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

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Abstract

This paper investigates the potential of frontiers to shape the economic geography of countries. I focus on the case of Spain to explore how historical frontier warfare affects the colonization of the territory and the distribution of the population across the space. Exploiting a spatial discontinuity in military insecurity during the Christian colonization of central Spain in the Middle Ages, my findings suggest that medieval frontier warfare heavily conditioned the settlement of the territory, resulting in a sparse occupation of the space, low settlement density and high population concentration. These initial features of the colonization process were already visible in the early 16th century and have persisted to this day, with potential negative consequences for economic development.

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, this paper explores how military insecurity in frontier regions can condition the political and economic occupation of the territory. I put forward the hypothesis that frontier warfare favors a colonization of the territory characterized by low settlement and population density and high population concentration. The underlying mechanisms are that violence and insecurity i) create incentives for a militarized occupation of the space based on the concentration of the population in a few well-defended settlements, and ii) favor livestock over agriculture, as mobile assets are easier to protect and less labor-intensive. Both factors, once established, have the potential to persist over time and reinforce themselves, perpetuating the initial pattern of settlement. To test this hypothesis, I exploit a geographic discontinuity in military insecurity during the 11^{th} to 13^{th} 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

[1] 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). 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. Fally *et al.* (2010) find a strong correlation between access to markets, given by location, and regional wage inequality in Brazil.

settlements. Bishko (1963) referred to this style of colonization as a "medieval ranching frontier", and the interplay between militarization and ranching contributed to the persistence of the initial spatial population structure.

The empirical analysis supports the above hypothesis by revealing a large and robust jump in settlement density and population concentration across the River Tagus, whereas there are no geographic and climatic discontinuities across it nor pre-existing differences in settlements and Roman roads. 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. 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).

The analysis also reveals some evidence of a discontinuity in population density, although it is less robust than the one in settlement density and population concentration. I argue that this is because the effect of frontier warfare has been less persistent on population density than on the settlement structure of the territory. I support this interpretation by showing that the discontinuity in population density was clearer in the 16th century than in later periods. The results further indicate that, consistent with my hypothesis, the intensity of land use is lower in the territory exposed to medieval ranching frontier, and that this territory is relatively poorer today, suggesting that the way the territory is settled matters 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 through 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, the Russian steppe frontier, or other contested frontiers in Europe, for instance with the Ottoman Empire.[2]

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

[2] When comparing the Spanish case to other European countries, 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 states and powerful North African empires.

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; Barjamovic et al., 2019).

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).[3] Compared to previous work, this article focuses on the effect of frontiers on the spatial 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. 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.[4]

Finally, this study is also related to a body of research on the interplay between history

[3] 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 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).

[4] 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.

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 provides a historical discussion about medieval frontier warfare in the Spanish Middle Ages. Sections 3 and 4 conduct an econometric study of the effect of frontier warfare on settlement and population patterns. Section 5 discusses the main findings of the investigation. Finally, Section 6 puts forward some implications and concludes.

2 Historical background

2.1 The Spanish Reconquest and the barrier of the River Tagus

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 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 (Sánchez-Albornoz, 1962; Oto-Peralías and Romero-Ávila, 2016, 2017).

The conquest of Toledo in 1085 by Castilian King Alfonso VI brought the frontier down to the River Tagus. This event triggered a process that led to the most violent period of the Reconquest. The taifa kingdoms that emerged after the collapse of the Cordoba Caliphate requested help from the Almoravids, the orthodox Muslim rulers in the Maghreb, which agreed to fight against the Christians and inflicted them an early defeat at Zallaqa (1086). However, their military help proved to be expensive as once they crossed the Gibraltar strait they incorporated the taifa kingdoms into their empire.

Almoravids -and later Almohads- put great effort into trying to reconquer Toledo, turning the territory south of the Tagus into a battlefield for almost one-and-a-half centuries (Bishko, 1963). During this period, the Christian kingdoms struggled to conquer and defend key frontier positions.[5] The River Tagus became a frontier landmark due to the

[5] 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

coincidence of the progress of the Reconquest over its course and the invasions of the Almoravid and Almohad armies from North Africa. South of the river there was a large frontier region that extended towards the mountains "Sierra Morena" (on the border with modern-day Andalusia) without precise boundaries.

The Tagus became thus the delimitation between two areas: a vanguard frontier region to the south of it (affected by high military insecurity) and a relatively safer territory to the north. It constituted a natural military barrier that created a discontinuity in the intensity of warfare suffered by the territory. 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). 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).

2.2 From frontier insecurity to militarized colonization and ranching

The Spanish case illustrates that medieval frontier warfare can be linked to a militarized occupation of the space and a ranching-oriented economy, resulting in low settlement density and high population concentration. 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).

Militarized colonization. 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, which -for instance- happened with most of the lands occupied by Alfonso VII as a result of the Almohad invasion (Sánchez-Albornoz, 1962). 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), namely, shortage of population, a ranching-oriented economy, and the prominence of the military orders as colonizer agents. The resettlement of the area was based on castles and fortresses

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).

as strategic centers (Vann, 1999) and Leonese and Castilian rulers had to rely on the military orders for the conquest, defense and colonization of the southern plateau, leading to a sparse and militarized occupation of the space.[6]

Historians have long identified militarization as the main feature of medieval frontiers (Berend, 1999), and militarization reached a peak 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).[7] Military orders' lordships were indeed overwhelmingly located south of the Tagus and exposed to an almost permanent frontier friction (Ayala Martínez, 1996).[8] They 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.[9]

Ranching. 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, frontier

[6] 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).

[7] 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).

[8] 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 south of the Tagus. 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.

[9] 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).

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, 1996).[10, 11]

In contrast to this settlement process, the territory north of the Tagus 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.

3 Frontiers and settlement patterns: Empirical evidence

This section exploits the spatial discontinuity in warfare and insecurity created by the River Tagus from the 11th to 13th centuries to analyze the relationship of medieval frontier warfare with settlement and population patterns. I first describe the data, then discuss the

[10] 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 tracts of lands. It is unquestionable 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).

