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Poor Institutions, Rich Mines: Resource Curse and the Origins of the Sicilian Mafia *

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Abstract

This study explains the emergence of the Sicilian mafia in the XIX century as the product of the interaction between natural resource abundance and weak institutions. We advance the hypothesis that the mafia emerged after the collapse of the Bourbon Kingdom in a context characterized by a severe lack of state property-right enforcement in response to the rising demand for the protection of sulfur - Sicily's most valuable export commodity - whose demand in the international markets was soaring at the time. We test this hypothesis combining data on the early presence of the mafia and on the distribution of sulfur reserves across Sicilian municipalities and find evidence of a positive and significant effect of sulphur availability on mafia's diffusion. These results remain unchanged when including department fixed-effects and various geographical and historical controls, when controlling for spatial correlation, and when comparing pairs of neighboring municipalities with and without sulfur.

Keywords: Natural Resource Curse, Weak Institutions, Mafia-type Organizations
JEL code: K42, N33, N54, 013, 043

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1 Introduction

A large literature in economics and political science has investigated the effect of natural resources on political and economic development (Sachs and Warner, 1995, 2001; Mehlum et al., 2006a,b; Haber and Menaldo, 2011). These studies have delivered rather mixed results, and a general consensus has not emerged on whether, ultimately, resource abundance should be viewed as a "blessing" or as a "curse".[1] But which factors explain why the discovery of valuable resources leads to desirable outcomes in some countries (e.g. Norway, Australia) and deleterious ones in others (e.g. Nigeria, Zimbabwe)? The quality of pre-existing political and legal institutions is arguably important: when institutions are dysfunctional, conflict over access to resource rents is likely to escalate, giving rise to increased corruption, rent-seeking, and even violence (Skaperdas, 2002; Collier and Hoeffler, 2002). Similarly, the literature on organized crime (Gambetta, 1993; Konrad and Skaperdas, 2012) has argued that the combination of weak institutions and resource abundance can be conducive to the emergence of mafia-type organizations which can have profound and long-lasting effect on a country's economic prospects.

The profound socio-economic consequences of organized crime has been a subject of growing interest among academics and policy-makers alike (Jennings, 1984; Fiorentini and Peltzman, 1997; Skaperdas, 2001). Research on the topic has focused, in particular, on the study of mafia-type organizations operating in various parts of the world.[2] While these contributions have expanded our knowledge of the nature and structure of such organizations, their economic origins remain largely unexplored.

Our paper attempts to fill this gap advancing the hypothesis that mafias - which following Gambetta (1993) we conceptualize as providers of private protection - emerge to protect valuable natural resources when public law-enforcement institutions are weak or absent. While this argument is applicable to a broad range of examples, our empirical analysis focuses on the particular case of the Sicilian mafia, the oldest and most notorious example of this sort of organizations which dates back to the XIX century and which has had a considerable and long-lasting effect on Sicily's socio-economic development.[3] More specifically, we argue that the Sicilian mafia emerged after the demise of feudalism and the collapse of the Bourbon Kingdom in a context characterized by a severe lack of state property-right enforcement in response to the rising demand for the protection of sulfur - one of Sicily's most valuable export commodity - whose demand in the international markets was soaring at the time. Such positive shock to the value of sulfur protection favored Mafia's emergence in areas endowed with sulfur reserves, naturally more prone to its production and commercialization.

To test this hypothesis we employ a comprehensive dataset which combines various measures of early mafia's diffusion across Sicilian municipalities with detailed information on natural resource endowments and a range of other geographical characteristics. Our identification strategy exploits exogenous differences in the geographic distribution of sulfur reserves, which exposed ex-ante similar Sicilian municipalities to an asymmetric shock to the value of protection, which lasted for most of the XIX century.

[1] See Frankel (2010) for a comprehensive survey on the topic.

[2] Relevant contributions on mafia-type organizations by sociologists include Gambetta's seminal work on the Sicilian mafia (1993), Varese's studies of the Russian mafia (2005), and of the Japanese Yacuza. Recent contributions by economists have looked the economic impact of the Sicilian mafia (Pinotti, 2011) and the workings of criminal networks in the context of the American mafia (Mastrobuoni and Patacchini, 2011).

[3] Lupo (1993) and Dickie (2004) provide an excellent account of the history of the Sicilian mafia and of its expansion to other regions of Italy and to the United States.

While documenting the magnitude of the shock and defending the exogeneity of its distribution is relatively straightforward, establishing that municipalities that experienced such a shock were ex-ante similar to those that did not is a more demanding task. One crucial difficulty lies in excluding that differences in the availability of natural resources are correlated to differences in other dimensions (e.g. institutional quality), which may affect mafia's emergence through other channels. To address this concern, we pursue several strategies. First, we document that differences in sulfur reserves are not correlated with population growth rates in previous centuries. Since in the context of a Malthusian regime population represents a good indicator of the degree of economic development, this is indicative of the fact that sulfur played no special economic role prior to the XIX century. Second, in our econometric analysis we control for a wide range of observables that are likely to be correlated with institutional quality, economic activity and geographic and demographic differences. Third, in all our specifications we include area fixed effects, which allows us to identify our main effect from variations in sulfur endowment within small areas, which are plausibly homogeneous along several non-observable dimensions. Finally, following Acemoglu et al. (2012), we perform additional tests of our hypothesis based on the comparison of pairs of neighboring municipalities with different sulfur endowment. Furthermore, to account for possible spatial correlation in mafia's emergence, we replicate our analysis using spatial regression methods.[4]

Our empirical findings provide strong support for our main hypothesis. In particular, we find that sulfur availability has a positive large and significant effect on early incidence of mafia activities. Our findings are robust to the use of different measures of early mafia incidence, to the introduction of a number of geographical and socio-economic controls, and to the use of the complementary approaches discussed above. We also discuss and test alternative explanations of the emergence of the Sicilian mafia proposed in the literature - such as the key role played by citrus production - which, however, do not appear to find support in the data. Although the focus of our analysis is on the emergence of the mafia, in the last part of the paper we also document the existence of a strong correlation between historical and current presence of the mafia, and discuss the possibility of using sulfur availability as an instrument for the latter.

Although specific to the case of the Sicilian mafia, we believe that our findings can be helpful to inform our understanding of the rise of mafia-type organizations in various different parts of the world, where similar economic and institutional conditions may have occurred.[5]"

The remainder of the paper is organized as follows. Section 2 illustrates our theoretical framework and relates our work to the literature on mafia-type organizations and resource curse. In section 3 we discuss the socio-economic and political conditions of XIX century Sicily that favored the emergence of the mafia, with particular regard for the collapse of the Bourbon regime and the upsurge in sulfur's value. In section 4 we present the data used in the empirical analysis, while in section 5 we describe our empirical strategy and discuss our findings. Section 6 concludes.

[4] Acemoglu et al. (2012) employ this strategy to estimate the effect of gold-mines-related slavery in Colombia. One advantage of our application is that we do not have to worry about the endogeneity of slavery, since we are directly interested in the effect of natural resources.

[5] It is the case, for example, of Yakuza in Japan, the Triad in Hong Kong and the Russian mafia. Indeed, Yakuza had its origins after the demise of the feudal system in Japan, while the Russian mafia after the dissolution of the USSR.

2 On mafia and resource curse

Various theoretical approaches have been proposed in the literature to study the structure and functioning of mafia-type organizations (see Fiorentini and Peltzman, 1997 and Anderson and Bandiera, 2005 among others). It is hence important to immediately clarify what is the working definition of mafia we refer to. Following Gambetta's seminal contribution (1993), we conceptualize the mafia as an industry for private protection; in this framework the equilibrium level of mafia's activity is determined by the interaction between demand and supply of protection services by private providers since public provision is lacking or greatly ineffective.

Our research relates to the vast literature on the socio-political impact of natural resources. This literature has discussed various mechanisms through which resource abundance may ultimately be regarded as a "curse": vast resources may fuel violence, theft and looting (Skaperdas, 2002), they may be used to finance rebel groups, warlords or civil wars (Collier and Hoeffler, 2002), or may favor the emergence of criminal organizations aiming to extract part of the wealth derived from their exploitation. Although some evidence suggests that resource-rich countries display worse economic performance than resource-poor ones (Sachs and Warner, 1995, 2001), no unanimous consensus on this matter has emerged (see for example Haber and Menaldo, 2011). In fact, as some observers have pointed out, whether natural resources may result in a "curse" or a "blessing" may crucially depend on a country's institutional quality (Mehlum et al., 2006a,b).[6] In the presence of weak institutions, our argument goes, natural resources are particularly vulnerable to predatory attacks; in this context, the (illegal) use of violence provides mafia-type criminal organizations with a competitive advantage in the supply of protection and extortion (Gambetta, 1993; Konrad and Skaperdas, 2012), resulting in the capacity to extract a substantial portion of natural-resource-based rents.

This research integrates two previous econometric studies that have looked at the historical emergence of the Sicilian mafia. The first one, by Bandiera (2003), uses a common agency model to formalize the idea that the mafia should have been historically more active in towns were land was more fragmented,[7] and finds support for this hypothesis using qualitative data from the 1885 parliamentary survey (Damiani, 1885) on 70 districts (*mandamenti*) in western Sicily. [8] The second one, by Pazzona (2010), expands Bandiera's sample to 160 observations, documenting that the mafia was more likely to emerge where the competition by new social actors was harsher, particularly in areas where land value was higher and land holdings larger, at the opposite of what Bandiera (2003) finds. We improve upon these contributions by expanding the scope of the analysis to a much larger and more detailed set of geographical units covering the entire island; this allows us to investigate the large differences in the incidence of the mafia across Sicilian areas, which is considered one of the most puzzling question about the history of the Sicilian mafia.[9]

[6]Institutional quality may, in turn, depends on features as diverse as geographic isolation, ethnic divisions, or state collapse (Skaperdas, 2011).

