became the rearguard of the kingdom and was vital for its defense. Towns and urban centers predominated, mostly under royal jurisdiction, with charters that granted extensive freedom and rights to settlers (Portela, 1985; González Jiménez, 1992). The area was much safer and attracted more settlers. This territory was protected by the Tagus and the system of castles surrounding Toledo, which allowed a more developed settlement and economic activities (Rodríguez-Picavea, 1999). All these conditions led to a more balanced and widespread settlement of the territory.

After defeat in Las Navas de Tolosa in 1212, Muslim military power was severely reduced, and in a short period of fifty years, Castile conquered the rest of southern Spain with the

[23] According to García Fitz (2001), the Almoravids developed the notion of a "front-line" located south of the Tagus that separated the territory under their control from the area beyond it, in which they undertook devastating raids. During the period of permanent and extreme violence due to the numerous attempts to retake Toledo by the Almoravids, all the Castilian positions south of the Tagus were lost, while only one north of it had the same fate (Talavera).

[24] In this regard, González (1976a) notes that "in the 12th century an attempt to found a new city south of the Tagus required heavy expenses in money and manpower, not always available, besides an uncertain success" (p. 22, author's translation). Similarly, he observes "the frontier with the Almoravids and Almohads led, in large fields from the Tagus onwards and for many years, to the triumph of the horse and the castle" (p. 26, author's translation). The exigencies and repercussions of war prevented the full repopulation of the territory, with large areas still to be occupied in the 13th and (even) the 14th centuries (González, 1976b).

[25] According to a map provided by Ayala Martínez (1996), it can be estimated that almost 90% of the area under military orders' control was located in the territory conquered by Castile and Leon in the 12th-13th centuries. Regarding the scarcity of settlements in the area, Ruiz Gómez (2006) estimates that, in the region south of the Tagus called "La Mancha", the military orders controlled about 20,000 km^2 which were administered from only 25 castles, rendering a ratio of 800 km^2 per castle. Yet, this fragile occupation of the territory was ruined after the defeat in Alarcos against the Almohads.

exception of the Nasrid Kingdom of Granada. Thus, in the second half of the 13th century the southern plateau finally became a secure region. The frontier had moved southward to Andalusia. However, conditions had already been created south of the Tagus for the persistence of low settlement density.

3.3 From frontier insecurity to ranching and to persistence in settlement patterns

The hypothesis that the high intensity of warfare in the southern plateau conditioned the resettlement of this frontier region, favoring the prominence of the military orders as colonizer agents and the development of a ranching-oriented economy, was put forward by Charles J. Bishko (1963). He traced the links between frontier insecurity, colonization strategy and ranching in Medieval Spain. Leonese and Castilian rulers had to rely on the military orders for the conquest, defense and colonization of the southern plateau, leading to a militarized and sparse occupation of the space. Military orders had extensive powers, including the monopoly of government in their territory. They also sought to attract settlers by granting charters (*fueros*) to the new towns and settlements; however, these charters only conceded limited rights compared to royal towns, which helps explain the lower urban development of the area under the orders' control.[26]

The main economic activity in this frontier region was "stock raising in that advanced form, more fruitfully developed in the Iberian Peninsula than anywhere else in the medieval world, which is properly called ranching" (Bishko, 1963, p. 54). The ranching activity, developed earlier in the northern plateau and incentivized by military conditions favoring mobile assets over crops, was widespread south of the Tagus. In fact, the frontier conditions made rural labor scarce and crop-farming hazardous, thereby favoring cattle and sheep, which were mobile and less demanding (Bishko, 1952). Thus, "by the second half of the [12th] century towns [...] and the military orders [...] were sending their herds and flocks into the Guadiana Basin in spite of the ever-present danger of Almohade attack", and after the defeat of the Muslims and "the opening up of the richest Manchegan and Extremaduran grasslands, there occurred [...] an explosive expansion of the ranching industry of the plains" (Bishko 1963, p. 54). Importantly, the main colonizer agents, the military orders, were heavily engaged in this ranching activity, owning large herds of sheep and cattle. Livestock indeed constituted one of their main sources of wealth, and was managed by specific commanders (Ayala Martínez,

[26] As mentioned above, royal towns played a secondary role south of the Tagus compared to the situation to the north. Settlers under royal jurisdiction had more freedom than in lordships. For instance, lords had the power to appoint the most important local authorities and to provide justice. Even in the absence of labor services, lordships had the monopoly over several activities such as public ovens, mills, and the forest (González, 1976b).

1996).[27, 28]

Hence, extreme frontier insecurity led to the prominence of the military orders, ranching, and the concentration of the sparse population in a limited number of fortified locations. Once the starting point was established, factors of persistence prevented the whole region from converging in settlement density to the rest of Spain and Europe. First, the prevalence of pastoralism created vested interests among ranchers to –for instance– maintain pasturelands with the same use.[29] Second, the fact that the frontier experienced a large southward expansion just at the time when the Muslim threat disappeared slowed down the resettlement process even further (Cabrera, 1985). This is important because it meant that the ranching character of the economy and the initial pattern of colonization had more time to become rigid. Third, a large percentage of the territory was under the jurisdiction of military orders. For example, in the provinces of Ciudad Real and Badajoz, 80% and 50% of the land, respectively, was in the hands of the orders in the early 16th century (López-González *et al.*, 1989). As mentioned above, they granted fewer rights to settlers than royal towns and heavily invested in livestock, which was an economic activity easier to manage both in frontier times and in subsequent centuries.[30] Given that jurisdictional rights lasted until the 19th century, this mechanism of persistence helps explain the long-term effect of the

[27] According to MacKay (1977), "[i]t was only when the Christians won the grass-lands of the plains and steppes of La Mancha and Extremadura that an integrated ranching economy emerged [...] The military orders owned large flocks. In 1243, for example, the Templars and Alcantarans quarrelled over the control of 42,000 sheep in the Tagus valley" (p. 74). But not only the lords, the townsmen "also derived their wealth from pastoralism rather than from their small arable holdings" (MacKay, 1977, p. 74). This region was also the pastureland of the large transhumant flocks of northern owners. Besides, livestock was also a convenient activity in the sense that it allowed the occupation and integration of large tracks of lands. It is not questionable that "'livestock colonization' became at the end of the 'great Reconquest' a major instrument of articulation of frontier areas" (Ayala Martínez, 2006, p. 109, author's translation).

[28] Bishko (1963) also concedes a role to geography when explaining the development of ranching. Influenced by the Turner (1920)'s view of the North American frontier, he partially sees the Castilian expansion as a fight with the environment, and compares the expansion of American colonists through the Great Plains with that of Castilians through the southern plateau. In his view, both military insecurity and the adaptation to adverse natural conditions are what gave rise to the ranching activity. Below, I attempt to isolate the effect of military insecurity by focusing on a territory that is geo-climatically very similar but was subject to different intensities of warfare. The discontinuity created by the River Tagus is what allows this analysis.

[29] Once ranching became the main economic activity, and landlords (i.e., military orders and nobles) and urban oligarchs invested in livestock, there were incentives in place to maintain the same economic structure. In this sense, commenting on the scarcity of settlements and the historical poor state of agriculture, Brenan (1950: 128) notes "again and again one finds the *Cortes* demanding that land which had recently been ploughed up should be compulsory returned to pasture". The predominance of ranching, in turn, reduced the necessity of attracting farmers to exploit the land as livestock raising works well in a context of low population density.

[30] When establishing new settlements, the military orders kept for themselves important seigniorial privileges, which made these places less attractive to settlers than other available territories (López Pita, 1994). The military orders also harmed urban development in other ways, as Cabrera (1985) illustrates for Merida. Shortly after the conquest the city passed to the Santiago Order's jurisdiction, which did not favor the creation of a powerful council and even prevented the city to become a bishopric. What was once the capital of Lusitania province had no representation in the *Cortes* under Christian rule.

initial frontier conditions.[31]

4 Frontiers and settlement and population patterns: Empirical evidence

4.1 Standard regressions: Average differences within Spain

I first compare the region conquered by Castile and Leon during the 12th and 13th centuries –which I call, for brevity, *treated region*– with the rest of Spain (see Figure 3C). With that purpose, Table 2 reports regressions of settlement density and population concentration on the set of climatic and geographic controls and the treated region dummy. I report Conley (1999)'s standard errors robust to spatial correlation of unknown form.[32] A grid cell is considered treated if its centroid falls within the treated region. To avoid having grid cells that only partially overlap with the treated area, I delete observations with a percentage of surface area falling within the treated region in the range 20%-80%.

Column 1 starts with the bivariate relationship between settlement density and the treated region dummy. The coefficient indicates that settlement density is on average more than 30 percentage points lower in the treated region. This dummy variable alone explains 28% of the variation in the dependent variable. Column 2 adds the baseline geo-climatic controls, while columns 3 and 4 include extended sets of control variables. The coefficient on the treated region slightly declines (in absolute value) but remains large and highly statistically significant.