[11] 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.

identification strategy, and finally present the results.

3.1 Data

The units of observation in the analysis are 250-km^2 grid cells. Five indicators are used to capture the spatial structure of the population. Three of these indicators are constructed using the GEOSTAT 2011 population grid (Eurostat 2016a), which 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 first indicator, *settlement density*, measures the extent of the settlement of the territory through the percentage of 10-km^2 grid cells that are inhabited in each unit of observation. A 10-km^2 grid cell is considered to be populated if it contains at least one 1-km^2 populated cell within it. 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. Figure 2-Panel A represents the indicator while Figure 3 illustrates its construction.

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. Third, I also calculate an indicator of population density. Panels B and C of Figure 2 depict the spatial distribution of both indicators. Regarding the correlation among these indicators, settlement density is negatively correlated with population concentration (-0.80) and positively with the logarithm of population density (0.58), while population concentration and population density are negatively correlated (-0.52).

Fourth, I also use 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). Fifth, I employ 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. Panels D and E of Figure 2 depict the values of both indicators.

Finally, 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 1 in the Supplementary Material.

Spain's economic geography. Figure 2 illustrates well the main characteristics of the spatial distribution of the population in Spain. The population is not uniformly distributed across the territory. Madrid and the coastline concentrate much of the country's population

whereas large tracts of lands north and south of Madrid have a very low density of it. This implies that the concentration of the population is high at the country level. Regarding settlement patterns, an interesting geographic contrast emerges: the density of settlements, population entities and municipalities is remarkably low in the South. The pattern of population density does not follow this contrast, which indicates that people in the South tend to live close together in towns and cities while in the North they are more scattered across the space. This fact is reflected in the pattern of population concentration, with higher values in the South. The levels of settlement density and population concentration are particularly low and high, respectively, in the Southern Plateau. For instance, settlement density and population concentration in modern-day Extremadura and Castilla-la-Mancha (except Guadalajara) are 57% lower and 38% higher, respectively, than in the rest of Spain. While many factors may contribute to explain these large differences, a relevant one is its past as a military insecure frontier region during the most violent period of the Reconquest (11^{th} to 13^{th} centuries). The rest of the section studies the link between historical frontier warfare and current population and settlement patterns.

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

The Tagus was a meaningful military barrier and a recognized frontier landmark during the 11^{th} to 13^{th} centuries, 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. More specifically, 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 and geographic factors, nor in pre-existing historical factors (including pre-existing settlements), iii) there are no differences in the institutional and cultural legacy of Christians vs Muslims across the river, and iv) 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).[12] Figure 1 provides anecdotal evidence of the Tagus as a strategic 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 1 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.[13] 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.[14] Moreover, the Tagus did not constitute the border of previous or subsequent political divisions. For instance, it was not the border of Roman provinces, Muslim states nor historical or contemporary provinces or regions.[15]

Concerning assumption "iii", the River Tagus did not create a discontinuity in the Christian-Muslim institutional and cultural legacy. Firstly, the Muslim presence right south of the Tagus was unimportant during this period. Indeed, the Almoravids developed the notion of a "front-line" located south of the Tagus that separated the territory under their control (further south in modern-day Andalusia) from the area beyond it, in which they undertook devastating raids (García Fitz, 2001). In addition, and more generally, the institutional-cultural Muslim legacy in Spain is minimal because the Christian kingdoms basically started from scratch by introducing its own institutions and people. The Muslim population was largely expelled or fled. This is consistent with the available evidence regarding the geographic genetic distribution of the population. Recent studies have found no evidence of a north-south gradient in northern Africa ancestors in the current population

[12] 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).

[13] Appendix 2 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.

[14] 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 largely 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 and population density.

[15] In this regard, I have checked that the results are robust to the inclusion of province fixed effects (see Section 4.1).

of Spain. According to the latest evidence: "north African ancestry does not reflect proximity to north Africa, or even regions under more extended Muslim control" (Bycroft *et al.* 2019: 8, see also Adams *et al.* 2008). This absence of a north-south gradient is also reflected in a complete absence of genetic differences across the Tagus. If cultural traits travel with gens, this implies absence of differences in Muslim cultural legacy.

With respect to assumption "iv", 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 1, column 7) is also consistent with this point. Moreover, it is shown later in Section 4.1 that there are no significant differences in settlement patterns across the Douro and Guadiana rivers, which suggests that (Spanish) rivers by themselves are not barriers big enough to create major obstacles to human spatial mobility. In addition, the available evidence of the spatial genetic distribution of the population shows absence of discontinuities across the Tagus as well as other rivers (Bycroft *et al.* 2019).

To sum up, the previous discussion suggests 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. Figure 4 takes a first look at the data by spatially smoothing the variables of interest. The graphs represent the spatial weighted average calculated separately on both sides of the Tagus for grid cells within a distance of 100 km from it and where weights depend inversely on distance until a threshold of 50 km.[16] In all cases, it can be observed a strong discontinuity in settlement and population patterns across the river -although it is slightly less pronounced for population density. Figure 5 follows the standard RD style of graphs by sorting observations in distance to the border. More specifically, I draw binned scatterplots with the nonparametric relationship between each indicator of settlement-population patterns and distance to the Tagus. The graphs reveal large jumps in the variables measuring density of settlements and population concentration (Graphs A – D) whereas there is no clear evidence for a discontinuity in population density.

[16] The local value's weight is 10% or its neighbor's value with the maximum weight if the latter is above 10%.

3.3 SRD design: Baseline results

Table 2 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 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,[17] $X'_{i,j}$ represents a vector of control variables that includes rainfall and temperature (both in linear and quadratic terms) and altitude, $f(geo.loc.)$ 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.[18] The sample used includes grid cells falling within a distance of 50 km from the Tagus, rendering about 210 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. Moreover, I focus on the territory historically controlled by Castile and Leon to further isolate the effect of medieval frontier warfare. Figure 6 depicts the area of study.