[7]The argument is based on the idea that the purchase of protection from a single landowner imposes a negative externality on the other ones (since it deflects thieves on their properties), and that, hence, landlords will be competing with each other to acquire protection and to exclude others from it. By increasing the number of competing landlords, land fragmentation should increase mafia's potential profits.

[8]We present and discuss in detail in the data section the parliamentary survey employed by Bandiera (2003) and the administrative jurisdictions in XIX century Sicily.

[9]This aspect has been discussed by historians, sociologists and economists alike. Some examples include

Following the first version of this paper, two independent contributions have explored alternative explanations for the mergence of the Sicilian mafia. While Dimico et al. (2012) propose an argument similar to ours but centered around the historical role of citrus fruits, Del Monte and Pennacchio (2012) investigate the relationship between organized crime and brigandage. In our empirical section we test the robustness of our results to these alternative explanations and discuss some important data and methodological issues which, in our view, raise concern over the solidity of these studies' respective findings.

More in general, the results of this research complement the literature on the emergence of persistent social institutions as the consequence of what can be viewed as 'historical accident' (Acemoglu et al. (2001)), which in the context our our study, would be represented by the sudden rise in international demand for Sicilian sulfur. Although geographical characteristics *per se* are not the focus of our study, the findings we present can also be interpreted in the context of the debate on the long-term impact of geography on socio-economic development. Previous research has documented that the environment can influence economic performance directly, through its effect on health and agricultural productivity (Landes (1998); Sachs and Malaney (2002)), and indirectly, by setting the conditions in which social norms and political institutions have formed (Sokoloff and Engerman (2000); Easterly and Levine (2003); Durante (2009); Nunn and Puga (2012) and Michalopoulos et al. (2010)) or by defining environmental constraints to population growth (Galor and Weil (2000)). The evidence presented here suggests that, under given economic circumstances, geographic characteristics may have contributed to the emergence of particular forms of social organizations (criminal ones in this case), which have persisted over time and continue to have relevant socio-economic effects.

3 Historical background

XIX century Sicily presented the two conditions that, according to the "resource curse" argument discussed above, are conducive to mafia's emergence: poor quality of law-enforcement institutions and soaring value of domestic natural resources. In what follows we discuss some aspects of the XIX century Sicily political and socio-economic context that are relevant to our analysis, with particular regard to the main sources of institutional weakness, and the impact of growing international demand for Sicily's high-value mining and agricultural production.

3.1 Institutional weakness and economic development

Two major political transformations characterized the history of Sicily during the XIX century: the demise of feudalism in 1812, and the collapse of the Bourbon's domination in 1861. Both these events contributed to the disruption of Sicilian law enforcement institutions and the deterioration of property-rights security.

Feudal barons had long been struggling with the monarchy, which imposed on them a heavy fiscal burden, and this struggle intensified when, in 1806, in an attempt to escape from the French, the Bourbons moved from Naples to Palermo, Sicily's capital. At the beginning of the XIX century most of Sicilian municipalities were under barons' direct jurisdiction; however, most feudal lords did not reside in their lands but in Palermo, the center of the

Lupo (1993); Gambetta (1993) and Sylos Labini (2003).

island's political, economic and social life.[10] Their lands, together with their feudal rights, were generally rented out to local administrators (*gabelloti*), who were in charge of managing the landholding's productive activities and who invested their own capital in it. The abolition of feudalism represented a profound institutional change, which officially transferred all feudal jurisdictions to the State. Yet, while barons' control over their lands had been weakened, limits to the power of the monarch had also been imposed by the establishment of a parliamentary system that assigned to the Parliament - largely dominated by the barons - extensive powers of control over the King's acts (Candeloro, 1956). The power struggle between landlords and the Bourbons continued until 1861, when the kingdom collapsed and its territories were annexed to the newly formed Italian State. This institutional struggle resulted in extremely low levels of law enforcement, a situation which did not improve under the unified State.

The feudal economy was primarily agrarian, based on extensive cultivations (mainly cereals) and characterized by very low productivity and peasants's extreme poverty. The abolition of feudalism had little *de facto* impact on land distribution and did not result in increased productivity (Blok, 1966, 1969). The most valuable productions were particularly exposed to predatory attacks from local bandits (*briganti*), and the lack of law enforcement by the State triggered the demand for private forms of protection. Where this demand emerged, the supply of individuals specialized in the use of violence was abundant, and information about potential customers as well as suppliers' reputation flew quickly. In the countryside, *gabelloti* were surrounded by a number of guards, former soldiers and former convicts, all trained in the use of violence, who, formerly employed by feudal lords, were now looking for new job opportunities. Local networks of such individuals quickly emerged: extremely well informed about the local context - about potential victims of violent predation and potential perpetrators alike - they were in the position to establish a credible reputation as effective protectors. In the words of Franchetti (1876), this process led to a "democratization of violence". As the violent threats used to protect their "clients" could also be used to intimidate them, early *mafiosi* were in a position to create their own demand; as a consequence, the distinction between supply of protection and threat of extortion was generally unclear. Indeed, various forms of agreements linked *briganti* and *mafiosi*, as the latter used the threat of the former to justify the services they offered.[11]

3.2 Sulfur

The case of the sulfur industry represents one of the clearest examples of how, in the absence of effective public law-enforcement institutions, a florid market for private protection emerged. Sulfur mines were rented out and, not unusually, the right to exploit them had to be defended from violent attacks. Furthermore, once extracted, sulfur minerals - largely produced for export purposes - had to be transported to Palermo or other ports, so cargoes' safety along the way had to be ensured as well. Starting in the first decades of the XIX century, international demand for sulfur soared, as this represented a fundamental intermediary input for industrial

[10]The port of Palermo was by far the more trafficked in the Island. In 1838, on a total of 480 Sicilian merchant vessels that left for foreign ports, 240 were from Palermo, while only 65 from Messina, the second port in order of importance (Petino, 1958).

[11]Moreover, private protection exerts negative externalities on those who are not protected, since it deflects the threats toward them, as in Bandiera (2003). This is another way in which supply creates its own demand.

and chemical productions, which were quickly expanding both in Britain and France.[12] For all of the XIX century and during the first decade of the XX century, Sicily represented the world's largest sulfur producer, accounting for up to 83% of world sulfur production in 1893.[13]

The increase in international demand for sulfur determined an increase in the value of its protection favoring mafia's emergence. To identify this effect, our empirical analysis exploits exogenous variations in the availability of sulfur across Sicilian municipalities. It is worth to stress that Sicilian sulfur was mainly superficial (Squarzina, 1963; Cancila, 1995) and hence no considerable investments were required to find and extract it, so the information on the presence of sulfur mines proxies very well the presence of sulfur itself. Key to our identification strategy is the assumption that the presence of sulfur reserves was unimportant for local economic activity prior to the XIX century. Available evidence on Sicily's sulfur export is consistent with this view: as shown in figure 1 Sicilian sulfur exports, virtually negligible at the beginning of the XIX century, exceeded 500 thousands tons by the beginning of the XX, accounting for about 6% of Sicilian GDP. Export growth was especially marked during the years comprised between the 1830s and the 1850s when it reached an astonishing 9% annual rate.[14] All these factors contributed to increase sulfur producers' demand for protection both around the mines and along the routes connecting these to the main ports.

Not surprisingly, the *Brotherhood of Favara*, the first documented mafia-type criminal organization, was discovered in 1883 in the heart of sulfur-producing Sicily (see Dickie, 2004). The discovery of this organization led to the arrest of more than 200 affiliated (on a total of more than 500 arrested), 107 of whom were convicted in the following trial. Of these 107, 72 were workers, at different layers, of the sulfur industry, coming from two rival factions, which found in the *Brotherhood* a way to achieve power in the market of protection in the context of sulfur extraction.

It is important to mention that the export of Sicilian sulfur rapidly declined over the first part of the XX century; this was mainly due to the development of new extraction technologies which made it cheaper to exploit previously untapped deep reserves in other parts of the world, thus reducing the comparative advantage of Sicilian superficial sulfur mines.