One might argue that I am comparing very heterogeneous regions within a single regression, and although many control variables are included in the model, there may be omitted factors creating a downward bias in the coefficient. To address this issue, I create 25 virtual regions by dividing the sample into five quantiles of longitude, and then each quantile of longitude into five quantiles of latitude. Each resulting virtual region has approximately the same number of observations (87 or 88). Next, I include this set of virtual region dummies in the equation, which implies that the regression is now comparing grid cells within relatively small and homogenous regions. Column 5 reports the results of this exercise. Reassuringly, the coefficient on the variable of interest remains largely unchanged.

Column 6 removes the territory corresponding to the former Crown of Aragon (the current regions of Aragon, Baleares, Catalonia and Valencia) since a large part of it also suffered frontier warfare during the invasions of the Almoravid and Almohad armies and, therefore, it may not be a valid comparison group. The size of the coefficient remains largely robust to this reduction in the sample. Finally, columns 7 to 12 use population concentration as the dependent variable, with the nature of the results being fairly similar.

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[31] The literature on agglomeration economies, although mainly concerned with the location of cities, is consistent with the idea of persistence in settlement patterns and the important role of history. Indeed, regarding the spatial distribution of economic activity, it is considered that there is "path dependency in the structure of the equilibrium, with history being as important as current circumstances" (Henderson *et al.*, 2001, p. 84).

[32] I employ cutoffs of 1 decimal degree, beyond which spatial correlation is assumed to be zero.

To sum up, this section shows that there exist large differences in the spatial occupation of the territory within Spain. The well-defined historical region delimited by the Castilian-Leonese conquests of the 12th and 13th centuries featured a much lower settlement density and a much higher population concentration than the rest of Spain, with the average difference ranging from 33 to 21% and from 24 to 17% for each variable, respectively.[33]

4.2 Spatial regression discontinuity (SRD) design: Discontinuity across the River Tagus

This section exploits the spatial discontinuity in warfare and insecurity created by the River Tagus from the 11th to 13th centuries. As described above, the Tagus was a meaningful military barrier and a recognized frontier landmark during this period of military instability, but arguably it is not a major obstacle to social and economic interactions. Therefore, this border can be considered exogenous and with a relevance circumscribed to the specific historical period in which the territory was conquered and resettled by Castile and Leon.

I narrow down the sample to grid cells falling within a distance of 50 km from the Tagus. The resulting sample size includes about 220 observations. In choosing the bandwidth, I have tried to reconcile a close geographic proximity with a sufficiently large number of observations to ensure good statistical power. The identification strategy contains the following assumptions: i) the River Tagus was a meaningful military barrier and largely delimited the territory subject to military insecurity; ii) there are no significant differences in climatic, geographic and pre-medieval historical factors across the river; and iii) the Tagus has not been a major barrier to social and economic interactions. If these assumptions are valid and there exists a significant discontinuity in settlement and population patterns across the Tagus, it would suggest that this discontinuity is due to the way the colonization of an insecure frontier region was achieved.

The validity of assumption "i" is justified above in the historical discussion. It is a very difficult task to test this assumption empirically. There are no data about casualties due to warfare, and simply counting the number of battles is not an appropriate approach. The latter is because medieval warfare, particularly when attempting to conquer a territory, was based on frequent cavalry raids, hitting the area over a long period of time, followed by sieges (García Fitz, 2015, 2016).[34] Figure 5 provides anecdotal evidence on the Tagus as a strategic

[33] I have checked that the results are similar (although the differences slightly smaller) when the treated region is considered as all the territory conquered after 1095 (Figure 3B). This is not surprising as there is a large overlapping between both ways of defining the territory affected by frontier warfare during the central period of the Middle Ages. I have also checked that the results are very similar when using the alternative indicators of settlement density employed in Section 4.2, namely density of municipalities and density of population entities. These results are available in Appendix 7.

[34] The war of conquest in medieval times consisted of the annexation of strongholds (castles and walled cities) through long campaigns of raids to devastate the enemy's territory followed by sieges: "the immediate goal of [cavalry raids] was often nothing more than looting, capturing some men, burning crops and devastating small farming villages [...] [In] frontier regions this was the common way of waging war and the necessary mechanism for bringing about future annexations" (García Fitz, 2016: 45-46).

defensive line during the period 1085-1230. North of the river all the territory was almost all the time in Christian hands, while south of the river Muslim and Christian alternated in the control of the space. In addition, notwithstanding the foregoing, it is revealing that the main (pitched) battles of the period took place south of the Tagus.

Regarding assumption "ii", its validity can be explicitly tested. Columns 1 to 6 in Table 3 compare the mean values in several climatic and geographic variables across the border. There are no statistically significant differences in rainfall, temperature, elevation, ruggedness, soil quality, and distance to the coast.[35] In addition and importantly, the last two columns show that there are no differences in pre-medieval settlements and distance to Roman roads either, which reduces concerns about potential preexisting historical differences before Christian colonization.[36]

With respect to assumption "iii", the main argument to support its validity is that the Tagus is not wide enough to create a significant barrier to social and economic interactions. In the Middle Ages there were several bridges and in the dry season it was easily fordable. Before the conquest of Toledo in 1085, there were at least five bridges (three Roman and two Muslim), and it was also possible to cross the river through fords at specific points and by boat (Torres Balbás, 1957; Malalana Ureña, 1990). The absence of differences in pre-medieval settlements across the river (Table 3, column 7) is also consistent with this point. It is worth emphasizing that while the Tagus was not a major obstacle to social and economic interactions, it was a crucial barrier from a military perspective, since bridges and fords were strongly defended. Put differently, the same natural obstacle was relatively minor for civil purposes but important from a military perspective.

Table 4 reports the baseline SRD results from equations taking the following form:

$$Y_{i,j} = \alpha_0 + \emptyset_j + \beta \cdot T_{i,j} + X'_{i,j} \cdot \delta + f(geo.loc.) + \varepsilon_{i,j}$$

where $Y_{i,j}$ is the dependent variable in cell (*pixel unit*) *i* along segment *j* of the border, α_0 is a constant term, $\emptyset_j$ is a set of four equal-length segments of the border –representing the closest one to the cell centroid–, $T_{i,j}$ is a dummy variable indicating whether the cell is located south of the River Tagus, $X'_{i,j}$ represents a vector of control variables, $f(geo.loc.)$ stands for a polynomial of variables referred to the geographic location of cell *i,* and $\varepsilon_{i,j}$ is the error term. The equation is estimated with OLS, reporting standard errors corrected for spatial dependence.[37]

Panels A and B use the variables of settlement density and population concentration

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[35] Appendix 8 also shows that there are no differences in aridity nor in important characteristics of the soil for agriculture, such as subsoil and topsoil available water capacity, depth to rock, soil erodibility, topsoil organic carbon content, and soil texture.

[36] Consistent with the latter, historical references also indicate that settlement density before the Christian conquest was not higher north of the Tagus. For instance, Sánchez-Albornoz (1962) maintained that the Duero Valley, particularly north of the river, was completely unpopulated before the Christian conquest and colonization. González (1976a) mentions that when Alfonso VI conquered Toledo, most of the area between the Duero and Tagus was unpopulated. Consequently, areas north of the Tagus did not start with an advantage in terms of settlement density.

[37] A more detailed discussion of the methodology and implementation of SRD design to historical settings can be found in Dell (2010), Becker *et al.* (2016), and Oto-Peralías and Romero-Ávila (2017).

employed so far. The rest of the table uses two additional indicators related to the occupation and management of the territory: Panel C uses a variable measuring the density of population entities, which is created from a comprehensive dataset of all population entities (i.e., villages, towns, etc.) existing in the country (Instituto Geográfico Nacional, 2016); and Panel D employs an indicator capturing the size of municipalities' jurisdictional areas, with a higher density of municipalities implying a lower size (Eurostat, 2016b). The latter variable is related to the management of the territory and reflects its division into local governmental areas. Given the persistence in jurisdictional boundaries over time, it is a good proxy for the historical organization of the territory, which is linked to how it was colonized.

Column 1 shows the results from a border specification, that is, without including the term $f(geo.loc.)$. In this regression, the coefficient of interest $-\beta-$ reports the average difference in settlement density on both sides of the border. This is an informative test given that the bandwidth is only 100 km and Table 3 rules out differences in geographic and climatic variables. The results are highly supportive of a statistically significant discontinuity in settlement patterns across the border. The territory south of the Tagus –and therefore affected by high military instability during the 11^{th}-13^{th} centuries– has a much lower settlement density and a much higher population concentration, the difference being about 25 percentage points in both cases. This difference is similar in magnitude to that reported in Table 2, which is remarkable given the geographical proximity among observations. Panels C and D also reveal large differences in density of population entities and municipalities across the border.

The rest of the columns in Table 4 estimate spatial discontinuity regressions aimed at identifying discontinuous jumps at the border in the dependent variable. Columns 2 and 3 use the quadratic polynomial in distance to the Tagus and to Madrid as forcing variables, while column 4 uses the quadratic polynomial in latitude and longitude. I prefer to avoid high-order polynomials because new evidence indicates that low-order polynomials perform better than their high-order counterparts, which often provide misleading confidence intervals (Gelman and Imbens, 2014). The results are remarkably robust. The effect of having been affected by high insecurity is statistically significant and economically important.