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 1 rules out differences in geographic and climatic variables. The results are highly supportive of a statistically significant discontinuity in settlement and population patterns across the border. Panels A and B show that the territory south of the Tagus –and therefore affected by high military instability during the 11th-13th centuries– has a much lower settlement density and a much higher population concentration, the difference being about 25 percentage points in both cases. Panels C and D also reveal large differences in density of population entities and municipalities across the river. Panel E indicates that the level of population density is also lower south of the Tagus.

The rest of the columns in Table 2 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

[17] To avoid having grid cells that are only partially located south of the Tagus, I delete observations with a percentage of surface area located south of this river in the range 20%-80%.

[18] I report Conley (1999)'s standard errors robust to spatial correlation of unknown form. I employ cutoffs of 1 decimal degree, beyond which spatial correlation is assumed to be zero. 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).

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 for the indicators measuring settlement patterns and population concentration. The effect of having been affected by high insecurity is statistically significant and economically important in Panels A to D. However, the existence of a discontinuity is less clear cut for population density. The standardized coefficient is much smaller than in the previous cases and loses statistical significance, particularly when including the quadratic polynomial in distance to Madrid. This is consistent with the pattern observed in Figure 5 and suggests that the effect of medieval frontier warfare has been more persistent in the way the territory is settled than in the amount of population living in each place. Arguably, the settlement structure of the territory is more difficult to alter once it is fixed than the size of the population (Section 5 further discusses this result).

Finally, Table 3 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. Similar to the previous table, the coefficients in Panels A to D (the variables related to settlement patterns and population concentration) have always the expected sign and are highly statistically significant, while for population density the coefficient is more unstable and loses statistical significance. These results indicate that there exists a robust discontinuity in settlement patterns and population concentration across the River Tagus while this is less clear for the case of population density. Given this evidence, the rest of the analysis focuses on the variables related to settlement patterns and population concentration.

4 Further evidence and implications for development

4.1 Sensitivity analysis

This section conducts falsification exercises and sensitivity tests to analyze the robustness of the discontinuity in settlement patterns across the Tagus. First, I run 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. Second, I conduct 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. Appendix 3 reports the results from these two placebo tests and, reassuringly, the coefficients are mostly insignificant and their magnitude much smaller, thereby indicating absence of discontinuities.

Third, I conduct a more systematic falsification 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. Figure A1 in Appendix 3 illustrates the cumulative distribution of coefficients of the placebo treatments, where the vertical line shows the "true" coefficients reported in Table 2. 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 (adding terrain ruggedness, soil quality and the quadratic polynomial in distance to the coast); ii) to include province fixed effects, iii) to exclude grid cells with centroids located in the province of Madrid; iv) to use alternative bandwidths of 50, 75, 125, 150, 175, and 200 km (note that the baseline bandwidth is 100 km), v) to remove cells that are not completely squared, and vi) 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.[19]

4.2 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 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 4 analyzes the existence of a discontinuity in settlement patterns across the Tagus

[19] All these results are available in Appendix 4.

in Portugal. I focus on the indicators settlement density, population concentration and density of municipalities, which are the variables constructed using Eurostat data. Figure 7 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.

4.3 Historical measures of settlement density

The evidence presented in Section 3 indicates the presence of a discontinuity in settlement patterns across the Tagus. My interpretation of the results, based on the historical account in Section 2, 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.[20] 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.[21] Table 5 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.

4.4 Contemporary economic outcomes

Thus far the analysis has focused on testing the effect of medieval frontier warfare on 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

[20] 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.

[21] 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.

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 6 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 outcome variables. I use as dependent variables two indicators measuring the intensity of land use in 1982 (when 16% of the Spanish population worked in agriculture -reaching 46% in rural areas), and 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.

Panels A and B of Table 6 show that, consistent with my argument, there exists a discontinuity in the intensity of land use. The agricultural sector was less labor intensive and produced less output per hectare south of the Tagus in the early eighties. The rest of the panels report a similar discontinuity for the indicators measuring economic development at the local level. 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.

5 Discussion

The findings of sections 3 and 4 provide support for the hypothesis that frontier warfare favors a colonization of the territory characterized by low settlement density and high population concentration. What follows discusses some points related to the interpretation of this paper's results.

5.1 Explanatory power within Spain

There are two points worth discussing regarding the validity of the results within the wider Spanish context. The first one has to do with the fact that the area of low settlement density and high population concentration is not circumscribed to the south bank of the Tagus. Rather, it affects large tracts of land in Spain, particularly in its southern half. This does not need to be a concern as most of southern Spain was highly affected by medieval frontier warfare. The historical discussion in Section 2 focuses on the Southern Plateau because I exploit the Tagus discontinuity, but other regions like the Ebro Valley also suffered extreme insecurity due to the Almoravid and Almohad invasions. In addition, the Guadalquivir valley was also affected by frontier insecurity until the end of the 15th century due to its vicinity to the Emirate of Granada. Another factor such as the fast Reconquest after the battle of Las Navas de Tolosa can also contribute to explain the way the area conquered after this battle was colonized. An alternative explanation not related to the Christian colonization would be that the territory characterized by low settlement density was conquered later and, therefore, Muslims stayed longer and have left a stronger legacy. I argue above against this possibility. First, most of the Southern Plateau was actually not under the effective Almoravid and Almohad control. Rather, Christians and Muslims alternated the control of key military strongholds. Second, the Tagus River did not constitute the limit of any political division before nor after the historical period analyzed here. Third, contrary to expectations, a longer Muslim presence is not related to more Muslim institutional or cultural legacy (see Section 3.2 above).