3.3 Citrus fruits

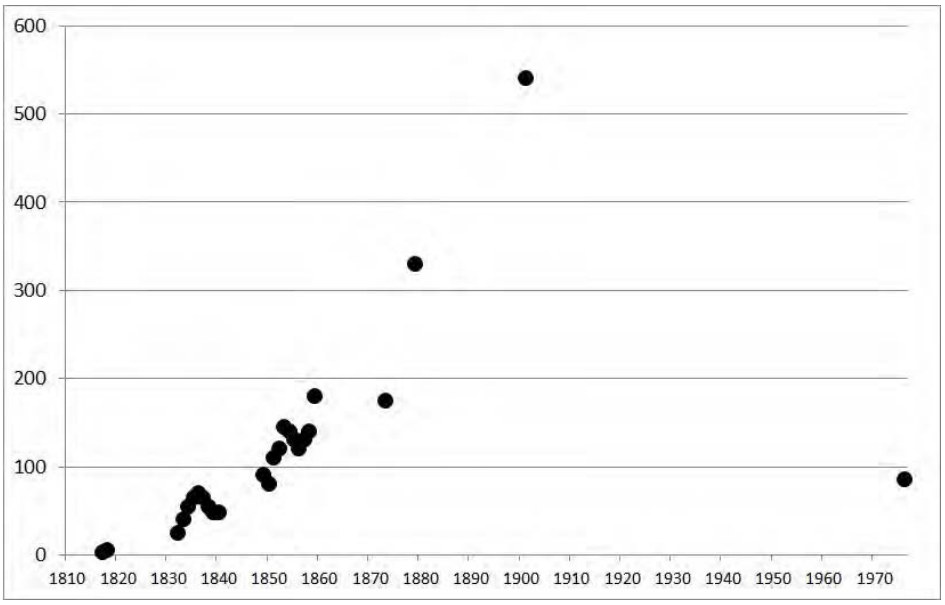
Some historians and commentators have advanced the hypothesis that the development of the citrus industry - which also took place in the XIX century - also played an important role in favoring the emergence of the Sicilian mafia, especially in the area around Palermo. As Dickie (2004) points out: "In 1834, over 400,000 cases of lemons were exported. By 1850, it was 750,000. In the mid-1880s an astonishing 2.5 million cases of Italian citrus fruit arrived in New York every year, most of them from Palermo". Indeed, the evolution of international demand for citrus fruits resembles that of sulfur, although the time pattern for citrus is less

[12] In 1855 over 70% of Sicilian sulfur was exported to France and Great Britain (Squarzina, 1963). Sulfur is the base of oil of vitriol, and of almost all the acids and alkalis which are extensively used in various manufacturing processes. It is also required for the manufacture of gunpowder as well as for the production of various medicines (Rawson, 1840). Even if industrial substitutes for sulfur have been discovered and developed since the late 1840s, the use of sulfur gained again momentum because of its use in grape cultivation as a fungicide. Still in 1940 sulfur accounted for 20% of Sicily's total export value (Pescosolido, 2010).

[13] Sicilian sulfur production and export almost coincided since, throughout the XIX century, virtually no sulfur-intensive industries were active in the region, letting aside its use in grape cultivation.

[14] We focus on export volumes because, around the 1830s, prices experienced considerable fluctuations due to the establishment and the subsequent dissolution of a monopoly (they remained relatively stable afterwards).

Figure 1: Export of Sicilian sulfur

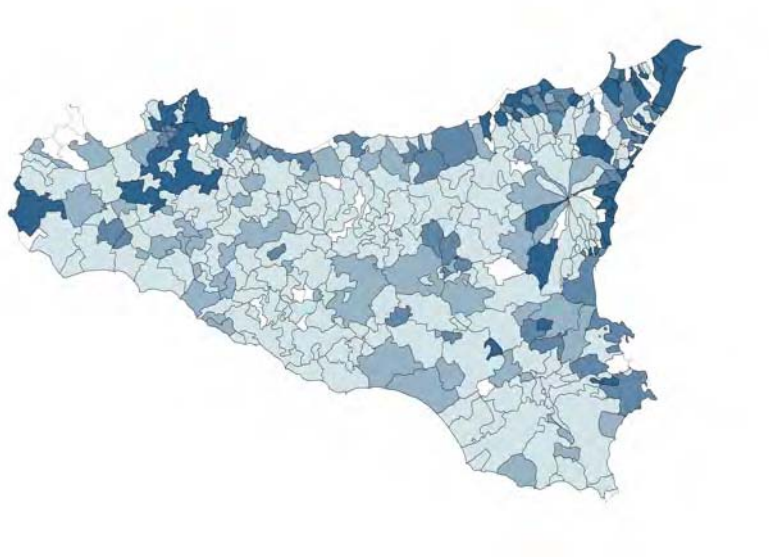


Note: Thousands of tons of sulfur exported from Sicily. Sources: Squarzina (1963) and Cancila (1995).

clear than for sulfur and Sicily was never a quasi-monopolist in the market for citrus fruits as it was in the sulfur market. Although citrus fruits cultivations were especially concentrated in the areas areas around Palermo and the surrounding Conca d'Oro where early mafia's presence was considerable, as reported in the 1885 parliamentary enquiry (Damiani, 1885) and depicted in figure 2, the cultivation of citrus was similarly widespread in the eastern part of Sicily, where the mafia remained virtually absent until the second part of the XX century. One possibly insightful way to empirically investigate this rather puzzling issue is to look at the distribution of the inputs employed in citrus cultivation: land and water. While Sicily's climatic conditions and soil composition are generally favorable to the cultivation of citrus fruits - particularly in coastal areas - such cultivation requires abundant and regular availability of water which, instead, tends to vary substantially across different areas of Sicily. Indeed, underground water basins tend to be scarcer in the Western part of Sicily, so that in this areas the provision of water to cultivated areas crucially depends on superficial water channels, which have historically been easily controllable by the mafia. As a result, the extortion power over citrus producers, and hence the possibility to appropriate rents from citrus cultivation, could be expected to be higher in Western than in Eastern Sicily. Indeed, most water guards in the second half of the XIX century were related to the mafia and not surprisingly, the first known mafia-related murder was that of a water guard, who was killed in 1874 in the context of the fight between different mafia families over water control (Cutrera, 1900).[15]

[15]All the other competing explanations of mafia activity (including, among others, land fragmentation, ruggedness and population density) will be discussed in the next section.

Figure 2: Citrus cultivation



Note: Share of land cultivated with citrus fruits over total cultivated land, by quintiles of the distribution. Darker shades represent higher shares. Missing values are represented in white. Source: Damiani (1885)

4 Data

To test the main predictions of our theoretical argument, we look at differences across Sicilian municipalities. To do so, we use historical data on the presence of the mafia and on the availability of sulphur in the late XIX century, as well as data on a wide range of geographical and historical controls. In what follows we describe the data sources and discuss how the variables used in the empirical analysis are constructed.

4.1 Mafia

Our primary source of data on the early diffusion of the mafia in Sicily is represented by the work of Cutrera (1900). Former law-enforcement official and one of the major experts of the phenomenon of the time, Cutrera collected detailed information on the intensity of the activity of the mafia in 285 Sicilian municipalities in the last decades of the XIX century. In particular, for each municipality, Cutrera assessed the intensity of mafia activity on a four-point scale ranging from none, to low, intermediate and high. Cutrera's data have been extensively used in previous historical and sociological studies on the Sicilian mafia, including Gambetta's seminal contribution (1993). An alternative source of information on the early incidence of mafia activity is represented by the Damiani-Jacini parliamentary enquiry (Damiani, 1885).[16] This was part of a nation-wide inquiry conducted between 1881 and 1885 with the primary aim of collecting information on the conditions of the peasantry

[16] An additional source is the Borsani-Bonfadini parliamentary enquiry on the conditions of Sicily conducted between 1874 and 1876. However, this inquiry only reports the 43 municipalities (out of 357) in which the mafia appears to be more widespread. Given its limited scope, we do not use these data in our empirical analysis.

under the newly unified state.[17] In addition to extensive municipal-level information on a variety of agriculture-related variables, the Damiani-Jacini inquiry contains information on the intensity of mafia activity in 158 Sicilian districts (*mandamenti*).[18] This information was collected through a questionnaire transmitted to lower court magistrates (*pretori*) who were asked to assess the intensity of the activity of the mafia in their district of jurisdiction on a four-point scale analogous to that used by Cutrera.[19]

We believe that Cutrera's data are preferable to Damiani-Jacini's for several reasons. First, unlike Damiani-Jacini's, Cutrera's data are available at the municipal level and cover the large majority of Sicilian municipalities (about 80%), allowing for a more extensive and finer empirical assessment of the relationship between sulfur availability and early mafia activity. One important drawback of the Damiani-Jacini's data is that the reported level of mafia activity is solely based on the subjective assessment of respondents and is therefore susceptible to differences in the evaluation criteria adopted by local officials. Actual unawareness, fear of retaliation or contiguity with the mafia would, for example, bias respondents towards underreporting the level of activity of the mafia in their jurisdiction, introducing measurement error in the measure. As discussed in Pazzona (2010), the problem would be even more severe if such factors were themselves correlated with actual mafia activity, (or to its determinants). Cutrera's measure is likely to be less vulnerable to this concern. On the one hand, there is no reason to believe Cutrera would employ different evaluation criteria when assessing the level of activity of the mafia in different municipalities. On the other hand, given his position of outside observer, it is reasonable to think that Cutrera's assessment of mafia activity would be relatively unresponsive to the specific incentives faced by local officials (and, indirectly, to the actual strength of mafiaactivity). We therefore believe that the use of Cutrera's measure would mitigate the empirical problems discussed above, although we do not claim that it eliminates them. Athough our empirical analysis will primarily rely on Cutrera's data, we will also test the robustness of our findings using the Damiani-Jacini's district-level data. In what follows, we indicate with *maf_c* and *maf_d*, the index of mafia intensity based respectively on Cutrera and Damiani-Jacini.