I next provide some graphical evidence on the discontinuity at the border. Figure 6 plots the predicted value from a regression of each dependent variable on distance to the border along with the 90 percent confidence intervals. The existence of a discontinuous jump at the border is apparent in the four graphs. Figure 7 follows the two-dimensional RD style of plots proposed by Dell (2010), in which the color of the figure represents the predicted value of each dependent variable from a regression on a quadratic polynomial in latitude and longitude and the treatment dummy variable. This style of RD figure is a good complement to represent spatial discontinuities, particularly in the case of long borders with a relatively short bandwidth. Consistent with the results reported in column 4, the figure reflects a clear discontinuity at the border.

4.3 SRD design: Sensitivity analysis

Table 5 conducts specification tests by using alternative polynomials in the variables of geographic location: i) a linear polynomial in distance to the Tagus, ii) an interacted polynomial between distance to the Tagus and $T_{i.j}$, iii) a linear polynomial in distance to Madrid, iv) an interacted polynomial between distance to Madrid and $T_{i.j}$, and v) a linear polynomial in latitude and longitude. In all cases, the coefficients on the variable of interest have the expected sign and are highly statistically significant, thereby providing support to the previous findings.

Table 6 provides the results from a falsification test consisting of moving the frontier 50 km northward and southward. The purpose of this exercise is to double-check that the treatment variable is not capturing a north-south gradient in settlement patterns. Reassuringly, the coefficients are mostly insignificant and their magnitude is much smaller. Table 7 reports the results from another placebo exercise testing differences across the Duero and Guadiana rivers, which have similar courses to the Tagus –north and south of it, respectively. According to this paper's argument, the Tagus created a discontinuity due to the coincidence of the progress of the Reconquest over its course with the Almoravid and Almohad invasions. Therefore, one should not find similar discontinuities in settlement patterns across the other rivers, and this is indeed what Table 7 shows.

I also conduct a more systematic placebo test, which involves drawing 1,000 random placebo borders. More precisely, placebo borders follow latitude lines between 37 and 42 degrees north, trying to replicate the roughly horizontal orientation of the Tagus. Observations falling to the south of the random borders are considered "treated". As in the main analysis, the sample is restricted to cells whose centroids are located within 50 km of the border. The figure contained in Appendix 9 illustrates the cumulative distribution of coefficients of the placebo treatments, where the vertical line shows the "true" coefficients reported in Table 4. The results from this falsification exercise again provide support for the existence of a genuine discontinuity at the Tagus border. Thus, in less than 1% of cases the placebo effect is greater than the "true" effect.

Finally, I also conduct the following robustness checks: i) to employ a larger set of geographic controls; ii) to exclude grid cells with centroids located in the province of Madrid; iii) to use alternative bandwidths of 50, 75, 125, 150, 175, and 200 km (note that the baseline bandwidth is 100 km), iv) to remove cells that are not completely squared, and v) to use an alternative larger cell size of 500 km^2. The results are very similar to the baseline findings, in that the coefficient on the variable 'south of the Tagus' has always the expected sign and is statistically significant.[38]

5 Further evidence and implications for development

5.1 A confirmatory analysis: Portugal

The validity of this paper's hypothesis and the general implications of the analysis would be stronger if similar results were found in analogous historical contexts. Portugal is undoubtedly the country with the most similar historical experience to medieval Spain, and therefore the

[38] These results are available in Appendix 10.

best candidate on which to conduct a "confirmatory analysis". The River Tagus also divides Portugal into two parts, and this kingdom also suffered the invasions of the Almoravid and Almohad armies. The weakening of the Almoravid power allowed Portuguese armies to retake the frontier stronghold of Santarém and conquer Lisbon in 1147, establishing their control over the Tagus (Lay, 2009). In the following decades, the Portuguese expanded southward as far as Silves in the Algarve, but their conquests were fragile since almost all the territory south of the Tagus was lost against the Almohads. As in the case of Castile and Leon, the control south of the river was not possible until the Christian victory at Las Navas de Tolosa in 1212.

Table 8 analyzes the existence of a discontinuity in settlement and population patterns across the Tagus in Portugal. I focus on the indicators settlement density*,* population concentration and density of municipalities, which are the variables constructed using Eurostat data. Figure 8 represents the geographic area of study along with the value of the settlement density indicator. As in the main analysis, the sample is restricted to grid cells whose centroids are within 50 km of the Tagus. Besides the four baseline specifications, I include another with the quadratic polynomial in distance to Lisbon, which is much more relevant to the case of Portugal. Both the results reported in the table and the figure itself show that the density of settlement is lower (and population concentration higher) south of the Tagus.

5.2 Historical measures of settlement density

The evidence presented in Section 4 indicates the presence of a discontinuity in settlement patterns across the Tagus. My interpretation of the results, based on the historical account in Section 3, is that it was the consequence of the high military insecurity experienced during the Middle Ages, which affected both sides of the river differently. If this interpretation is correct, then the discontinuity across the Tagus should exist not only today, but also in the past, just after the territory was colonized. To shed some light on this, I collect census data on population entities from the *Censo de Pecheros de Carlos I* of 1528 (INE, 2008), and from the *Censo de Floridablanca* of 1787 (INE, 1987). These data sources include all the population entities of the country at the time.[39] As information is available about the modern-day municipality to which each 16th or 18th-century settlement belongs, data can be georeferenced. These indicators of the 16th and 18th centuries are convenient because they are not affected by the profound developments in urbanization that came about with the industrial revolution, thereby reducing potential confounding factors and providing credibility to this paper's hypothesis.[40] Table 9 shows that there was also a discontinuity in settlement density across the Tagus in these early periods, reflecting that it was the result of something happening during the Middle Ages and thereby supporting my reading of the results.

[39] The 1528 census only covers 16th-century Castile, excluding the Kingdom of Granada, the Basque Country and Navarra, but given the restriction of the sample to 50 km from the Tagus, this does not affect the analysis.

[40] Note that the indicator of settlement density from the 1528 census is not even affected by the transformations that took place during the Modern era.

5.3 Contemporary economic outcomes

Thus far the analysis has focused on the medieval frontier origins of Spain's settlement and population patterns. In this section, I briefly discuss whether settlement patterns matter for economic development. There are several reasons why this should be the case. From a historical perspective, the way in which the territory is occupied has important implications when land is the main factor of production. In pre-industrial times, when agriculture was the main source of wealth, a balanced occupation of the territory with many settlements scattered across the space was necessary for intensive use of land. Before the age of motor vehicles, geographical proximity made a difference in transportation costs and allowed more intensive forms of land exploitation (e.g., agriculture rather than livestock). Thus, areas with higher settlement density may have developed more intensive forms of land exploitation, thereby becoming wealthier. Given path dependency in prosperity (Comin *et al.,* 2010; Chanda *et al.*, 2014; Guiso *et al.*, 2016; Maloney and Valencia, 2016), early economic development may lead to better economic outcomes today.

Although it is beyond the scope of this paper an in-depth investigation of this issue, Table 10 provides some evidence. Before reporting the results, it is worth noting that identifying the effect of settlement patterns is a very difficult task. They are the result of historical processes of colonization, and other factors can also be considered co-original. My aim here is to show that the reported discontinuity in settlement and population patterns overlaps with discontinuities in several current outcome variables. I use as dependent variables the following four proxies for economic development at the local level: light density at night, average socioeconomic condition, number of vehicles per household, and labor force activity rate. Interestingly, Table 10 shows that a similar discontinuity arises when using these outcome variables. Given the absence of geographic differences across the border and the fact that the River Tagus hardly implies a major geographic barrier to economic interactions, it is plausible to assume that these differences in outcomes are the consequence of the way the territory was colonized in the Middle Ages. Low settlement density along with other related factors –such as political and economic inequality and the prevalence of livestock– could have created the conditions for slower economic growth in the long-run.

6 Discussion

The findings of sections 4 and 5 provide support for the frontier origins hypothesis of Spain's settlement and population patterns. According to this hypothesis, the high level of military insecurity suffered by the large frontier region of the southern plateau from the 11^{th} to 13^{th} centuries conditioned the colonization of the territory by Castile and Leon. The main features of the initial colonization strategy were intense militarization, the concentration of the population in a few well-defended settlements and castles, and a ranching-oriented economy. This extreme form of initial colonization sowed the seeds for the sparse settlement density of the territory to this day.

There are three points worth discussing. The first one has to do with the validity of the

Tagus discontinuity to explain the overall southern Spain's settlement and population pattern. The comparison of the results in Tables 2 and 4 is revealing in this regard: the coefficient on the treated region in Table 2 is similar in size to the analogous coefficient when restricting the sample to cells located within 50 kilometers of the Tagus (Table 4). This means that the discontinuity across the Tagus captures almost all the difference in settlement patterns within Spain.[41] Thus, the data support Bishko (1975)'s conjecture that "to [the persistence for so long of an open frontier of war and conquest] can be traced in great measure [...] the predominance of walled towns and castles over dispersed village communities" (p. 455).