The second point worth discussing relates to the fact that other areas in Spain also suffered warfare in different periods but have not ended up with such low (high) levels of settlement density (population concentration). The Duero Valley, for example, experienced frequent Muslim attacks but managed to create a dense network of settlements. This is an interesting case because this valley was largely unpopulated before the Reconquest (Sánchez-Albornoz, 1962; with nuances in Portela, 1985). The different outcome was arguably because the intensity of warfare was higher and lasted for longer in the episode studied here (i.e., the Almoravid and Almohad invasions) than in others (García Fitz, 2016). For instance, the numerous attacks led by Almanzor during the second half of the 10th century against the Christian frontier did not ruin the colonization of the Duero Valley - only delayed the progress of the resettlement process (Barrios, 1985). Thus, the colonization of the Duero Valley succeeded in creating a dense network of settlements, at least partially, because its settlers did not suffer the intense frontier warfare of the 11th to 13th centuries.

5.2 Persistence in settlement patterns

Why has the effect of medieval frontier warfare on settlement patterns and population

concentration persisted for so long? The discussion in Section 2 traced the link between frontier insecurity, militarized colonization, ranching, and low settlement density. Once the starting point was established, factors of persistence prevented the whole region from converging to the rest of Spain. First, the prevalence of pastoralism created vested interests among ranchers to –for instance– maintain pasturelands with the same use. Thus, once ranching became the main economic activity, and landlords (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.

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). 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.[22] Given that jurisdictional rights lasted until the 19th century, this mechanism of persistence also helps explain the long-term effect of the initial frontier conditions.[23]

5.3 Discontinuity in settlement patterns vs population density

While the evidence for the existence of a discontinuity in settlement patterns and population concentration is fairly robust, this does not seem to be the case for population

[22] 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.

[23] 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).

density. My interpretation is that the effect of frontier warfare has been more persistent in the settlement structure of the territory than in the amount of population living in each place. This is because the former is very difficult to alter once it is created while there are many factors that can influence the latter. To further explore this issue, I have created indicators of population density from the 1528 and 1787 censuses and checked whether there exists a discontinuity in these periods. The results, reported in Table 7, show that the existence of a discontinuity is more robust in 1528 than in 1787 and 2011, which is consistent with my interpretation of an effect on population density vanishing over time.[24] Therefore, frontier warfare appears to have an effect on population density, settlement density and population concentration, although the effect on population density is less persistent.[25]

5.4 Framing within the literature on the legacy of military conflicts

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).[26] 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 tends to persist over time. Relatedly, the type of warfare in frontier areas is that of territorial expansion, and medieval

[24] The comparison of the baseline results (Table 2-Panel E) with these historical indicators of population density must be done cautiously because the methodology for their construction is different. Data is aggregated at the municipality level and then imputed to each grid cell. In addition, the 1528 Census does not provide the number of inhabitants but the number of taxpayers (*pecheros*).

[25] Notwithstanding the foregoing, the less robust results found for population density in Tables 2 and 3 are largely driven by four observations with a value of zero in population. Given that the existence of "empty grid-cells" can be, at least partially, the result of the historical process studied here, I have preferred to keep them in the main analysis. For the sake of completeness, Appendix 6 replicates Tables 2 and 3 excluding these four observations. When doing so, the coefficients for population density are much more robust. However, the RD figures reported there (Figure A2) show again absence of a clear discontinuity in this variable. All in all, it can be concluded that historical frontier warfare has affected both population and settlement density, although the effect on population density is less robust. The latter is arguably because the persistence of the effect is higher on settlement density than on population density.

[26] 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.* (2019) 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).

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.[27]

6 Conclusions

This article shows that historical frontiers can shape the economic geography of countries. I focus on Medieval Spain to explore how frontier insecurity can condition the occupation of the territory. I put forward the hypothesis that frontier warfare favors a colonization of the territory characterized by low settlement and population density and high population concentration. First, it is discussed that 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. Second, standard regression analysis and spatial regression discontinuity techniques provide support for the frontier warfare hypothesis by revealing a sharp jump in settlement density and population concentration across the River Tagus.

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. Regarding the link between frontier warfare and population density, the evidence in favor of a discontinuity is less clear cut. I argue that this is because the effect of frontier warfare has been less persistent on population density than on the settlement structure of the territory. Consistent with this view, I show that a clear discontinuity in population density existed in the 16th century but has weakened over time.

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

[27] 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.

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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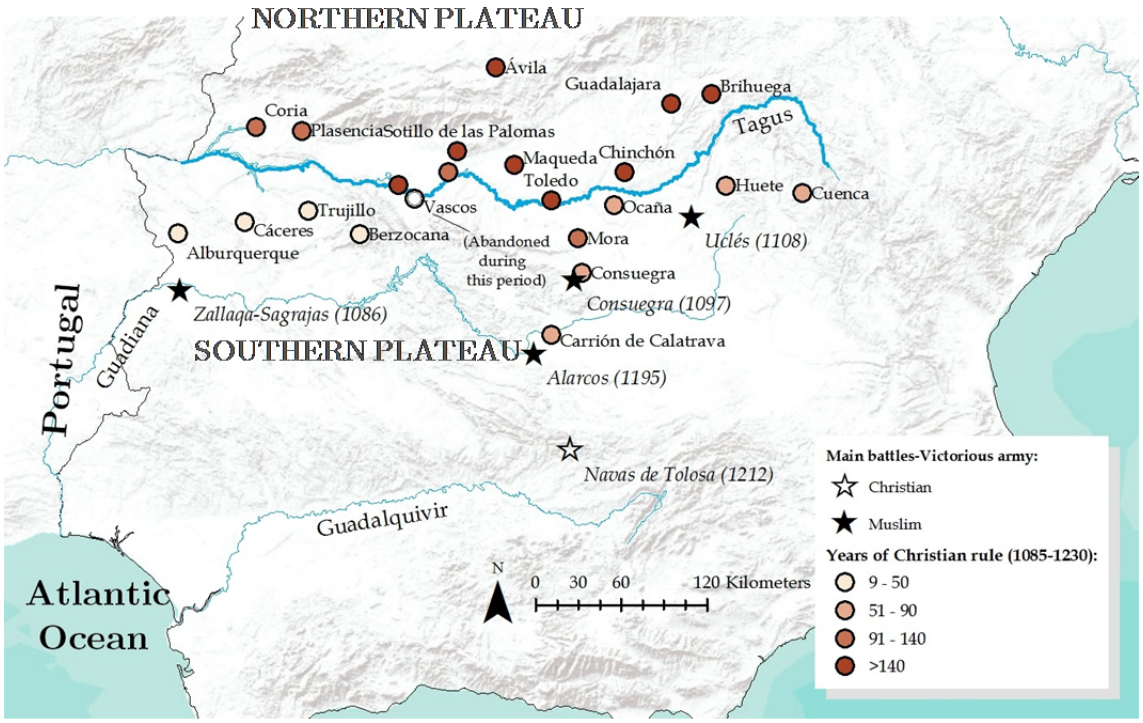

Figure 1. Instability around the Tagus between 1085 and 1230

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.