The geographical distribution of the Sicilian mafia in the late XIX century, based respectively on Cutrera's and Damiani-Jacini's data, is depicted in Figure 4.1. Relative to Damiani-Jacini's, Cutreras' data indicate that the mafia was more present in the Western part of the island, particularly in the areas around Palermo and Agrigento. This pattern, largely consistent with numerous reports from historians and early mafia experts (see Lupo, 1993 and Sylos Labini, 2003 among others), is further reassuring on the accuracy of Cutrera's

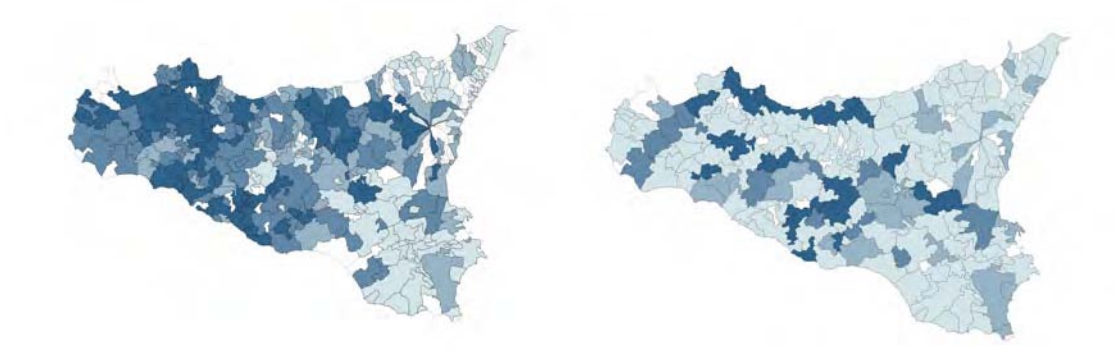
[17]The inquiry started in 1881 and was completed at the end of 1884. The main questionnaire on the conditions of the agrarian class was transmitted to all Sicilian mayors on May 20th 1883. A complete version of the questionnaire can be found at page V, volume XIII, tome II, fascicle IV of the official inquiry report.

[18]Post-unification Sicily was characterized by four levels of administrative division: the largest was the province, followed by the department (*circondario*), the district (*mandamento*), and the municipality (*comune*). Overall, Sicily was divided into 7 provinces (Caltanissetta, Catania, Girgenti, Messina, Noto, Palermo, Trapani), 24 departments, 179 districts and 357 municipalities.

[19]The jurisdiction of low court magistrates coincided with the district; hence their assessment of the activity of the mafia reported in the Damiani-Jacini inquiry has to be understood as referring to the *entire* district area, and not just to one or more municipalities within the district. This aspect has generated some confusion among users of the Damiani-Jacini's data (Bandiera, 2003; Pazzona, 2010; Dimico et al., 2012), who appear to have erroneously interpreted the information on the activity of the mafia as referring to the municipal rather than the district level. This confusion can probably be attributed to the presence, in most districts, of municipalities with the same name as the district they are part of (e.g. municipality of Messina in the district of Messina, municipality of Girgenti in the district of Girgenti, etc.).

data.[20]

Figure 3: Geographic distribution of the Sicilian mafia in the late XIX century



(a) Cutrera (b) Damiani-Jacini

The figure reports the assessment of the intensity of mafia activity according to Cutrera (left) and Damiani-Jacini (right), with darker colors indicating more intense mafia's activity (missing values are reported in white). Cutrera's data are at the municipality level while Damiani-Jacini's are at the district level. Missing values correspond to cases for which it was not possible to match historical municipalities (or districts) to current ones, e.g. for municipalities created in the XX century.

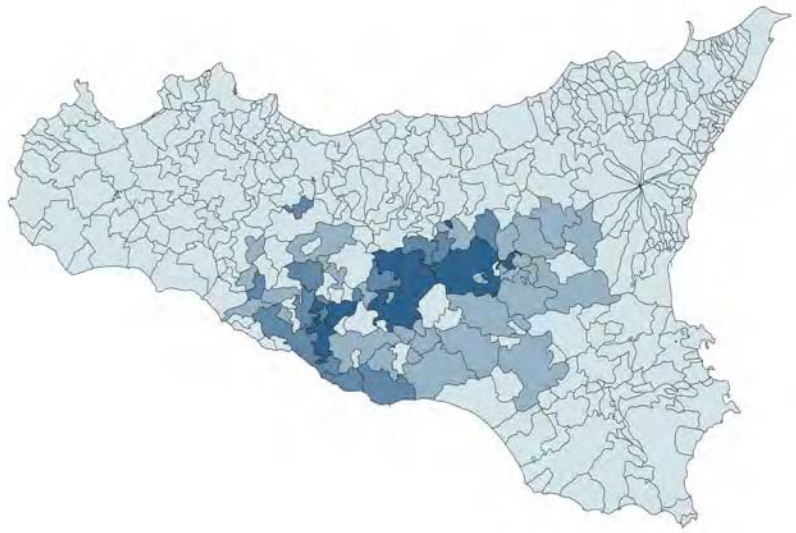
4.2 Sulfur and other geographical and historical controls

With regard to the presence of sulfur, comprehensive municipal data are available from Squarzina (1963). These include information on the number of sulfur mines in each Sicilian municipality in 1886 - that is, around the pick of Sicily's sulfur export boom. Since we are interested in gauging the original stock of sulphur available in each municipality - hence prior to the intense depletion which took place throughout the XIX century - we consider those mines that were still operating in 1886 as well as those that were already exhausted by then. It is worth emphasizing, once again, that Sicilian sulfur was generally superficial so that its extraction was relatively unchallenging and did not require considerable investments; as a consequence, at the peak of Sicily's sulfur export boom, virtually all major sulfur reserves on the island had been tapped (Squarzina, 1963). In light of this fact, the presence of sulfur mines can be considered a good proxy for the exogenous distribution of sulfur reserves, which is ultimately our variable of interest. The distribution of sulfur mines in each municipality (labeled *sulfur* henceforth), is summarized in Figure 4.2.

In our empirical analysis we control for a range of other geographical and historical variables at the municipal level. We focus, in particular, on factors that may have influenced the demand and supply of protection and, at the same time, may be correlated with the presence

[20] A visual inspection of the two maps highlights incoherent patterns in Damiani-Jacini's data, that are at odds with a diffusive process as the mafia is likely to be. Take for example the northwestern area around Palermo: Palermo and its surrounding coastal municipalities are all characterized by high mafia activity, while most of the other neighboring southern municipalities are all coded as having no mafia activity. Going further south, again many municipalities turn to be flagged as high mafia ones. Conversely, Cutrera's map shows a much smoother spatial pattern in terms of intensity of mafia activity, suggesting a more careful and homogeneous assessment of the variable.

Figure 4: Geographic distribution of Sicilian sulfur mines (1886)



The figure reports the number of sulfur mines (both active and exhausted) recorded in each Sicilian municipality in 1886 on a four-color scale: 0 (lighter gray), 1-10, 11-30, more than 30 (darker gray).

of sulfur, in order to test that sulphur availability has an independent effect on the emergence of the mafia and is not merely proxying for other characteristics.

To account for difference in topography, we control for terrain ruggedness and elevation. As discussed by Nunn and Puga (2012), in addition to its obvious effect on agricultural productivity and trade, rugged terrain - in the form of hills, caves and cliffs - provides lookout posts and hiding places for individuals trying to escape. Arguably, in the context of Sicily rugged areas provided outlaws with better protection from police forces. This view is consistent with accounts by various historians; for example, when discussing the widespread presence of the mafia in the mountainous towns of Gangi, Lupo (2004) emphasizes the importance of the town's impervious location which made it particularly difficult for law enforcement officers to establish control over the surrounding area and apprehend criminals. To account for this aspect, we include in our regressions a municipal measure of terrain ruggedness constructed from the Global Land One-km Base Elevation Project (GLOBE), a global gridded digital elevation data set covering the Earth's surface at a 10-minute spatial resolution (approximately 1km).[21] Relatedly, we also control for difference in elevation within a given area, a variable which has been identified in the literature as imposing significant limitations on both agriculture and breeding activities (Michalopoulos, 2011; Grigg, 1995; Lupo, 1993). In particular, we use data on the maximum difference in altitude in a given municipality available from the Italian Institute of Statistics (ISTAT).

[21]The GLOBE data set has superseded the GTOP30 which, before the introduction of GLOBE, was considered the most accurate digital elevation data set and had been used, among others, by Nunn and Puga (2012).

We are also interested in controlling for the suitability of local land for various types of crops, as this is likely to have affected the demand for protection of agricultural goods. In fact, while some low-value crops (i.e. cereals) were consumed locally, others (e.g. citrus fruits, olive, sumac) were high-value export goods which demanded a degree of protection similar to that of sulfur. To account for this aspect, we include in our regressions measures of land suitability for the three most widespread crop categories in XIX century Sicily: i) citrus fruits, ii) cereals, and iii) olives. These measures are constructed using data on crop-specific agro-ecological suitability available from the IIASA-FAO Global Agro-Ecological Zones project (GAEZ).[22] The GAEZ data are in grid format, have a very high resolution (1'), and assign to each grid cell a value from 0 (totally unsuitable), to 100 (very suitable). To obtain suitability measures at the municipality level we average the individual suitability score of all the cells in a given municipality. We focus on crop suitability - determined in large part by exogenous soil properties and climatic conditions - rather than on actual crop production to minimize concerns of possible reverse effects of the presence of the mafia on the prevalence of particular crops. Nevertheless, in the last part of our analysis, to test one of the alternative hypothesis about the emergence of the mafia, we use information on the proportion of land devoted to the cultivation of citrus fruits in each municipality, available from the Damiani-Jacini's inquiry. Given the importance of irrigation for several of the crops mentioned above, and in light of the accounts of various observers about the crucial role played by the mafia in controlling water supply, we also control for the relative scarcity of water in a given area using data on the presence of underground water basins available from the Sicilian Waters Observatory.