Another interesting point to discuss is whether military insecurity can explain the entire difference in settlement density and population concentration between southern Spain and Europe. This gap is about 50 and 35 percentage points for both variables, respectively (Figure 4), while the discontinuity across the Tagus is about 20 points (Table 4). Even though it can be argued that this estimate is a lower bound as the whole Spanish territory was subject to insecurity, frontier warfare is unlikely to explain the entire difference with respect to the European average. There are probably also nationwide factors contributing to explain this gap, as can be inferred when looking at the Spanish borders with France and Portugal. However, the aforementioned estimate of 20 points is what makes southern Spain particularly anomalous in Europe.

Finally, one may wonder why military insecurity led to adverse outcomes in Spain but to positive ones in Europe -as shown by Dincecco and Onorato (2016). As argued in the Introduction, military conflicts may foster urban growth in consolidated states or kingdoms but not in frontier regions. Frontiers are special areas; they are sparsely populated and politically unorganized, and military conflicts can determine the initial occupation of the territory, including its political and economic structure, which tend to persist over time. Relatedly, the type of warfare in frontier areas is that of territorial expansion, and medieval warfare of this kind was not characterized by pitched battles but by raids (García Fitz, 2015, 2016). Moreover, Dincecco and Onorato (2016)'s methodology is very different since they analyze a panel of cities with century intervals; therefore, my results are not necessarily contradictory.[42]

[41] A related concern is that while within a distance of 50 km from the Tagus there were no pre-existing differences in settlement patterns, further south, the Guadiana basin was largely unpopulated (Cabrera, 1985). Yet, this does not affect the conclusions of the analysis because the Duero Valley, north of the Tagus, was almost a dessert before the Reconquest (Sánchez-Albornoz, 1962; with nuances in Portela, 1985) and however its repopulation succeeded in creating a dense network of settlements. The latter was possible, at least partially, because the early settlers of the Duero Valley did not suffer the intense frontier warfare of the 11th to 13th centuries.

[42] Dincecco and Onorato (2017) argue that the warfare-to-wealth effect took place in Europe because of the combination of steady warfare, high political fragmentation and low land-labor ratio, which favored rural-urban migration and hence urban growth. By contrast, in a situation of *high* land-labor ratio, such as the case of Sub-Saharan Africa, they argue that rural-rural migration becomes the most likely option to escape war, and the style of warfare consists of raids and slave capture. Even though in medieval frontiers the land-labor ratio was also high, the belligerent parties did seek the control of the territory. Thus, the intensity of warfare determined the way the territory was colonized by the conqueror, including its demographic, economic and political organization.

7 Conclusions

This article shows that historical frontiers can shape the economic geography of countries. I focus on Medieval Spain to explore how extreme frontier insecurity can condition the occupation of the territory in such a way to make it one of the most desert areas in Europe in terms of settlement density. First, I provide evidence that Spain stands out with an anomalous spatial distribution of the population, characterized by a very low density of settlements and high population concentration in its southern half, which is not explained by geographic and climatic factors. The second part of the article investigates the medieval frontier origins of this phenomenon. Spain's southern plateau was subject to extreme warfare and insecurity during the Middle Ages, which led to a colonization of the territory characterized by the concentration of the population in a small number of settlements, the prominence of military orders, and a ranching orientation of the economy. Standard regression analysis and spatial regression discontinuity techniques provide support for the frontier origins hypothesis. I further show that differences in settlement patterns were already visible in the 16th and 18th centuries and that they overlap with differences in several indicators of current economic outcomes.

This article's results relating to the importance of frontiers in the settlement and population structure of the territory –and the potentially high-level persistence of this– contribute to the debates regarding the role played by location fundamentals and the persistence and dynamics of the urban system (Bleakley and Lin, 2012; Michaels and Rauch, 2017; Bosker and Buringh, 2017). While there is a large tradition of research on urbanization processes, little work has been done on how regions and countries are actually settled, which can be viewed as the most basic layer of interaction between economic agents and the territory.

This paper is also linked to other strands of the economic literature. First, it contributes to the new empirical literature on frontier societies by investigating the impact of medieval frontiers on the social occupation of the space (García-Jimeno and Robinson, 2011; Oto-Peralías and Romero-Ávila, 2016, 2017; Droller, 2017; Bazzi *et al.*, 2017). Second, this paper relates to a growing literature on the legacy of military conflicts on urban growth and development. In contrast to previous works finding long-term positive effects of conflicts (e.g., Voigtländer and Voth, 2013; Dincecco and Onorato, 2016), the analysis shows that military insecurity may have negative implications in frontier regions. Third, this work also adds to a body of research on the contingent role that geographic factors play in development (e.g., Dell, 2012; Nunn and Puga, 2012). The River Tagus created a discontinuity in settlement patterns due to a contingent factor (high military insecurity) which in turn was the consequence of "historical accidents" such as the Almoravid and Almohad invasions.

Finally, while this article has focused on the determinants of settlement patterns, their implications are also worth studying. The importance of settlement density for agriculture before the age of mechanization has been noted. It may also stimulate communications and trade, with long-term positive effects. In addition, settlement patterns and population concentration may have effects in the short-term, notably in the labor market. For a given population density, higher settlement density may facilitate interactions and increase labor mobility. These and related topics are interesting areas of research.

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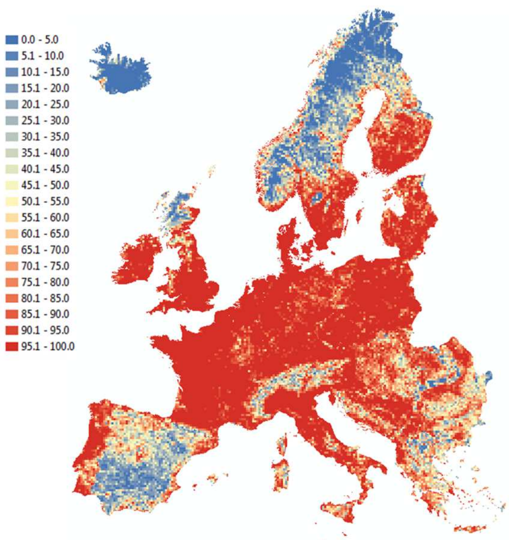
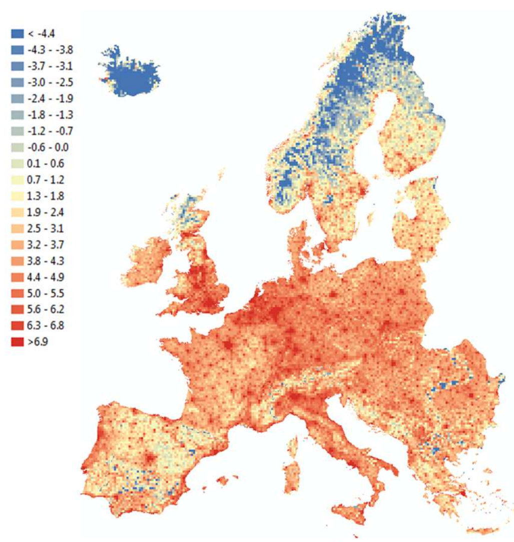
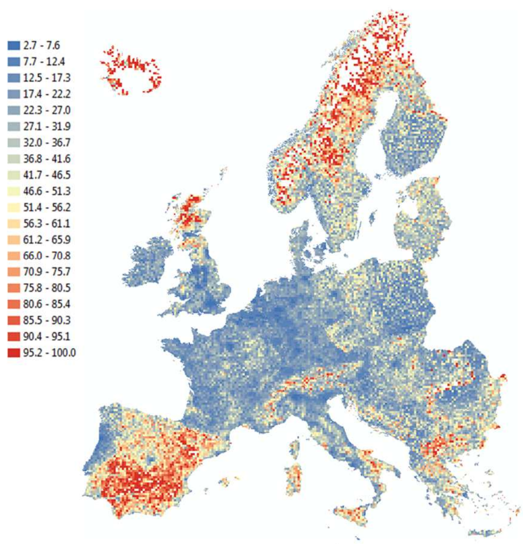
Figures and Tables



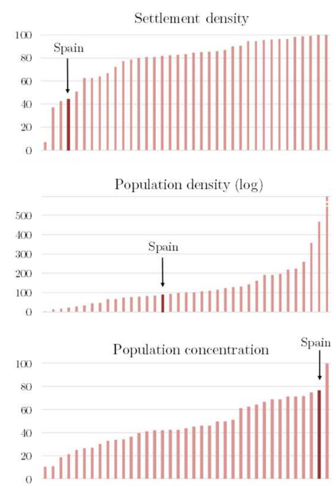
A. Settlement density



B. Population density (ln)



C. Population concentration



D. Countries aggregate values

Figure 1. Settlement and population patterns in Europe

Notes: Panel A represents an indicator of settlement density that measures the percentage of 10-km^2 grid cells that are populated. Panel B represents the logarithm of population density. Panel C shows an indicator of population concentration that measures the percentage of the population living in the most populated one percent of the territory. Panel D depicts the values of each indicator aggregated at the country level. The data correspond to 2011 and the units of observation are 250-km^2 grid cells.