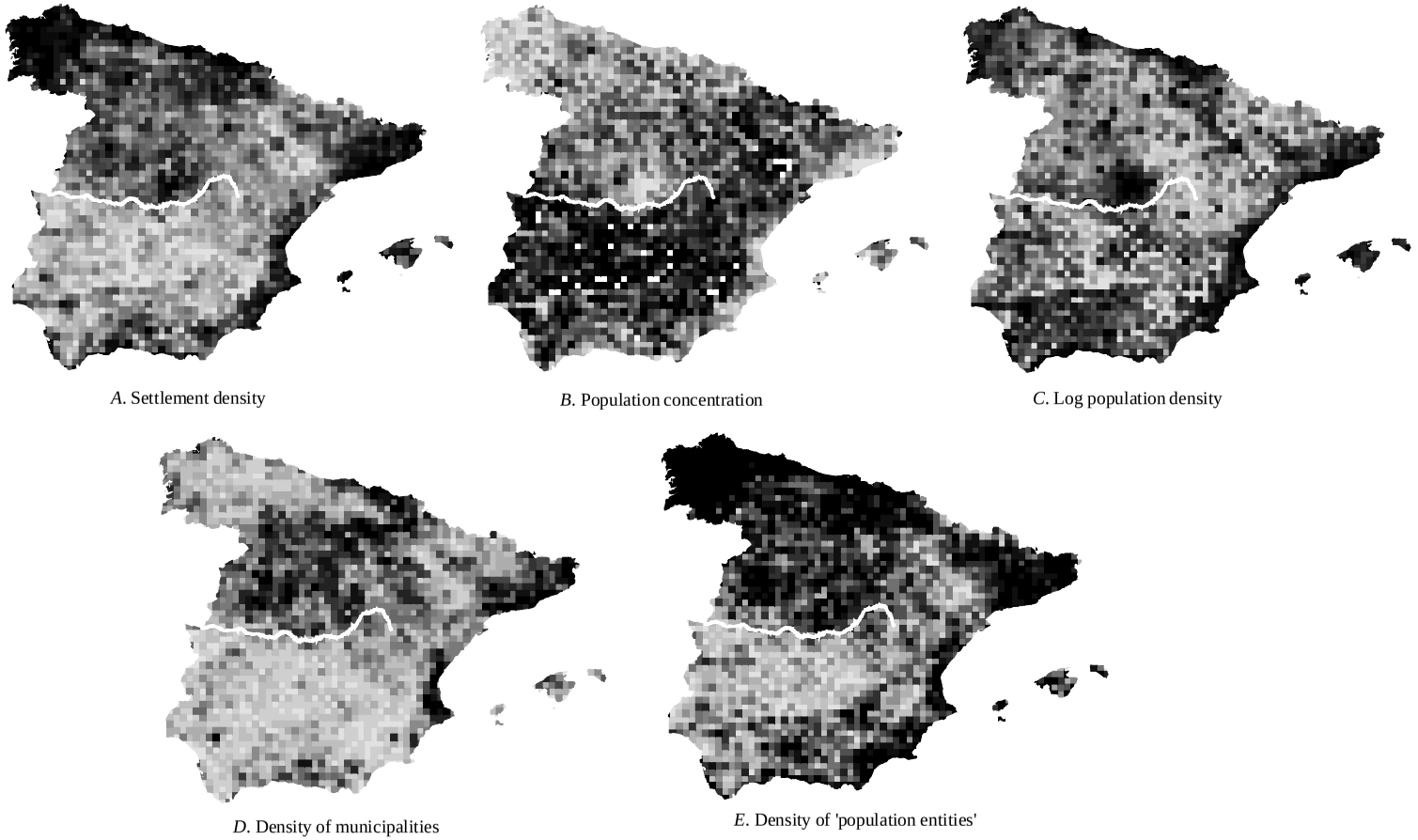

Figure 2. The spatial distribution of the population in Spain

Note: A darker color indicates a higher value. The River Tagus is highlighted in white. For space considerations, the Canary Islands are excluded.White pixels surrounded by dark ones in Map B correspond to missing values (grid-cells without population).

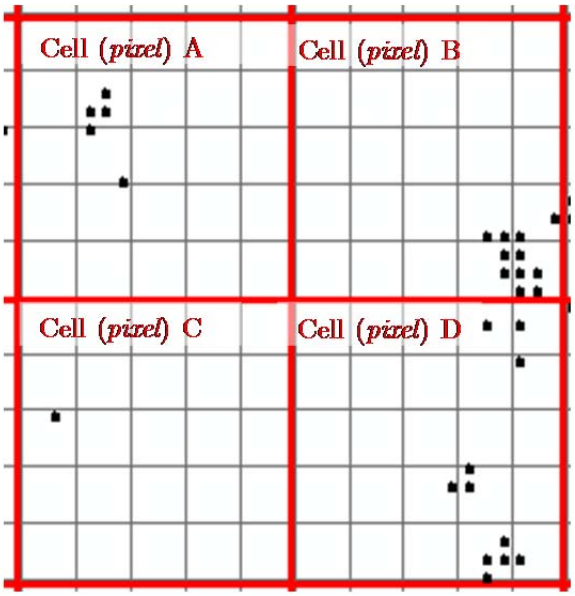

Figure 3. Example of the construction of the indicator of settlement density

Notes: The figure illustrates the construction of the indicator of settlement density. There are three layers of data: i) a grid of 250-km^2 cells, which are called in the text *pixel units* (red lines), ii) a grid of 10-km^2 cells (black lines), and iii) the GEOSTAT 1-km^2 population grid (black dots). The value of the indicator is 8 for cell A (i.e., 2 populated 10-km^2 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).