Another set of controls is intended to capture factors such as access to major ways of communication and proximity to the main ports, which were arguably important determinants of the value of protection. The first variable, labeled as *postal roads*, indicates whether, at the beginning of the XIX century, a municipality had direct access to one of the postal roads which connected Sicily's largest towns. The data are derived from the digitalization and geo-referentiation of a detailed historical map of Sicily in late XVIII century (Cary, 1799), hence prior to the steady rise in sulfur's international demand. Other variables include the distance of a municipality's centroid from the closest non-seasonal river (*river distance*), and distance from the closest commercial port (*port distance*).[23]

We also control for a set of socio-economic and demographic characteristics which could potentially be related to both sulphur availability and mafia presence. In particular, to account for the fact that crime incidence might be higher in more densely populated areas (Glaeser et al., 1996; Glaeser and Sacerdote, 1999; Buonanno et al., 2012) we control for a measure of population density (*density*) based on data on municipal population from the 1861 census.[24] Relatedly, to control for possible differences between rural and urban areas,

[22]More information on the FAO-GAEZ project can be found at *http://www.gaez.iiasa.ac.at/*. Data from FAO-GAEZ have been used extensively by economists in recent years to investigate a variety of topics. Examples include Nunn and Qian (2011), Michalopoulos (2011) and Durante (2009).

[23]Sicily's main commercial ports were: Mazara del Vallo, Porto Empedocle, Trapani, Siracusa, Catania, Palermo and Messina.

[24]By 1861 Sicily's total population amounted to 2.1 million, accounting for more than 10% of Italy's population. Population density was more than 81 inhabitants per squared kilometer, roughly comparable to the current density of Spain. Since then, the increase in population has been rather homogeneous across Sicilian municipalities, resulting in a correlation between population in 2001 and in 1861of of 0.95. Palermo, the capital, was Sicily's largest and denser city, with a population of 185,000 inhabitants and a density of 1,000 inhabitants per squared kilometer, comparable to that of current mid-size Italian cities.

we also define a dummy variable, *urban*, indicating whether a municipality is located at a distance of 10Km or less from one of Sicily's then five largest cities.[25]

Finally, we also control for the degree of land fragmentation, a factor which previous contributions have related to the development of a florid market for private protection and the consequent emergence of the mafia (Bandiera, 2003). Information on the degree of land fragmentation in each municipality is available from one of the questionnaires of the Damiani-Jacini's inquiry in which mayors where asked to report whether land in their municipality was prevalently composed by small, medium or large landholdings. In particular, we define a dummy variable, *fragmentation*, taking value one for municipality where small and medium landholdings were prevalent, and zero in those in which large landholding still existed. Due to the rather low response rate to this question, data on fragmentation are available for only 237 out of the 285 municipalities in our sample.

The availability of data at the municipal level allow us to include in all our regression department specific fixed effects which capture the political and historical background common to municipalities in the same department. In particular, since in the period under examination the Sicilian administrative, judicial and law-enforcement systems were organized at department level, the inclusion of 24 department fixed effects allow us to estimate the effect of sulphur on mafia by comparing municipalities characterized by a fairly homogenous level of institutional quality.

5 Empirical Analysis

This section presents the empirical assessment of how geographical variations in sulfur endowment contributed to the emergence of the Sicilian mafia. As discussed above, over the XIX century Sicily experienced the collapse of the Bourbon Kingdom and a generalized situation of weak law enforcement. Over the same century, international demand for sulfur soared and most of the world supply came from Sicily. Municipalities with sulfur reserves thus experienced a boom in the value of their natural resources.[26] We exploit the exogenous distribution of sulfur reserves to identify the effects of such boom on mafia's emergence. We document a resource curse, by which valuable natural resources fostered protection demand and extortion opportunities, thus favoring the emergence of organized crime.

5.1 Municipality-level estimates

Table 2 provides our first clear evidence of the importance of sulfur for mafia's emergence. It reports municipality-level OLS estimates of our preferred mafia measure (*maf_c*) on the number of sulfur mines (*sulfur*). The different columns gradually increase the number of control variables.[27] Column 1 shows that, in a univariate regression (including a constant, as in all regressions in all tables), the estimated coefficient on *sulfur*, significant at the 1% level, is equal to 0.033, implying that a one standard deviation increase in *sulfur* leads to an increase

[25] These include: Palermo, Catania, Trapani, Messina and Girgenti.

[26] As already shown in figure 1, sulfur export in Sicily grew at an impressive rate of 9% throughout the period 1830 and 1860 and in that period Sicily served around 90% of the world sulfur demand. sulfur export was negligible at the beginning of the XIX century, peaked at the end of that century (reaching 540,000 tons in 1901) and sharply declined in the XX century (by 1976, it was only 85,000 tons).

[27] Since *maf_c* is an ordinal variable, we repeated the entire analysis using ordered probit, obtaining analogous results, which are available upon request.

in *maf_c* by more than one sixth of a standard deviation.[28] Column 2 adds department fixed effects. This is our first step in tackling the issue of whether differences in sulfur endowment pick up differences in other variables, which may matter for mafia's emergence. Such fixed effects control for any characteristic that was common within each department. The result shows that even within each department, municipality-level variations in sulfur endowment were positively and significantly associated to variations in early mafia's presence (the point estimate is 0.022 and it is significant at the 1% level).

To minimize the risk that within-department variations in sulfur endowment are related to differences in other variables, which may themselves be related to mafia activity, columns 3 to 7 progressively add municipality-level controls for differences in agriculture, geography, transportation and communication, socio-demographic variables and land fragmentation (always including department fixed effects). No matter which controls we include, *sulfur* remains highly significant and the magnitude of the coefficient is barely affected, suggesting that our main result is not driven by any omitted variable.[29]

The first group of additional control variables contains exogenous soil characteristics, which are related to agricultural activity: column 3 includes soil suitability for cultivation of citrus fruits, cereals and olives, as well as a dummy for water scarcity. It is important to control for such factors because many scholars have argued that mafia's emergence was related to citrus cultivation (Lupo, 2004; Gambetta, 1993; Dickie, 2004; Del Monte and Pennacchio, 2012; Dimico et al., 2012) and also to mafia's possibility to control scarce water resources and thus have high extortionary power towards agricultural production (Sylos Labini, 2003). Both suitability for cereals and for citrus have a significant effect, the former positive and the latter negative, but only the former effect remains significant as additional controls are introduced. These results do not support the widely held idea that early mafia's development was related to citrus cultivation. Column 4 adds two geographic controls: average ruggedness and difference in elevation (Nunn and Puga, 2012; Michalopoulos, 2011). Ruggedness is never significant, while difference in elevation is strongly significant and positive. Column 5 adds the presence of 1799 postal roads, as well as distance from the closest non-seasonal river and from the closest commercial port. Mafia's presence was significantly higher in municipalities along old postal roads, whereas distances from rivers and ports are not significant. Column 6 further adds population density in 1861 and a dummy for urban municipalities. Such variables are related to the level of economic activity, both legal and illegal (see, e.g. Glaeser and Sacerdote, 1999; Buonanno et al., 2012). In line with the literature, we find that population density is positively and significantly related to mafia's emergence. Finally, column 7 adds land fragmentation, which according to Bandiera (2003) should be relevant for mafia's emergence, but we find no support for her thesis.

As an additional robustness check, we re-run our baseline regression substituting the number of sulfur mines (*sulfur*) with a dummy (*sulfur_d*) for the presence of at least a mine in the municipality. Using *sulfur_d* is important because we do not have information on the quantity of sulfur extracted in each mine and we therefore put ourselves in the worst case scenario, that is we do not exploit at all the information on the intensive margin in the distribution of sulfur. Table 3 reproduces the same specifications of Table 2, but it replaces

[28] Given the linearity implied by the measure of mafia activity, it takes 30 mines more to have an increase in mafia activity from one level (not present, presence is low, intermediate, high) to the next.

[29] The coefficient on *sulfur* is only raised when we add land fragmentation to the controls. Yet, notice that this reduces sample size from 282 to 237 municipalities since, as discussed in the previous section, information on fragmentation are available only for 237 municipalities.

sulfur_d (the dummy for the presence of at least a sulfur mine in a municipality) for *sulfur*. For the sake of space, we only report the coefficient of *sulfur_d*. Results show that, even if we neglect the information on the intensive margin of sulfur extraction and only rely on the extensive margin, the presence of sulfur is still significant to explain Mafia's emergence. Yet, the slight decrease in significance levels also suggests that the intensive margin was relevant as well.

While the above analysis suggests that omitted variables are not driving our results, as an additional check we control for possible spatial effects. There is no reason to believe that mafia's activity follows the administrative boundaries of municipalities. Mafia lords may indeed offer protection and practice extortion in neighboring municipalities, whose territory they control. They may also establish agreements with other mafia lords, who control different territories, for instance to grant protection to their clients' goods transiting through them. Moreover, protection externalities may foster mafia's activity in a municipality just because the mafia is active in neighboring municipalities. There may therefore be relevant spatial spillovers from a municipality to its neighbors. Omitting to take them into account may reduce the efficiency of our estimates and bias them.

To address this issue, we estimate a spatial model by means of the generalized spatial two stage least squares (GS2SLS) estimator of Kelejian and Prucha (1998). Results are presented in table 4, which reproduces the same specification of column 6 of table 2.[30] We employ both a non-standardized (columns 1 to 3) and a row-standardized (columns 4 to 6) contiguity matrix. We implement a spatial error model (columns 1 and 4), a spatial autoregressive model (columns 2 and 5) and a model that combines the two by considering both a spatial lag and a spatial error structure (columns 3 and 6).[31]

Spatial analysis is consistent with our baseline estimates. Interestingly, the coefficients on the spatial structure are almost always significant when using the row-standardized contiguity matrix, suggesting that mafia's activity in neighboring municipalities is indeed relevant and thus spatial estimates are justified. Yet, the sign of the spatial lag is not robust across specifications, so one should be cautious in its interpretation. By contrast, the main result of the spatial analysis is that, across all specifications, *sulfur* is always positively and significantly related to mafia density, with a point estimated which is very close to the one estimated in table 2, column 6.