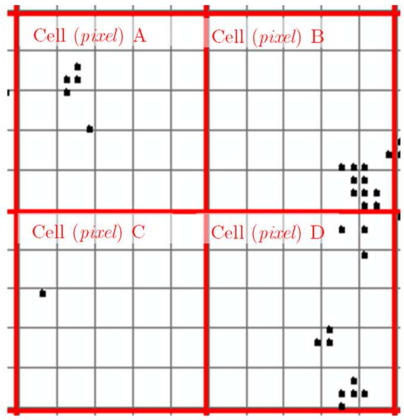
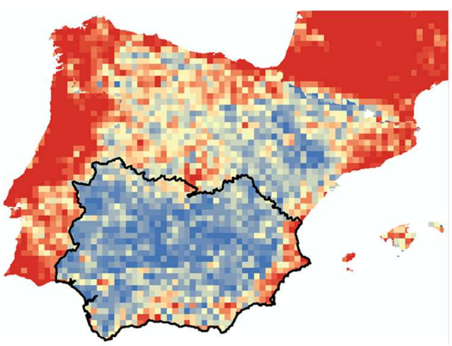
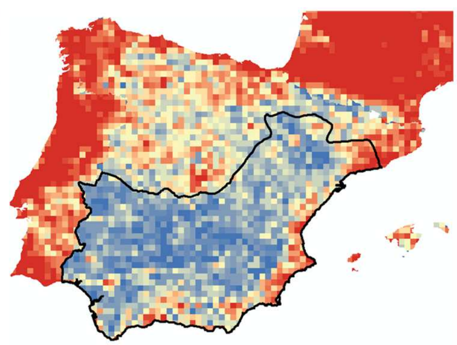


Figure 2. Example of the construction of the indicator of settlement density

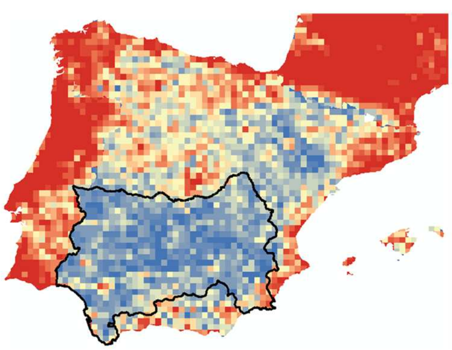
Notes: The figure illustrates the construction of the indicator of settlement density. There are three layers of data: i) a grid of 250-km² cells, which are called in the text *pixel units* (red lines), ii) a grid of 10-km² cells (black lines), and iii) the GEOSTAT 1-km² population grid (black dots). The value of the indicator is 8 for cell A (i.e., 2 populated 10-km² cells over 25 cells, multiplied by 100), 16 (4/25x100) for cell B, 4 for cell C (1/25x100) and 28 for cell D (7/25x100).



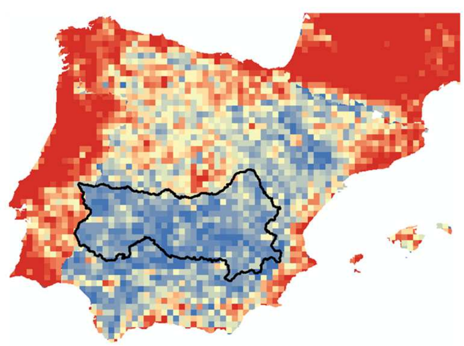
A. Sourthern Spain



B. Post 1095 conquest (except Balearic Islands)



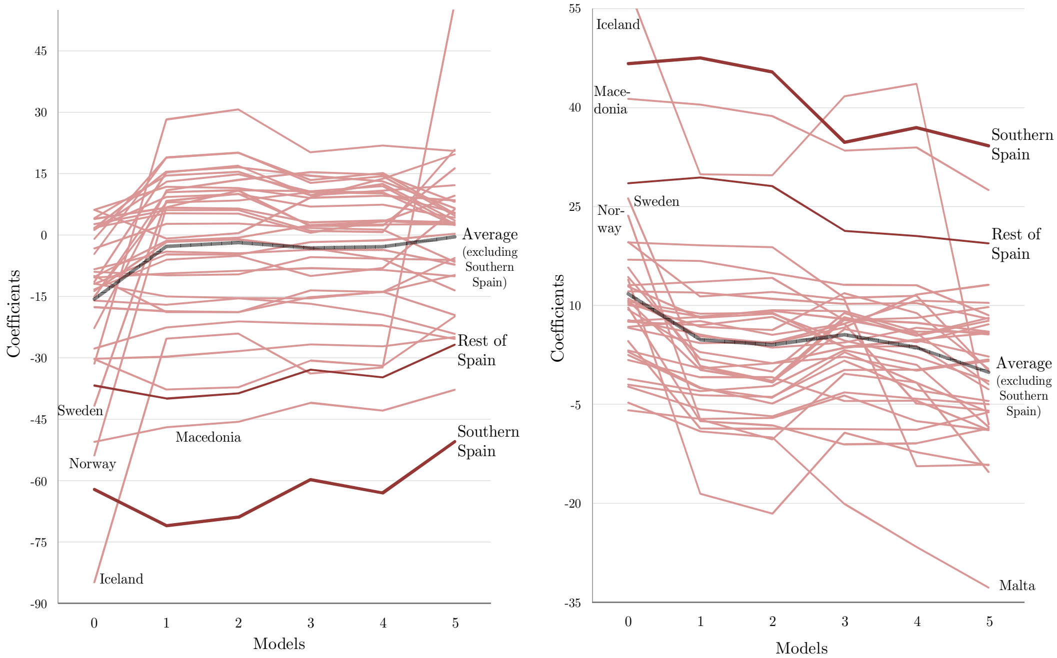
C. Conquered by Leon and Castile approx. during the 12th and 13th centuries



D. Southern platteau (Extremadura and Castilla-la-Mancha south of the Tagus)

Figure 3. Sourthern Spain and several historically defined regions

Notes: The background color represents the indicator of settlement density used in Figure 1A.



A. Dependent variable: Settlement density

B. Dependent variable: Population concentration

Figure 4. Settlement and population patterns in Europe: Countries' coefficients

Notes: The graphs depict the coefficients on country dummies from regressions of settlement density and population concentration. Spain appears split into two parts, northern and southern Spain. Model 0 only includes country dummies while models 1 to 5 also include the control variables used in columns 1 to 5 of Table 1. The reference category is France.

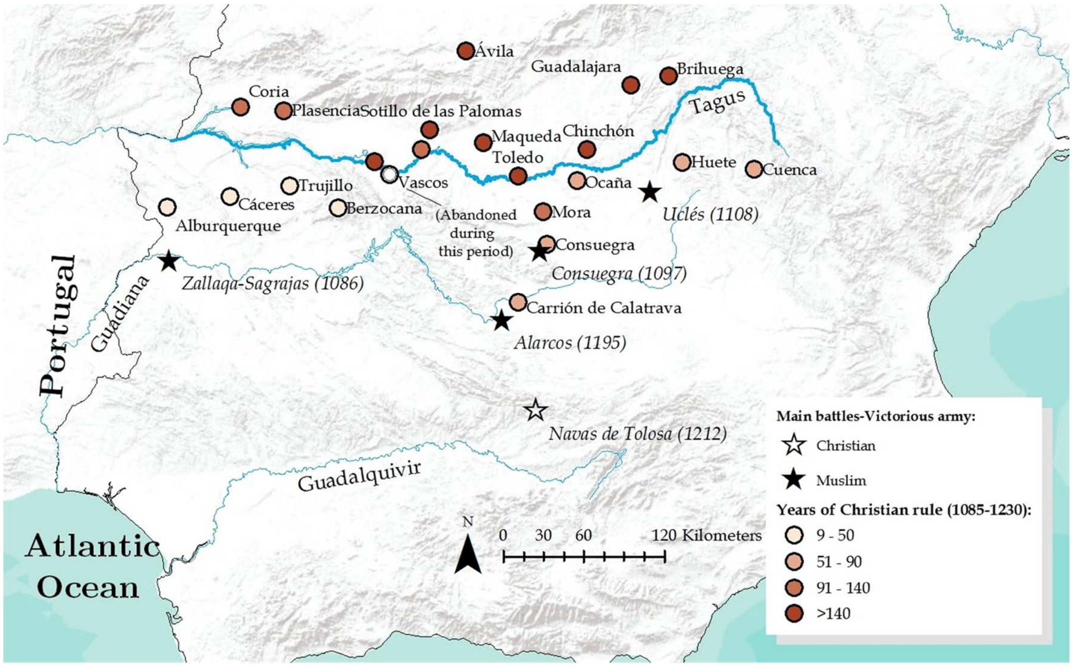
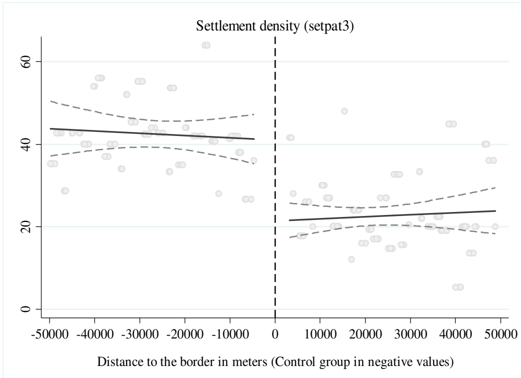
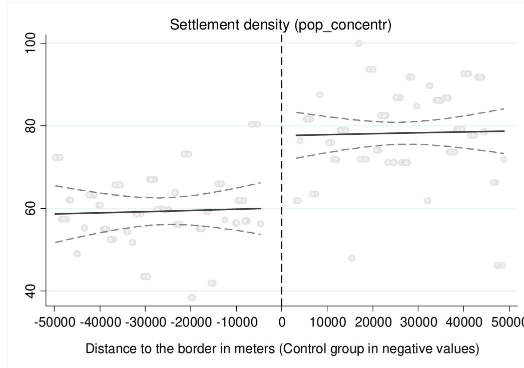