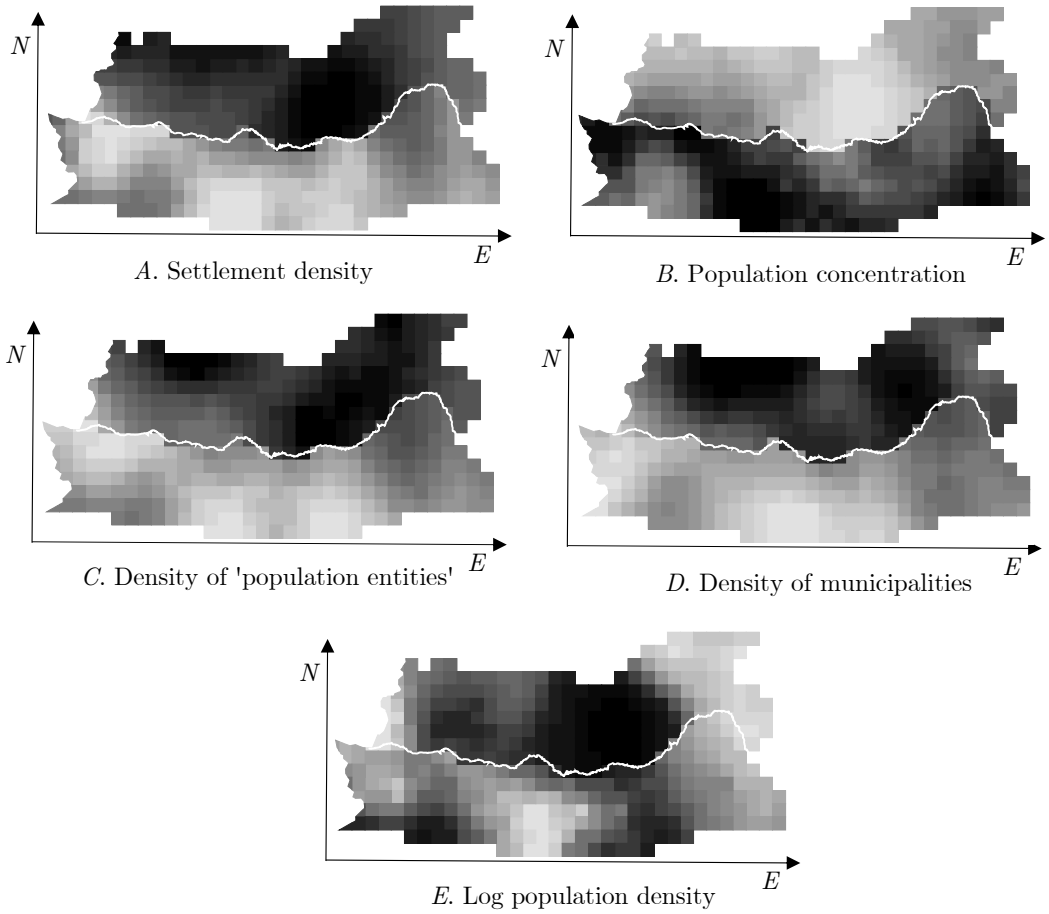

Figure 4. Spatial smoothing in settlement and population patterns

Note: A darker color indicates a higher value. Spatial weighted averages are calculated separately on both sides of the Tagus where weights depend inversely on distance until a threshold of 50 km. The local value's weight is at least 10% and cannot be lower than any of the other weights. The sample is restricted to grid cells within a distance of 100 km from the Tagus.