The above analysis controls for a great number of observed variables, as well as for any unobserved variable that is common to all municipalities in a department. Yet, in principle there is still the possibility that sulfur-rich municipalities differ from other municipalities of the same department along some other unobserved characteristic, that might be relevant for mafia's emergence. This for instance might be the case if sulfur had always been a relevant source of rents, even in previous centuries. Although we have already documented that

[30] We use column 6 rather than column 7 to avoid the reduction in sample size implied by missing data for land fragmentation. Yet, results are robust to the inclusion of the latter variable.

[31] If neighboring units have similar intercepts due to their proximity, spatial dependence appears only in the error term (LeSage and Pace, 2009) and a Spatial Error model (SEM) should be estimated. In that case, omitting the spatial specification of the error term would reduce efficiency of the estimator, while preserving consistency (Anselin, 1988). In turn, if mafia's density in one municipality is directly affected by mafia's activity in neighboring locations, one should estimate a Spatial Autoregressive model (SAR), which includes among regressors a spatial lag, that is, a weighted average of mafia's activity in neighboring municipalities. A (non-standardized) contiguity is a proximity matrix that associates 1 to each pair of municipalities sharing a border and 0 to any other pair (the diagonal is set to 0 by convention). Row-standardization is obtained by normalizing the sum of each row of the matrix to 1. The difference between the first and the second case is that the spatial lag captures total and average mafia's activity in neighboring municipalities, respectively.

sulfur exports were negligible at the beginning of the XIX century, to indirectly test for this possibility we investigate whether sulfur presence was correlated to population growth in the XVII and XVIII centuries.[32] We focus on those Sicilian municipalities for which we have data for years between 1600 and 1800 (a period characterized by Malthusian regime in which development is proxied by population growth) and construct long term yearly population growth rates.[33] Different specifications of a growth regression that have *sulfur* (and log of initial population to control for convergence) as controls show that sulfur had no economic role in the economic development of Sicilian municipalities before the beginning of the XIX century. Results are reported in table 5.

5.2 District-level estimates

In our baseline regressions we used our preferred measure of mafia intensity, *maf_c*, which is available at the municipality level. In order to obtain estimates directly comparable with other studies (Bandiera, 2003; Pazzona, 2010; Dimico et al., 2012), we employ the mafia measure as defined in the Damiani-Jacini parliamentary inquiry, *maf_d*, which is only available at district level, for 158 Sicilian districts.

We replicate the analysis proposed in our baseline regression presented in table 2, with the same specification: regressing *maf_d* on *sulfur* and the controls presented and discussed in the previous sections. Since estimates exploit district-level information on mafia's activity, we correspondingly re-define all our regressors at this level of geographical and administrative aggregation. District-level findings are presented in table 6. Throughout all the regressions, the estimated coefficient on *sulfur* is strongly significant and is extremely stable, suggesting that our results are not driven by any omitted variable.

As previously stated, the use of *maf_d* is not only useful as a robustness check, but it also allows a more direct comparison with earlier and subsequent contributions. In particular, Bandiera (2003), who also uses district-level data, provides early evidence, based on 70 districts located in the western part of Sicily, supporting the idea that land fragmentation may have favored mafia's emergence; while on the contrary Pazzona (2010) provides evidence that the origins of the Sicilian mafia are rooted in the presence of large landholdings. Our results, both those based on all the 158 available districts, as well as those presented in Table 2, based on 237 municipalities, do not support their arguments.

5.3 Neighbor-pair fixed effects

So far we have presented consistent and robust findings, documenting the significant effect of the presence of sulfur on mafia's origins. Since sulfur is not randomly distributed across Sicily, but rather geographically concentrated, we have relied on department fixed effects and on municipality-level controls to make sure that differences in sulfur endowment do not pick up the effects of some other characteristics, which may be relevant for mafia's emergence. In this section we go even deeper and, rather than comparing municipalities with different sulfur endowments within a given department, we follow Acemoglu et al. (2012) and exploit variations in sulfur endowments across direct neighbors.

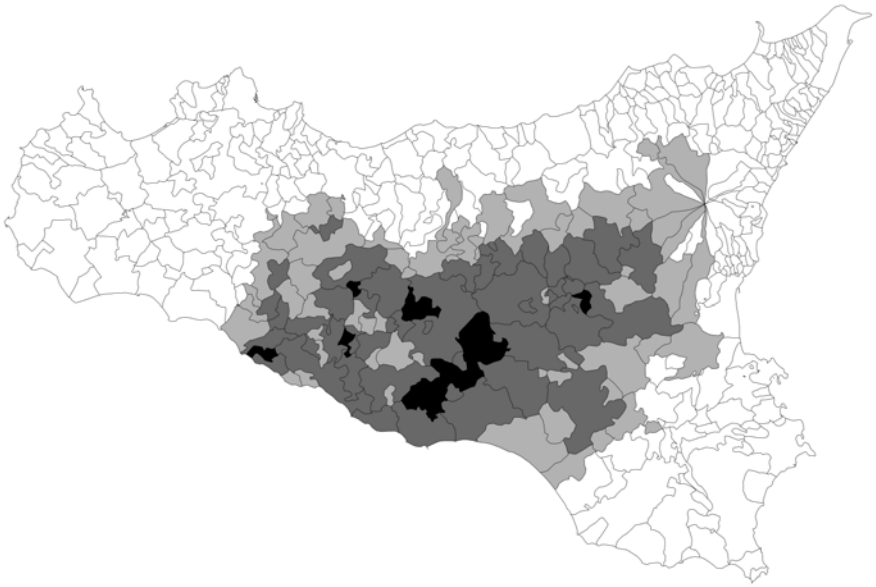
[32] Under the assumption that Sicily was on a Malthusian development path before the XIX century, if sulfur was a relevant source of rents, this should translate in higher rates of population growth where it was present.

[33] Data for population of Italian towns between 1300 and 1861 are available from Paolo Malanima at: http://www.paolomalanima.it/DEFAULT_files/Page646.htm

In particular, we restrict our analysis to the 48 municipalities which have sulfur mines and the 54 municipalities without sulfur mines which are adjacent to them.[34] As in Acemoglu et al. (2012), we implement the neighbor-pair fixed effects estimator, very similar to a matching methodology and to a regression discontinuity design, comparing each sulfur-mining municipality to each of its neighbors. Figure 5 visually presents municipalities with sulfur mines and their neighbors.

This empirical strategy makes it possible to directly control for unobservables that are common across adjacent municipalities by including neighbor-pair fixed effects. Indeed, we rely on the assumption that adjacent municipalities faced similar institutional and contextual conditions (i.e. law enforcement, state presence, culture, labor market, geography), and are likely to be very similar across any other unobservables. Within the neighbor pair, we claim that the exogenous source of variation in mafia's activity is the presence of sulfur mines.

Figure 5: Municipalities with sulfur mines and their neighbors



Note: White municipalities are excluded from the analysis because both them and their neighbors do not host sulfur. Light grey municipalities are those 54 without sulfur that have neighboring municipalities with sulfur (the 35 in dark grey). Black municipalities are excluded because, even if endowed with sulfur, they do not neighbor any non-sulfur municipality.

Formally (see Acemoglu et al. (2012) for a more complete description), we define with S the subset of municipalities with sulfur mines and with *N(s)* all the adjacent municipalities without sulfur mines of each element of S. We use s and i to index municipalities with and without sulfur mines, respectively. We estimate the following model by means of OLS:

$$maf\_c_s = \beta sulfur_s + \gamma X'_s + \psi_{si} + \nu_s \qquad s \in S \tag{1}$$

[34]Note that although 48 municipalities have sulfur mines, 13 of them have as only neighbors other municipalities with sulfur, so they cannot be exploited in this analysis.

$$maf\_c_i = \beta sulfur_i + \gamma X_i' + \psi_{si} + \nu_i \qquad i \in N(s) \tag{2}$$

where X_t' collects municipality-level controls, ψ_{si} represents common unobservables for the neighbor pair (s,i) and ν_t represents municipality-specific unobservables. Neighbor-pair fixed effects estimates are presented in table 7. For simplicity we only present the coefficient on sulfur, but consistently with table 2 we progressively add all the controls described in the previous section. The coefficient of *sulfur* in the neighbor-pair fixed effects estimates is always significant and its magnitude is very close to our baseline findings, providing additional and compelling evidence on the role played by sulfur endowment in mafia's emergence.

5.4 Citrus cultivation

Here we further explore whether the hypothesis, often carried on in the literature that there is a strong connection between cultivation of citrus fruit and the Sicilian mafia, is supported by empirical evidence. In most of the specifications previously presented, to which we refer to, we included an exogenous measure of land suitability for citrus cultivation from GAEZ (discussed above). This variable never appeared to be significant.[35] In order to differently address the issue related to the role of citrus we now include, among the controls, a transformation of the share of cultivable land cultivated with citrus fruits as reported by Damiani (1885).[36] In particular, given the skewed distribution of this variable, we define 5 different dummies equal to 1 whether the share of citrus crops in a municipality is respectively higher than 0, higher than 1%, higher than 5%, higher than 10% and higher than the mean of all municipalities.[37] Table 8 presents results that include, among the regressors, the citrus dummies previously defined. The first five columns uses data at municipality level and therefore our main dependent variable *maf_c*. None of the dummies flagging those municipalities with high incidence of citrus cultivation turns positive and significant, suggesting that, if any, everything has already been controlled for the exogenous drivers of citrus cultivation.[38] It is in fact true that the share of citrus cultivation can be highly endogenous and therefore a causal effect difficult to be identified.[39] Replicating the analysis using district-level data and *maf_d* as dependent variable does not change the results, i.e. none of the dummies for citrus cultivation are significant.