Figure 5. Instability around the Tagus between 1085 and 1230

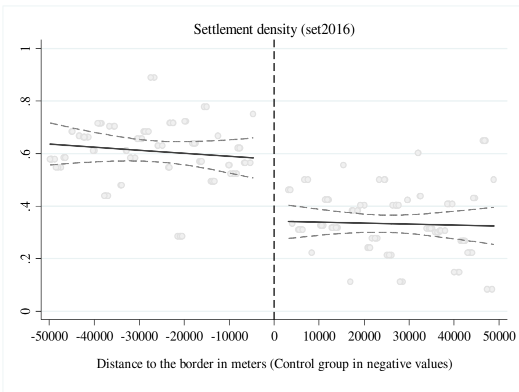
Notes: The map shows some towns and the main battles around the Tagus during the period of the Almohad and Almoravid invasions. Towns are colored in a white-red range representing how many years they were under Christian rule, ranging from 9 for Caceres to 145 for most of the towns north of the Tagus.



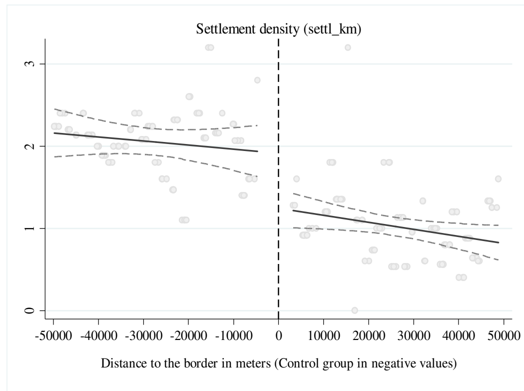
A. Settlement density



B. Population concentration



C. Density of 'population entities'



D. Density of municipalities

Figure 6. One-dimensional RD figures showing the discontinuity at the border

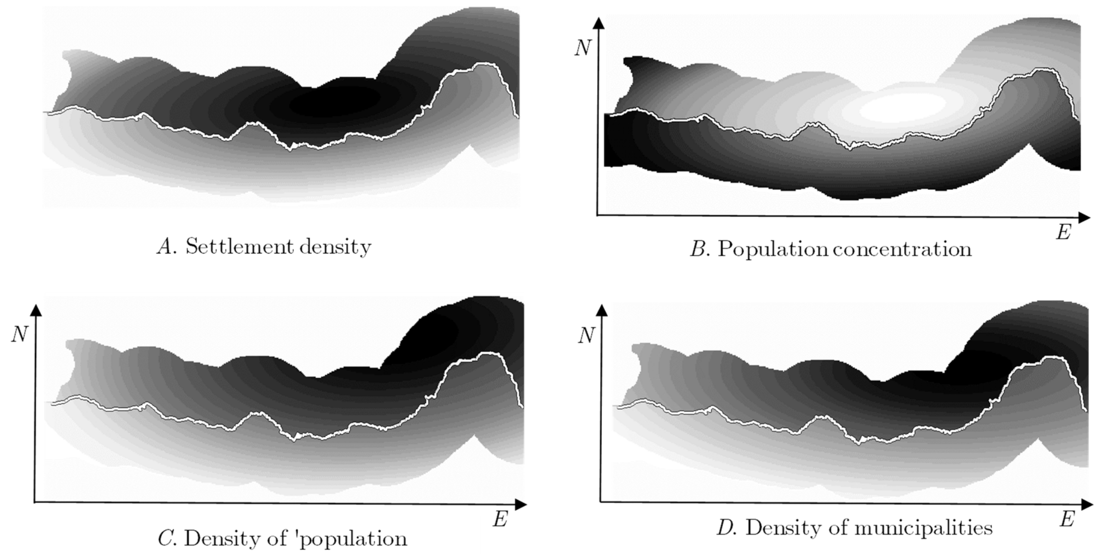


Figure 7. Two-dimensional RD figures showing the discontinuity at the border

Note: A darker color indicates a higher value.

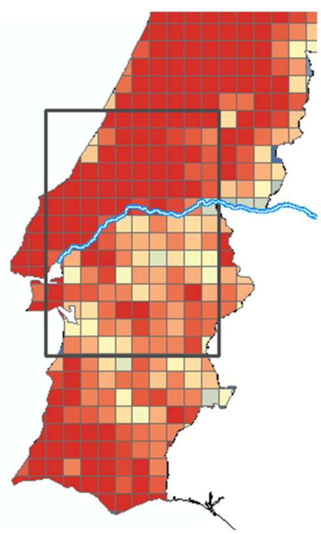


Figure 8. Discontinuity across the Tagus River in Portugal

Note: A darker color indicates higher settlement density.

Table 1

Determinants of settlement density and population concentration in Europe

	A. Dependent variable is settlement density					*B. Dependent variable is population concentration*				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Temperature	11.255***	10.968***	9.698***	9.798***	1.756	-6.858***	-6.465***	-5.723***	-5.164***	-0.201
	(0.979)	(1.135)	(1.09)	(1.282)	(1.405)	(0.961)	(1.034)	(0.914)	(0.876)	(0.785)
Temperat. sq	-0.572***	-0.559***	-0.503***	-0.515***	-0.174**	0.376***	0.353***	0.321***	0.294***	0.132**
	(0.072)	(0.071)	(0.063)	(0.076)	(0.083)	(0.052)	(0.049)	(0.043)	(0.051)	(0.057)
Precipitation		3.549	6.136*	7.489**	7.605***		-3.489	-5.239**	-6.464***	-6.28***
		(3.991)	(3.524)	(3.184)	(2.022)		(2.408)	(2.056)	(1.746)	(1.165)
Precipit. sq		-0.197	-0.263*	-0.308**	-0.295***		0.156	0.203**	0.243***	0.22***
		(0.167)	(0.133)	(0.125)	(0.091)		(0.101)	(0.077)	(0.068)	(0.05)
Altitude			-0.026***	-0.032***	-0.044***			0.018***	0.029***	0.041***
			(0.008)	(0.01)	(0.012)			(0.006)	(0.005)	(0.007)
Ruggedness				0.006	0.022**				-0.034**	-0.04***
				(0.021)	(0.01)				(0.013)	(0.011)
Soil quality				-0.501	0.281				-0.695	-0.619
				(1.084)	(0.768)				(0.612)	(0.508)
Dist to coast				0.045*	-0.017				-0.046**	-0.002
				(0.025)	(0.026)				(0.017)	(0.017)
Dist to coast sq				0.000	0.000				0.000	0.000
				(0.00)	(0.00)				(0.00)	(0.00)
Island dummy				5.692	8.22*				-3.923	-5.318
				(6.052)	(4.294)				(3.738)	(3.215)
$(\text{Lat} + \text{Lon})^2$					Yes					Yes
Constant	31.402***	18.665	18.419	13.177	-293.337**	61.65***	76.752***	77.107***	91.197***	191.177**
	(4.977)	(18.947)	(13.476)	(17.468)	(118.725)	(5.111)	(12.554)	(9.38)	(10.792)	(82.954)
R-sq	0.40	0.41	0.50	0.55	0.65	0.20	0.21	0.29	0.37	0.45
Obs	23,411	23,411	23,385	21,284	21,284	22,457	22,457	22,415	20,322	20,322

Notes: Variables descriptions are provided in Table A1. Standard errors clustered at the country level are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 2

Frontiers and settlement and population patterns: Average differences within Spain