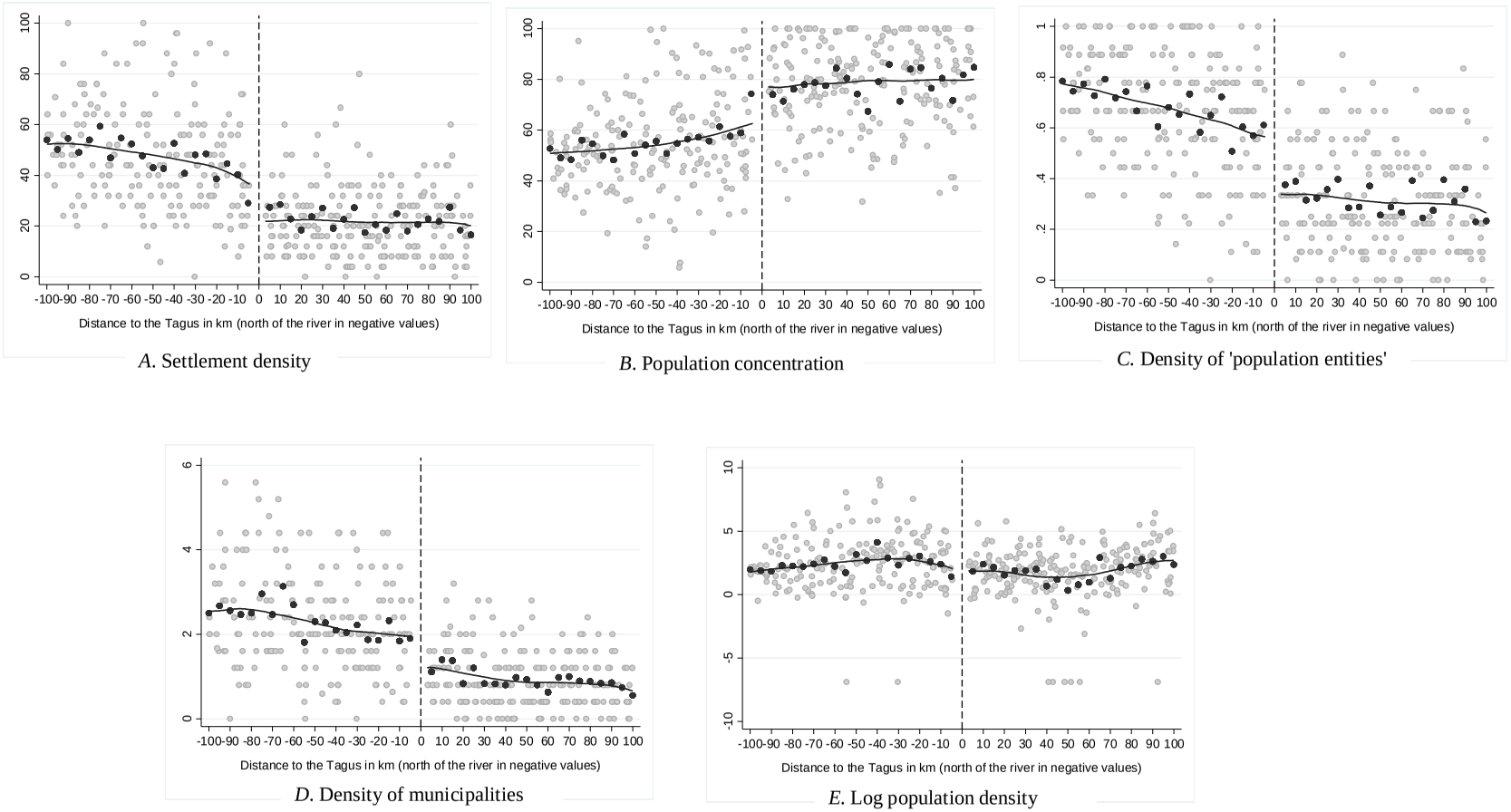

Figure 5. One-dimensional RD figures showing the discontinuity at the River Tagus

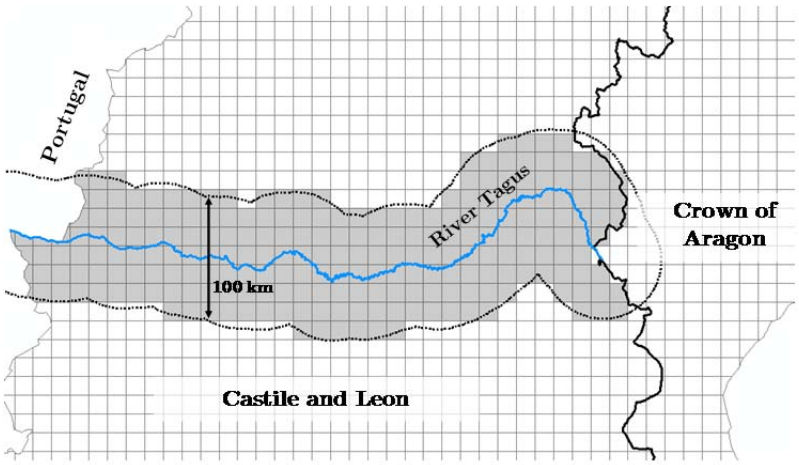

Figure 6. Area of study

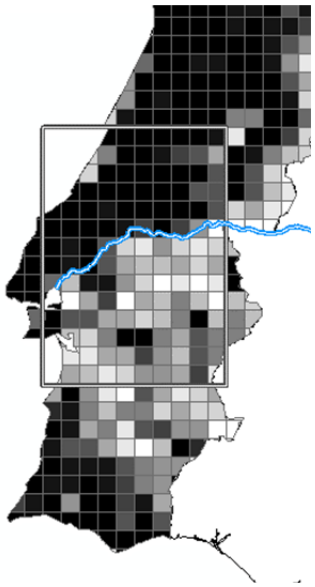

Figure 7. Discontinuity across the Tagus River in Portugal

Note: A darker color indicates higher settlement density.

Table 1

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	0.324	0.678	-28.172	-18.35	-0.078	-23.009	-0.006	2.675
(high military insecurity)	(0.263)	(0.65)	(91.66)	(19.344)	(0.305)	(18.727)	(0.006)	(5.744)
R-sq	0.03	0.02	0.00	0.02	0.00	0.04	0.00	0.00
Obs	209	209	209	209	207	209	208	209

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,

Table 2

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	-25.165***	-24.601***	-16.273***	-21.056***
military insecurity)	(6.241)	(6.155)	(3.923)	(4.04)
Standardized coefficient	-0.612	-0.598	-0.396	-0.512
R-squared	0.43	0.44	0.55	0.53
Observations	209	209	209	209
Panel B: Population concentration				
South of the Tagus (high	23.881***	23.669***	16.026***	19.751***
military insecurity)	(5.437)	(5.3)	(3.773)	(3.17)
Standardized coefficient	0.565	0.56	0.379	0.468
R-squared	0.38	0.38	0.45	0.45
Observations	205	205	205	205
Panel C: Density of 'population entities'				
South of the Tagus (high	-0.284***	-0.281***	-0.202***	-0.224***
military insecurity)	(0.065)	(0.066)	(0.048)	(0.051)
Standardized coefficient	-0.52	-0.515	-0.371	-0.412
R-squared	0.55	0.55	0.59	0.60
Observations	208	208	208	208
Panel D: Density of municipalities				
South of the Tagus (high	-0.844***	-0.874***	-0.584***	-0.68***
military insecurity)	(0.176)	(0.186)	(0.191)	(0.181)
Standardized coefficient	-0.412	-0.427	-0.285	-0.332
R-squared	0.41	0.42	0.45	0.47
Observations	209	209	209	209
Panel E : Population density				
South of the Tagus (high	-1.367**	-1.363***	-0.359	-0.875*
military insecurity)	(0.535)	(0.491)	(0.526)	(0.483)
Standardized coefficient	-0.312	-0.311	-0.082	-0.199
R-squared	0.29	0.29	0.38	0.38
Observations	209	209	209	209
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 3