[35] As already reported, Cancila (1995) stresses that citrus fruits were mainly cultivated in the eastern part of Sicily (in the provinces of Catania and Messina), while those cultivated in the Conca d'Oro around Palermo were mainly for the local market.

[36] Dimico et al. (2012) use a dummy equals to one whether citrus is the dominant crop in the department, while Del Monte and Pennacchio (2012) use as citrus intensity a 1 to 3 scale of undefined productivity subjectively attributed from Cutrera (1900) to the 24 Sicilian departments. It is worth to stress that Dimico et al. (2012) do not include data for the municipalities belonging to the province of Caltanissetta, despite data on Caltanissetta are available in the anastatic reprints of the five volumes of the Damiani (1885) inquiry cited above.

[37] More than 55% of Sicilian municipalities did not have crops cultivated with citrus fruits, while the share of land cultivated with citrus fruits was more than 10% and 20% in the 12% and 5% of the Sicilian municipalities, respectively.

[38] We also replicate the same estimates excluding citrus suitability from the set of controls, however estimates remain unchanged.

[39] Dimico et al. (2012) instrument their variable on citrus prevalence with altitude. As we widely described altitude and ruggedness may exert a direct effect on mafia emergence. Thus, altitude does not satisfy the exclusion restriction.

5.5 Mafia's persistence

Although the main purpose of our research is to shed light on the historical determinants of the emergence of the mafia, we are also interested in understanding to what extent these factors have had persistent effect on the presence of the mafia today. In particular, we analyze whether the incidence of mafia activities today is correlated with the presence of the mafia in the early stages of its development. In order to pursue our goal we measure today mafia intensity by means of several variables available at the municipality level: (i) dissolution of municipal administration due to mafia infiltrations; (ii) seized firms and (iii) seized real estate properties. We define a dummy that takes value one whether the municipality council dissolved due to mafia infiltration over the period 1991 to 2011 (source: *Ministero dell'Interno*) and two dummies equal to one respectively whether at least a firm and at least a real estate/property have been seized by the Italian judicial authority in the municipality at the end of 2011 (source: *Agenzia del Demanio*).[40] It is worth to notice that over the considered period more than 10% of Sicilian municipalities were dissolved and firms and real estate properties were seized respectively in more than 23% and 44% of Sicilian municipalities. Morevoer, we also consider non-mafia related crime rates per 100,000 inhabitants at the municipality level as a falsification test (source: *Polizia di Stato, Ministero dell'Interno*). Indeed, we should expect that given the strict territorial control exerted by the Sicilian mafia, property crime should be unaffected or even lowered in municipalities with a stronger presence of mafia. We propose a simple instrumental variable approach in which the first stage is specification presented in column 2 of table 2 (i.e. *maf_c* regressed on *sulfur* and department fixed effects) and the second stage is a measure of crime today on the instrumented measure of historical mafia (i.e., *maf_c*). Instrumental variable estimates, presented in table 9 show a strong effect of early mafia on the actual presence of mafia, confirming the persistence of the phenomenon over time. Moreover, petty crime rates (i.e., theft, burglary, car theft and robbery) are in some cases negatively affected by the presence of the mafia in the early stages of its development, suggesting that the territorial and social control of mafia acts as a deterrent to non-mafia related crimes.

6 Conclusions

We presented a general framework useful to interpret the emergence of mafia-type organizations as a combination of weak state and the presence of valuable natural resources. We have applied this framework to the case of the emergence of the Sicilian mafia, occurred during the XIX century, arguing that the demise of Sicilian feudalism and of Bourbon Kingdom generated a widespread power vacuum that triggered the development of a large potential supply of private protection. At the same time, in those areas characterized by the extraction and commercialization of sulfur, whose international demand was soaring, the demand for private protection boomed. We collected a new dataset with detailed information on mafia activity and presence of sulfur mines at the municipality level and we indeed found a strong causal effect of the presence of sulfur, proxied by the number of mines, on mafia activity. We claim the effect of sulfur on mafia activity to be causal, or its lower bound estimate, since sulfur is exogenously distributed as any natural resource, it is easily discoverable in Sicily since it

[40] Law n. 221 (July 1991) sets the rule for council dissolution due to mafia infiltration. Law n. 646 (September 1982), known as Law "Rognoni - La Torre" rules the seizure of firms and real estate properties belonging to mafia-like organizations.

is mainly superficial and until the beginning of XIX it was commercially barely useless. Our findings are robust when using data at a lower level of aggregation and using another, less reliable measure of mafia activity. Also, allowing for a spatial structure of both the level of mafia and the errors leads to the same results. Lastly, restricting the analysis only to pairs of adjacent municipalities with and without sulfur mines, in a RDD fashion, does not change the main message.

On top of finding a fundamental result on the causal link running from sulfur to mafia, our work also reviews and tests previous findings on the causes of the emergence of Sicilian mafia. In general none of the usual suspects for the emergence of mafia are empirically relevant, in particular once we control for fixed effects at the level of the 24 districts, the judicial and administrative divisions at which law enforcement was organized. Specifically, we do not find neither an historical nor an empirical support for the claim, proposed by old and recent literature, that the presence of citrus cultivation should causally provoke the emergence of mafia.

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Table 1: Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
maf_c	282	1.433	1.140	0	3
maf_d	158	.689	1.064	0	3
Sulfur	282	1.986	7.099	0	61
Sulfur dummy	282	.167	.373	0	1
Citrus suitability	282	15.608	7.658	0	48
Cereals suitability	282	17.728	11.149	1.490	66.380
Olive suitability	282	30.906	12.065	3.478	69.273
Water scarcity	282	0.702	0.458	0	1
Ruggedness	282	433.630	195.940	58.017	1,149.332
Diff. elevation	282	796.837	519.126	48	3,232
Postal roads	282	0.550	0.498	0	1
River distance	282	9.279	7.247	.992	42.075
Port distance	282	37.924	19.371	0.132	83.919
Urban	282	0.124	0.330	0	1
Density	282	132.412	126.861	4.856	1,177.986
Fragmentation	237	0.759	0.428	0	1

Note: Descriptive statistics of the main variables used in the empirical analysis. Data is at the municipality level except for *maf_d* that is collected at the district level.

Table 2: Baseline estimates

Dependent variable: maf_c

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sulfur	.0329***	.0224***	.0237***	.0228**	.0234**	.0239***	.0549***
	(.0105)	(.0082)	(.0089)	(.0091)	(.0092)	(.0089)	(.0127)
Citrus suitabiliy			-.0251*	-.0155	-.0235	-.0227	-.0293
			(.0150)	(.0151)	(.0163)	(.0166)	(.0180)
Cereals suitabiliy			.0235**	.0223**	.0224**	.0224**	.0296***
			(.0108)	(.0108)	(.0107)	(.0110)	(.0111)
Olive suitabiliy			-.0037	-.0039	.0009	-.0016	-.0001
			(.0119)	(.0119)	(.0131)	(.0129)	(.0145)
Water scarcity			.1267	-.0460	-.0231	.0057	-.0548
			(.1986)	(.1990)	(.1923)	(.1933)	(.2010)
Ruggedness				-.0011	-.0010	-.0011	-.0006
				(.0008)	(.0008)	(.0008)	(.0009)
Diff. elevation				.0004***	.0004***	.0005***	.0006***
				(.0001)	(.0001)	(.0001)	(.0002)
Postal roads					.0811	.0975	.1470
					(.1008)	(.1002)	(.1127)
River distance					.0101	.0045	.0091
					(.0092)	(.0094)	(.0101)
Port distance					-.0087	-.0034	-.0022
					(.0060)	(.0069)	(.0080)
Urban						.1855	.0925
						(.1898)	(.2133)
Density						.0013***	.0012**
						(.0005)	(.0005)
Fragmentation							.0961
							(.1315)
Department FEs	N	Y	Y	Y	Y	Y	Y
Obs.	282	282	282	282	282	282	237
R^2	0.042	0.567	0.577	0.594	0.601	0.618	0.659

Note: This table presents the results of OLS estimates for Sicilian municipalities for which values for all the variables are available. The dependent variable is *maf_c*, the level of mafia activity at the end of XIX century as coded by Cutrera (1900) on a 0 to 3 scale (0 is no mafia activity, 3 is large mafia activity). The main explanatory variable *Sulfur* is the number of sulfur mines as collected by Squarzina (1963), while the other control variables are described in the main text. Department fixed effects are included in all specifications except the first. Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.

Table 3: Baseline with sulfur dummy

Dependent variable: maf_c

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sulfur dummy	.5532***	.3594*	.4501**	.3968*	.4165*	.4916**	.4550**
	(.1765)	(.2193)	(.2286)	(.2370)	(.2449)	(.2237)	(.2168)
Controls							
Department FEs	N	Y	Y	Y	Y	Y	Y
Suitability and water	N	N	Y	Y	Y	Y	Y
Geomorphological	N	N	N	Y	Y	Y	Y
Distances	N	N	N	N	Y	Y	Y
Sociodemographic	N	N	N	N	N	Y	Y
Obs.	282	282	282	282	282	282	237
R^2	0.033	0.559	0.570	0.587	0.593	0.613	0.639

Note: Note: This table presents the results of OLS estimates for Sicilian municipalities, for which values for all the variables are available. The dependent variable is *maf_c*, the level of mafia activity at the end of XIX century as coded by Cutrera (1900) on a 0 to 3 scale (0 is no mafia activity, 3 is large mafia activity). The main explanatory variable, *Sulfur dummy*, is a dummy taking value one if the number of sulfur mines as collected by Squarzina (1963) is greater than zero, while the other control variables are described in the main text. Department fixed effects are included in all specifications except the first. Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.