	Dependent variable is settlement density						*Dependent variable is population concentration*					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Treated region (conquered by	-32.322***	-33.283***	-25.96***	-23.598***	-20.796***	-22.595***	24.063***	24.802***	20.881***	19.128***	17.102***	18.148***
Leon and Castile 12^{th}-13^{th}	(3.01)	(3.188)	(3.353)	(3.236)	(3.69)	(4.12)	(2.277)	(2.416)	(2.63)	(2.688)	(2.973)	(3.44)
Temperature		7.411***	7.563***	7.159**	6.065*	-1.682		-1.616	-0.529	0.212	2.135	10.258**
		(2.842)	(2.304)	(3.109)	(3.546)	(5.073)		(2.867)	(2.323)	(2.654)	(2.909)	(4.162)
Temperat. sq		-0.232***	-0.299***	-0.121	-0.013	-0.147		0.029	0.018	-0.136	-0.258***	-0.309***
		(0.088)	(0.072)	(0.094)	(0.086)	(0.119)		(0.091)	(0.078)	(0.086)	(0.087)	(0.111)
Precipitation		2.854	3.859	6.872***	11.111***	8.851***		1.512	-0.711	-1.637	-4.512**	-0.651
		(3.265)	(2.983)	(2.493)	(2.706)	(3.208)		(2.209)	(2.017)	(2.018)	(2.229)	(2.49)
Precipit. sq		0.06	-0.061	-0.306**	-0.524***	-0.369**		-0.238**	-0.071	0.064	0.217*	-0.046
		(0.178)	(0.153)	(0.127)	(0.137)	(0.167)		(0.119)	(0.106)	(0.112)	(0.115)	(0.127)
Altitude		-0.017*	-0.008	0.012	0.01	-0.054**		0.01	0.004	-0.012	-0.01	0.027
		(0.009)	(0.008)	(0.014)	(0.017)	(0.025)		(0.007)	(0.006)	(0.011)	(0.013)	(0.02)
Additional geographic variables			Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes
$(Lat + Lon)^2$				Yes	Yes	Yes				Yes	Yes	Yes
Virtual regions fixed-effects					Yes	Yes					Yes	Yes
R-sq	0.28	0.47	0.54	0.57	0.62	0.65	0.24	0.34	0.39	0.42	0.47	0.50
Obs	2,091	2,091	2,000	2,000	2,000	1,558	2,042	2,042	1,959	1,959	1,959	1,527

Notes: Variables descriptions are provided in Table A1. Regressions include a constant term which is omitted for space considerations. The set of additional geographic variables includes ruggedness, soil quality, distance to the coast (linear and squared) and an island dummy. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 3

Differences across the Tagus River: Geo-climatic variables and pre-existing conditions

	Precipitation	*Temperature*	*Altitude*	*Ruggedness*	*Soil quality*	*Distance to the coast*	*Pre-medieval settlements*	*Distance to Roman roads*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
South of the Tagus (high military insecurity)	0.301	0.967	-65.251	-18.818	-0.075	-13.67	-0.007	4.241
	(0.255)	(0.675)	(93.1)	(17.915)	(0.291)	(19.495)	(0.006)	(5.569)
R-sq	0.03	0.05	0.01	0.02	0.00	0.01	0.00	0.01
Obs	219	219	219	219	217	219	218	219

Notes: Variables descriptions are provided in Table A1. South of the Tagus (high military insecurity) is a dummy variable indicating whether the grid cell is located south of the Tagus. Sample restricted to grid cells within 50 km of the border. Regressions include a constant term which is omitted for space considerations. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 4

Baseline results: Border specification and spatial RD regressions

	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in latitude and longitude
	(1)	(2)	(3)	(4)
Panel A: Settlement density				
South of the Tagus (high military insecurity)	-25.738***	-25.32***	-16.069***	-20.32***
	(6.001)	(5.938)	(3.671)	(3.632)
Standardized coefficient	-0.638	-0.627	-0.398	-0.503
R-squared	0.42	0.43	0.54	0.52
Observations	219	219	219	219
Panel B: Population concentration				
South of the Tagus (high military insecurity)	24.79***	24.803***	16.02***	19.469***
	(5.066)	(5.024)	(3.494)	(2.929)
Standardized coefficient	0.596	0.597	0.385	0.468
R-squared	0.37	0.37	0.44	0.44
Observations	215	215	215	215
Panel C: Density of 'population entities'				
South of the Tagus (high military insecurity)	-0.308***	-0.31***	-0.191***	-0.209***
	(0.063)	(0.064)	(0.045)	(0.044)
Standardized coefficient	-0.575	-0.577	-0.356	-0.389
R-squared	0.50	0.50	0.57	0.58
Observations	218	218	218	218
Panel D: Density of municipalities				
South of the Tagus (high military insecurity)	-0.894***	-0.916***	-0.601***	-0.66***
	(0.166)	(0.171)	(0.173)	(0.151)
Standardized coefficient	-0.441	-0.451	-0.296	-0.325
R-squared	0.40	0.41	0.44	0.46
Observations	219	219	219	219
Boundary fixed effects	Yes	Yes	Yes	Yes
Geo-climatic controls	Yes	Yes	Yes	Yes

Notes: Variables descriptions are provided in Table A1. South of the Tagus (high military insecurity) is a dummy variable indicating whether the grid cell is located south of the Tagus. Regressions include a constant term which is omitted for space considerations. Sample restricted to grid cells within 50 km of the border. The set of geographic–climatic controls includes rainfall and temperature (both in linear and quadratic terms) and altitude. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 5

Specification tests

	Linear polynomial in distance to the Tagus	Interacted polynomial in distance to the Tagus	Linear polynomial in distance to Madrid	Interacted polynomial in distance to the Madrid	Linear polynomial in latitude and longitude
	(1)	(2)	(3)	(4)	(5)
Panel A: Settlement density					
South of the Tagus (high military insecurity)	-25.582***	-19.152***	-18.768***	-41.463***	-19.382***
	(5.959)	(4.748)	(4.092)	(6.696)	(4.753)
Standardized coefficient	-0.634	-0.474	-0.465	-1.027	-0.48
R-squared	0.42	0.43	0.47	0.54	0.45
Observations	219	219	219	219	219
Panel B: Population concentration					
South of the Tagus (high military insecurity)	24.799***	17.948***	18.172***	33.905***	18.53***
	(4.997)	(3.981)	(3.727)	(5.997)	(3.791)
Standardized coefficient	0.596	0.432	0.437	0.815	0.446
R-squared	0.37	0.38	0.40	0.44	0.39
Observations	215	215	215	215	215
Panel C: Density of 'population entities'					
South of the Tagus (high military insecurity)	-0.311***	-0.236***	-0.205***	-0.42***	-0.194***
	(0.064)	(0.069)	(0.048)	(0.07)	(0.054)
Standardized coefficient	-0.578	-0.44	-0.382	-0.782	-0.362
R-squared	0.50	0.51	0.56	0.59	0.55
Observations	218	218	218	218	218
Panel D: Density of municipalities					
South of the Tagus (high military insecurity)	-0.912***	-0.7***	-0.665***	-1.323***	-0.671***
	(0.17)	(0.227)	(0.168)	(0.22)	(0.194)
Standardized coefficient	-0.45	-0.345	-0.328	-0.652	-0.331
R-squared	0.41	0.42	0.43	0.45	0.42
Observations	219	219	219	219	219
Boundary fixed effects	Yes	Yes	Yes	Yes	Yes
Geo-climatic controls	Yes	Yes	Yes	Yes	Yes

Notes: Variables descriptions are provided in Table A1. South of the Tagus (high military insecurity) is a dummy variable indicating whether the grid cell is located south of the Tagus. Regressions include a constant term which is omitted for space considerations. Sample restricted to grid cells within 50 km of the border. The set of geographic–climatic controls includes rainfall and temperature (both in linear and quadratic terms) and altitude. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 6

Placebo tests (I): Moving the frontier southward and northward

	Moving the frontier 50 km northward				Moving the frontier 50 km southward			
	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in latitude and longitude	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in latitude and longitude
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Settlement density								
South of the placebo border	-5.84*	-5.74*	-3.511	-0.143	3.565	3.348	5.313**	2.486
	(3.175)	(3.228)	(2.723)	(2.762)	(2.677)	(2.669)	(2.469)	(3.215)
Standardized coefficient	-0.145	-0.142	-0.087	-0.004	0.124	0.116	0.185	0.087
R-squared	0.41	0.41	0.43	0.47	0.25	0.26	0.30	0.34
Observations	224	224	224	224	242	242	242	242
Panel B: Population concentration								
South of the placebo border	4.906	5.004	2.79	1.634	-2.458	-2.406	-4.202	-4.785
	(3.794)	(3.759)	(3.011)	(3.13)	(3.57)	(3.677)	(3.77)	(4.778)
Standardized coefficient	0.13	0.133	0.074	0.043	-0.07	-0.068	-0.119	-0.135
R-squared	0.36	0.37	0.39	0.39	0.18	0.18	0.23	0.28
Observations	222	222	222	222	236	236	236	236
Panel C: Density of 'population entities'								
South of the placebo border	-0.05	-0.049	-0.031	0.024	0.052	0.05	0.082**	0.04
	(0.037)	(0.037)	(0.034)	(0.041)	(0.047)	(0.049)	(0.042)	(0.044)
Standardized coefficient	-0.107	-0.106	-0.066	0.052	0.115	0.112	0.182	0.089
R-squared	0.37	0.37	0.41	0.45	0.32	0.33	0.37	0.43
Observations	223	223	223	223	241	241	241	241
Panel D: Density of municipalities								
South of the placebo border	-0.213	-0.197	-0.298	-0.287	-0.021	-0.032	0.035	-0.01
	(0.237)	(0.234)	(0.197)	(0.315)	(0.134)	(0.138)	(0.14)	(0.171)
Standardized coefficient	-0.094	-0.087	-0.132	-0.126	-0.014	-0.022	0.024	-0.007
R-squared	0.32	0.33	0.33	0.33	0.36	0.37	0.37	0.40
Observations	224	224	224	224	242	242	242	242
Boundary fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geo-climatic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Variables descriptions are provided in Table A1. South of the placebo border is a dummy variable indicating whether the grid cell is located south of the placebo border. Regressions include a constant term which is omitted for space considerations. Sample restricted to grid cells within 50 km of the border. The set of geographic–climatic controls includes rainfall and temperature (both in linear and quadratic terms) and altitude. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 7