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	-24.577***	-16.847***	-17.662***	-40.337***	-17.866***
military insecurity)	(6.193)	(4.828)	(4.091)	(6.577)	(4.818)
Standardized coefficient	-0.598	-0.41	-0.429	-0.981	-0.434
R-squared	0.44	0.45	0.48	0.55	0.46
Observations	209	209	209	209	209
Panel B: Population concentration					
South of the Tagus (high	23.671***	15.981***	17.241***	33.147***	17.356***
military insecurity)	(5.292)	(4.031)	(3.738)	(6.012)	(3.914)
Standardized coefficient	0.56	0.378	0.408	0.785	0.411
R-squared	0.38	0.39	0.41	0.44	0.40
Observations	205	205	205	205	205
Panel C: Density of 'population entities'					
South of the Tagus (high	-0.281***	-0.184***	-0.21***	-0.439***	-0.191***
military insecurity)	(0.066)	(0.065)	(0.051)	(0.073)	(0.06)
Standardized coefficient	-0.515	-0.337	-0.386	-0.807	-0.35
R-squared	0.55	0.56	0.57	0.61	0.57
Observations	208	208	208	208	208
Panel D: Density of municipalities					
South of the Tagus (high	-0.874***	-0.649***	-0.619***	-1.297***	-0.611***
military insecurity)	(0.186)	(0.243)	(0.182)	(0.233)	(0.218)
Standardized coefficient	-0.427	-0.317	-0.302	-0.634	-0.298
R-squared	0.42	0.42	0.43	0.45	0.43
Observations	209	209	209	209	209
Panel E : Population density					
South of the Tagus (high	-1.358***	0.126	-0.46	-1.813**	-0.706
military insecurity)	(0.495)	(0.536)	(0.547)	(0.723)	(0.612)
Standardized coefficient	-0.31	0.029	-0.105	-0.413	-0.161
R-squared	0.29	0.33	0.34	0.37	0.32
Observations	209	209	209	209	209
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 4

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 5

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)	-0.015***	-0.015***	-0.011***	-0.005^{+}
	(0.003)	(0.003)	(0.004)	(0.003)
Standardized coefficient	-0.467	-0.465	-0.356	-0.18
R-squared	0.58	0.58	0.60	0.65
Observations	209	209	209	209
Panel B: Census of "Floridablanca" (1787)				
South of the Tagus (high military insecurity)	-0.013***	-0.013***	-0.009***	-0.006**
	(0.003)	(0.003)	(0.003)	(0.003)
Standardized coefficient	-0.463	-0.46	-0.315	-0.208
R-squared	0.65	0.65	0.68	0.71
Observations	209	209	209	209
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 11, 10, 5 and 1% level, respectively.

Table 6

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: Labor units per hectare				
South of the Tagus (high	-0.609***	-0.587***	-0.597***	-0.542***
military insecurity)	(0.143)	(0.141)	(0.178)	(0.153)
Standardized coefficient	-0.41	-0.395	-0.402	-0.365
R-squared	0.64	0.65	0.65	0.72
Observations	209	209	209	209
Panel B: Gross margin per hectare				
South of the Tagus (high	-0.544***	-0.544***	-0.503***	-0.514***
military insecurity)	(0.086)	(0.082)	(0.106)	(0.118)
Standardized coefficient	-0.623	-0.623	-0.576	-0.588
R-squared	0.49	0.50	0.49	0.50
Observations	209	209	209	209
Panel C: Log light density at night				
South of the Tagus (high	-1.369***	-1.358***	-0.643*	-1.039***
military insecurity)	(0.278)	(0.253)	(0.365)	(0.361)
Standardized coefficient	-0.403	-0.399	-0.189	-0.306
R-squared	0.46	0.46	0.52	0.53
Observations	209	209	209	209
Panel D: Average socioeconomic condition				
South of the Tagus (high	-0.087***	-0.084***	-0.052***	-0.054***
military insecurity)	(0.022)	(0.021)	(0.017)	(0.02)
Standardized coefficient	-0.549	-0.534	-0.328	-0.341
R-squared	0.51	0.51	0.59	0.58
Observations	209	209	209	209
Panel E: Average number of vehicles per household				
South of the Tagus (high	-0.161***	-0.15***	-0.111***	-0.153***
military insecurity)	(0.043)	(0.044)	(0.031)	(0.034)
Standardized coefficient	-0.488	-0.454	-0.337	-0.464
R-squared	0.46	0.48	0.53	0.47
Observations	209	209	209	209
Panel F: Labor force activity rate				
South of the Tagus (high	-3.239***	-3.225***	-2.285**	-2.1**
military insecurity)	(1.028)	(0.987)	(1.077)	(1.052)
Standardized coefficient	-0.471	-0.469	-0.332	-0.305
R-squared	0.27	0.27	0.30	0.32
Observations	209	209	209	209
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 7

Historical indicators of population 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: Log population density in 2011 (as in Table 2)				
South of the Tagus (high military insecurity)	-1.367**	-1.363***	-0.359	-0.875*
	(0.535)	(0.491)	(0.526)	(0.483)
Standardized coefficient	-0.312	-0.311	-0.082	-0.199
R-squared	0.29	0.29	0.38	0.38
Observations	209	209	209	209
Panel B: Log population density in 1787				
South of the Tagus (high military insecurity)	-0.526***	-0.535***	-0.253	-0.274*
	(0.139)	(0.131)	(0.166)	(0.145)
Standardized coefficient	-0.391	-0.398	-0.188	-0.204
R-squared	0.42	0.42	0.48	0.51
Observations	209	209	209	209
Panel C: Taxpayers density in 1528				
South of the Tagus (high military insecurity)	-1.417***	-1.433***	-0.683**	-1.129***
	(0.329)	(0.336)	(0.284)	(0.299)
Standardized coefficient	-0.55	-0.556	-0.265	-0.438
R-squared	0.43	0.43	0.53	0.51
Observations	209	209	209	209
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.