Table 4: Spatial estimates

Dependent variable: maf_c

	(1)	(2)	(3)	(4)	(5)	(6)
Sulfur	.0229***	.0234***	.0227***	.0211***	.0234***	.0231***
	(.0072)	(.0071)	(.0072)	(.0071)	(.0071)	(.0066)
λ	.0143		.0149	.4762***		.6857***
	(.010)		(.010)	(.138)		(.113)
ρ		.0144	-.0038		0.0497	-0.6252***
		(.022)	(.025)		(.103)	(.149)
Controls						
Department FEs	N	Y	Y	Y	Y	Y
Suitability and water	N	N	Y	Y	Y	Y
Geomorphological	N	N	N	Y	Y	Y
Distances	N	N	N	N	Y	Y
Sociodemographic	N	N	N	N	N	Y
Obs.	282	282	282	282	282	282

Note: This table presents the results of a spatial model estimated by means of the generalized spatial two stage least squares (GS2SLS) estimator of Kelejian and Prucha (1998). Included controls are the same as in the specification of column 6 of table 2. Columns 1 to 3 employ a non-standardized contiguity matrix, while a row-standardized one is used in columns 4 to 6. A Spatial Error model, a Spatial Autoregressive model and a model that combines the two by considering both a spatial lag and a spatial error structure are respectively presented in columns 1 and 4, columns 2 and 5 and columns 3 and 6. λ is the spatial error term, while ρ is the spatial lag. The dependent variable is *maf_c*, the level of mafia activity at the end of XIX century as coded by Cutrera (1900) on a 0 to 3 scale (0 is no mafia activity, 3 is large mafia activity). The main explanatory variable, *Sulfur*, is the number of sulfur mines as collected by Squarzina (1963), while the other control variables are described in the main text. Department fixed effects are included in all specifications except the first. Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.

Table 5: Growth regressions

Dependent variable: population growth

	1600-1700	1700-1800	1600-1800
	(1)	(2)	(3)
ln(population 1600)	-.1660***		-.0900**
	(.0576)		(.0404)
ln(population 1700)		-.0761	
		(.0608)	
Sulfur	.0003	-.0002	-.0002
	(.0030)	(.0028)	(.0022)
Obs.	47	56	50
R^2	.159	.029	.097

Note: This table presents the results of OLS estimates for Sicilian municipalities for which population was positive in at least two of the years 1600, 1700 or 1800, according to Malanima's data (http://www.paolomalanima.it/DEFAULT_files/Page646.htm). The dependent variable is the yearly population growth while the explanatory variables are the log of population at the beginning of the period and *Sulfur*, the number of sulfur mines as collected by Squarzina (1963). Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.

Table 6: District level estimates

Dependent variable: maf_d

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sulfur	.0354***	.0318***	.0325***	.0327***	.0326***	.0347***	.0322**
	(.0080)	(.0115)	(.0116)	(.0117)	(.0121)	(.0122)	(.0127)
Citrus suitability			.0413	.0483	.0444	.0399	.0378
			(.0315)	(.0324)	(.0344)	(.0351)	(.0352)
Cereals suitability			-.0034	.0024	.0022	.0042	.0016
			(.0193)	(.0188)	(.0196)	(.0197)	(.0201)
Olive suitability			-.0203	-.0203	-.0212	-.0207	-.0155
			(.0180)	(.0177)	(.0198)	(.0199)	(.0210)
Water scarcity			.2763*	.2842	.2669	.2365	.2078
			(.1678)	(.1730)	(.1711)	(.1720)	(.1820)
Ruggedness				.0010	.0013	.0009	.0007
				(.0002)	(0.0002)	(.0002)	(.0002)
Diff. elevation				.0002	.0002	.0003	.0003
				(.0002)	(.0002)	(.0002)	(.0002)
Postal roads					.2210	.2877	.2680
					(.1906)	(.1947)	(.1993)
River distance					.0026	-.0022	-.0040
					(.0177)	(.0182)	(.0184)
Port distance					-.0009	.0016	.0002
					(.0126)	(.0145)	(.0144)
Urban						-.1216	-.1115
						(.4075)	(.4097)
Density						.0014*	.0014*
						(.0008)	(.0008)
Fragmentation							-.1847
							(.2467)
Department FEs	N	Y	Y	Y	Y	Y	Y
Obs.	158	158	158	158	158	158	158
R^2	0.105	0.232	0.249	0.259	0.266	0.283	0.288

Note: This table presents the results of OLS estimates for Sicilian districts for which values for all the variables are included. The dependent variable is *maf_d*, the level of mafia activity around 1883 as coded by Damiani (1885) on a 0 to 3 scale (0 is no mafia activity, 3 is large mafia activity). The main explanatory variable *Sulfur* is the number of sulfur mines as collected by Squarzina (1963), while the other control variables are described in the main text. Department fixed effects are included in all specifications except the first. Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.

Table 7: Neighbor pair fixed effect estimates

Dependent variable: maf_c						
	(1)	(2)	(3)	(4)	(5)	(6)
Sulfur	.0206***	.0172**	.0231**	.0216**	.0196**	.0207***
	(.0061)	(.0073)	(.0093)	(.0094)	(.0094)	(.0055)
Controls						
Department FEs	N	Y	Y	Y	Y	Y
Suitability and water	N	N	Y	Y	Y	Y
Geomorphological	N	N	N	Y	Y	Y
Distances	N	N	N	N	Y	Y
Sociodemographic	N	N	N	N	N	Y
Obs.	162	162	162	162	162	162
R^2	0.054	0.637	0.667	0.672	0.681	0.795

Note: This table presents the results of OLS estimates for Sicilian municipalities for which values for all the variables are available. Observations are all those municipalities that form a couple in which a municipality has sulfur and its neighbor has not. Each municipality in a pair shares a common pair fixed effect. The dependent variable is *maf_c*, the level of mafia activity at the end of XIX century as coded by Cutrera (1900) on a 0 to 3 scale (0 is no mafia activity, 3 is large mafia activity). The main explanatory variable *Sulfur* is the number of sulfur mines as collected by Squarzina (1963), while the other control variables are described in the main text. Pair fixed effects are included in all specifications. Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.

Table 8: Testing for citrus

	maf_c	maf_c	maf_c	maf_c	maf_c	maf_d	maf_d	maf_d	maf_d	maf_d
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sulfur	0.0234***	0.0232***	0.0232***	0.0231***	0.0231***	0.0329***	0.0345***	0.0349***	0.0347***	0.0348***
	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.013)	(0.012)	(0.013)	(0.012)	(0.012)
Citrus dummy	- 0.0237					0.3832				
	(0.107)					(0.232)				
Citrus dummy (>1%)		-0.0446					0.4879			
		(0.133)					(0.292)			
Citrus dummy (>5%)			-0.0185					-0.0761		
			(0.189)					(0.235)		
Citrus dummy (>10%)				0.1131					0.1131	
				(0.152)					(0.354)	
Citrus dummy (>mean)					-0.0756					0.1072
					(0.139)					(0.299)
Controls										
Department FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Suitability and water	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geomorphological	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Distances	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sociodemographic	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs.	280	280	280	280	280	158	158	158	158	158
R^2	0.614	0.615	0.614	0.615	0.615	0.297	0.294	0.276	0.276	0.277

Note: This table presents in columns 1 to 5 (6 to 10) the results of OLS estimates for Sicilian municipalities (districts) for which values for all the variables are available. The dependent variable is *maf_c* (*maf_d*), the level of mafia activity at the end of XIX century as coded by Cutrera (1900) (Damiani (1885)) on a 0 to 3 scale (0 is no mafia activity, 3 is large mafia activity). The main explanatory variable *Sulfur* is the number of sulfur mines as collected by Squarzina (1963) and the variables *Citrus dummy (>X%)* indicates a share of land cultivated with citrus fruits greater than *X%*, while the other control variables are described in the main text. Department fixed effects are included in all specifications. Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.

Table 9: Persistence

	Council	Real estates	Firms	Theft	Burglary	Car theft	Robbery
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
maf_c	.0706***	.1477***	.1524***	-183.9049***	3.1591	-28.3848***	-2.2930
	(.0187)	(.0325)	(.0277)	(52.9439)	(10.1428)	(9.4874)	(2.0695)
Obs.	282	282	282	282	282	282	282

Note: This table present the result of instrumental variable estimates in which the first stage is specification presented in column 2 of table 2 (i.e. *maf_c* regressed on *sulfur* and department fixed effects) and the second stage is a measure of crime today on the instrumented measure of historical mafia (i.e., *maf_c*). Today mafia presence is measured by: (i) dissolution of municipal administration due to mafia infiltrations; (ii) seized firms and (iii) seized real estate properties. *Council* is a dummy that takes value one whether the municipality council dissolved due to mafia infiltration over the period 1991 to 2011 (source: *Ministero dell'Interno*), *Real estates* is a dummy equals to one whether at least a real estate property has been seized by the Italian judicial authority and *Firms* is a dummy equals to 1 whether at least a firm has been seized (source: *Agenzia del Demanio*). *Theft*, *Burglary*, *Car theft* and *Robbery* are crime rates per 100,000 inhabitants for each Sicilian municipality (source: *Polizia di Stato, Ministero dell'Interno*). Robust standard errors are presented in parentheses. *, ** and *** denote rejection of the null hypothesis of the coefficient being equal to 0 at 10%, 5% and 1% significance level, respectively.