Placebo tests (II): Duero and Guadiana rivers

	Testing differences across the Duero river				Testing differences across the Guadiana river			
	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in latitude and longitude	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in latitude and longitude
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Settlement density								
South of the placebo border	3.193	3.717	3.103	2.67	-1.18	-1.726	-1.633	-6.238*
	(3.28)	(3.061)	(3.212)	(3.81)	(2.67)	(2.709)	(2.99)	(3.682)
Standardized coefficient	0.109	0.127	0.106	0.091	-0.049	-0.072	-0.068	-0.259
R-squared	0.14	0.16	0.15	0.16	0.23	0.23	0.24	0.29
Observations	141	141	141	141	205	205	205	205
Panel B: Population concentration								
South of the placebo border	-6.975**	-7.454**	-6.029**	-4.914	-0.753	-0.652	-2.286	0.565
	(3.25)	(2.89)	(2.774)	(3.601)	(3.751)	(3.775)	(3.87)	(4.149)
Standardized coefficient	-0.229	-0.245	-0.198	-0.162	-0.022	-0.019	-0.067	0.017
R-squared	0.11	0.13	0.14	0.13	0.22	0.22	0.24	0.25
Observations	141	141	141	141	196	196	196	196
Panel C: Density of 'population entities'								
South of the placebo border	0.012	0.019	0.007	-0.04	-0.007	-0.008	0.000	-0.044
	(0.036)	(0.034)	(0.034)	(0.046)	(0.031)	(0.032)	(0.031)	(0.036)
Standardized coefficient	0.036	0.056	0.022	-0.119	-0.019	-0.022	0.001	-0.115
R-squared	0.19	0.22	0.19	0.24	0.28	0.29	0.30	0.35
Observations	141	141	141	141	205	205	205	205
Panel D: Density of municipalities								
South of the placebo border	-0.021	0.054	-0.113	-0.169	0.091	0.099	0.154	-0.047
	(0.323)	(0.277)	(0.289)	(0.296)	(0.092)	(0.097)	(0.11)	(0.095)
Standardized coefficient	-0.009	0.023	-0.049	-0.073	0.081	0.089	0.137	-0.042
R-squared	0.19	0.27	0.20	0.25	0.22	0.23	0.26	0.32
Observations	141	141	141	141	205	205	205	205
Boundary fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geo-climatic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Variables descriptions are provided in Table A1. South of the placebo border is a dummy variable indicating whether the grid cell is located south of the placebo border. Regressions include a constant term which is omitted for space considerations. Sample restricted to grid cells within 50 km of the border. The set of geographic–climatic controls includes rainfall and temperature (both in linear and quadratic terms) and altitude. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 8

Discontinuity across the Tagus River in Portugal

	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in distance to Lisbon	Quadratic polynomial in latitude and longitude
	(1)	(2)	(3)	(4)	(5)
Panel A: Settlement density					
South of the Tagus (high military insecurity)	-19.109***	-19.902***	-19.915***	-20.014***	-18.333***
	(5.774)	(5.057)	(5.92)	(5.758)	(6.4)
Standardized coefficient	-0.542	-0.565	-0.565	-0.568	-0.52
R-squared	0.68	0.71	0.70	0.69	0.73
Observations	67	67	67	67	67
Panel B: Population concentration					
South of the Tagus (high military insecurity)	11.417***	12.912***	11.751***	11.003**	12.074**
	(3.566)	(3.75)	(4.349)	(4.14)	(4.516)
Standardized coefficient	0.324	0.366	0.333	0.312	0.342
R-squared	0.65	0.66	0.68	0.67	0.69
Observations	67	67	67	67	67
Panel C: Density of municipalities					
South of the Tagus (high military insecurity)	-2.313**	-2.328**	-2.098**	-2.154**	-2.218**
	(0.954)	(0.965)	(0.915)	(0.974)	(0.902)
Standardized coefficient	-0.539	-0.542	-0.489	-0.502	-0.517
R-squared	0.59	0.59	0.64	0.61	0.66
Observations	67	67	67	67	67
Boundary fixed effects	Yes	Yes	Yes	Yes	Yes
Geo-climatic controls	Yes	Yes	Yes	Yes	Yes

Notes: Variables descriptions are provided in Table A1. South of the Tagus (high military insecurity) is a dummy variable indicating whether the grid cell is located south of the Tagus. Regressions include a constant term which is omitted for space considerations. Sample restricted to grid cells within 50 km of the border. The set of geographic–climatic controls includes rainfall and temperature (both in linear and quadratic terms) and altitude. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 9

Historical variables of settlement density

	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in latitude and longitude
	(1)	(2)	(3)	(4)
Panel A: Census of "Pecheros" of Carlos I (1528)				
South of the Tagus (high military insecurity)	-0.016***	-0.016***	-0.013***	-0.007*
	(0.004)	(0.004)	(0.004)	(0.004)
Standardized coefficient	-0.453	-0.455	-0.355	-0.20
R-squared	0.45	0.45	0.46	0.49
Observations	211	211	211	211
Panel B: Census of "Floridablanca" (1787)				
South of the Tagus (high military insecurity)	-0.014***	-0.014***	-0.009***	-0.006**
	(0.003)	(0.003)	(0.003)	(0.003)
Standardized coefficient	-0.425	-0.428	-0.27	-0.178
R-squared	0.47	0.47	0.51	0.55
Observations	219	219	219	219
Boundary fixed effects	Yes	Yes	Yes	Yes
Geo-climatic controls	Yes	Yes	Yes	Yes

Notes: Variables descriptions are provided in Table A1. South of the Tagus (high military insecurity) is a dummy variable indicating whether the grid cell is located south of the Tagus. Regressions include a constant term which is omitted for space considerations. Sample restricted to grid cells within 50 km of the border. The set of geographic–climatic controls includes rainfall and temperature (both in linear and quadratic terms) and altitude. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

Table 10

Discontinuity in current economic outcomes

	OLS	Quadratic polynomial in distance to the Tagus	Quadratic polynomial in distance to Madrid	Quadratic polynomial in latitude and longitude
	(1)	(2)	(3)	(4)
Panel A: Log light density at night				
South of the Tagus (high military insecurity)	-1.392***	-1.346***	-0.81**	-1.08***
	(0.247)	(0.245)	(0.339)	(0.329)
Standardized coefficient	-0.417	-0.403	-0.243	-0.323
R-squared	0.45	0.46	0.50	0.52
Observations	219	219	219	219
Panel B: Average socioeconomic condition				
South of the Tagus (high military insecurity)	-0.087***	-0.085***	-0.062***	-0.067***
	(0.02)	(0.02)	(0.016)	(0.019)
Standardized coefficient	-0.546	-0.53	-0.386	-0.419
R-squared	0.52	0.53	0.59	0.58
Observations	219	219	219	219
Panel C: Average number of vehicles per household				
South of the Tagus (high military insecurity)	-0.15***	-0.142***	-0.109***	-0.155***
	(0.043)	(0.041)	(0.03)	(0.032)
Standardized coefficient	-0.461	-0.438	-0.335	-0.477
R-squared	0.45	0.48	0.52	0.47
Observations	219	219	219	219
Panel D: Labor force activity rate				
South of the Tagus (high military insecurity)	-3.294***	-3.253***	-2.725***	-2.892***
	(0.936)	(0.916)	(0.995)	(0.989)
Standardized coefficient	-0.469	-0.463	-0.388	-0.412
R-squared	0.30	0.30	0.31	0.32
Observations	219	219	219	219
Boundary fixed effects	Yes	Yes	Yes	Yes
Geo-climatic controls	Yes	Yes	Yes	Yes

Notes: Variables descriptions are provided in Table A1. South of the Tagus (high military insecurity) is a dummy variable indicating whether the grid cell is located south of the Tagus. Regressions include a constant term which is omitted for space considerations. Sample restricted to grid cells within 50 km of the border. The set of geographic–climatic controls includes rainfall and temperature (both in linear and quadratic terms) and altitude. Standard errors corrected for spatial dependence are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% level, respectively.

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