

POOR INSTITUTIONS, RICH MINES: RESOURCE CURSE IN THE ORIGINS OF THE SICILIAN MAFIA*

Paolo Buonanno, Ruben Durante, Giovanni Prarolo and Paolo Vanin

With weak law-enforcement institutions, a positive shock to the value of natural resources may increase demand for private protection and opportunities for rent appropriation through extortion, favouring the emergence of mafia-type organisations. We test this hypothesis by investigating the emergence of the mafia in twentieth century Sicily, where a severe lack of state property-rights enforcement coincided with a steep rise in international demand for sulphur, Sicily's most valuable export commodity. Using historical data on the early incidence of mafia activity and on the distribution of sulphur reserves, we document that the mafia was more present in municipalities with greater sulphur availability.

In 1883 Sicily was shaken by the discovery, in the heart of its sulphur-producing area, of the first documented mafia-type criminal organisation, the Brotherhood of Favara (Dickie, 2004). More than 200 affiliates (on a total of above 500) were arrested; 107 of them were convicted in the following trial. Of these 107, 72 were workers, at different layers, of the sulphur industry. We document in this article that this episode was not just a *curiosum*: there is a systematic causal link from sulphur availability to the mafia's emergence (and persistence) in Sicilian municipalities. We argue that this reflects a broader phenomenon, namely the fact that under weak institutions an increase in the value of lootable natural resources may foster mafia-type organisations.

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.*, 2006*a, b*; Voth and Drelichman, 2008; 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 what factors explain why the discovery of valuable resources can lead to desirable outcomes in some countries (e.g. Norway, Australia) and to deleterious ones in others (e.g. Nigeria, Zimbabwe)? The quality of pre-existing

* Corresponding author: Giovanni Prarolo, Department of Economics, University of Bologna, Piazza Scaravilli 2, 40125 Bologna, Italy. Email: giovanni.prarolo@unibo.it.

We are grateful to the editor Stephen Machin and an anonymous referee for their remarks. We also thank Francesco Amodio, Oriana Bandiera, Giorgio Chiovelli, Francesco Cinnirella, Carl-Johan Dalgaard, Alfredo Del Monte, Arcangelo Dimico, Giovanni Federico, Oded Galor, Diego Gambetta, Paola Giuliano, Luigi Guiso, Nathan Nunn, Paolo Pinotti, Nancy Qian, Mathias Thoenig, David Weil and one anonymous referee for helpful comments. We also thank participants in the Transatlantic Workshop on the Economics of Crime, the Frontier Research in Economic and Social History Meeting, the CEPR-EIEF Conference on Economics of Interactions and Culture, the Conference on Intergenerational Transmission of Entrepreneurship, Occupations and Cultural Traits in the Process of Long-run Economic Growth, the SIE Conference, the 2013 annual Conference of the Royal Economic Society and the 2013 NBER Summer Institute and seminar participants at DIW, Collegio Carlo Alberto, University of Barcelona, University of Bologna, University of Neuchâtel, Free University of Berlin and University of San Andrés, PUC Rio de Janeiro, and University of Milan for helpful discussion. All errors are our own. All necessary data sets and programs to replicate results are available online.

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

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 (Collier and Hoeffler, 2002; Skaperdas, 2002); resources may be diverted from human capital accumulation and other productive uses (Cabrales and Hauk, 2011; Dal Bó and Dal Bó, 2011; Dube and Vargas, 2013). Similarly, the literature on organised 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 organisations, which can have profound and long-lasting effects on a country's economic prospects.

The socio-economic consequences of organised crime have 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 organisations operating in various parts of the world.² While these contributions have expanded our knowledge of the nature and structure of such organisations, their economic origins remain largely unexplored.

Our article attempts to fill this gap advancing the hypothesis that, when public law-enforcement institutions are weak or absent, a boom in the value of natural resources significantly contributes to the emergence of mafias, because it creates both a demand for private protection and opportunities to extract rents through extortion, two dimensions along which mafia-type organisations have a competitive advantage, thanks to the coordinated use (or threat) of violence (indeed, protection and extortion are often hard to disentangle; they appear as the two sides of the mafia coin). While this argument can potentially be applied to a variety of mafia-type organisations around the world, we test it empirically for the specific case of the Sicilian mafia, the oldest and most notorious mafia, which dates back to the nineteenth century and which has had a considerable and long-lasting effect on Sicily's socio-economic development.³

After the demise of feudalism and the collapse of the Bourbon Kingdom, Sicily was characterised by a severe and widespread lack of state enforcement of law, which was even more pronounced in sulphur mines than elsewhere. At the same time, the value of its sulphur reserves boomed, due to a sharp increase in sulphur demand from industrialised countries. Due to abundant and superficial availability, Sicilian sulphur extraction correspondingly rose, up to the point that, by the end of the nineteenth century, Sicily was covering more than 80% of the world sulphur market. Since the actual shock to the value of natural resources depended on sulphur presence, we exploit the exogenous distribution of sulphur reserves across Sicilian municipalities to identify how such a shock contributed to the mafia's emergence. As it will be clear throughout the rest of the article, we do not claim that sulphur was the sole cause of

² Relevant contributions on mafia-type organisations by sociologists include Gambetta's seminal work on the Sicilian mafia (1993), Varese's (2005) studies of the Russian mafia and of the Japanese Yakuza. Recent contributions by economists have looked at the economic impact of the Sicilian mafia (Pinotti, 2015) and the workings of criminal networks in the context of the American mafia (Mastrobuoni and Patacchini, 2012).

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.

the emergence of Sicilian mafia. What we indeed claim is that the effect of sulphur on the emergence of mafia is the only one:

- (i) clearly identifiable; and
- (ii) empirically robust.

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 the mafia's emergence through other channels. To address this concern, we pursue several strategies. First, we document that differences in sulphur 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 sulphur played no special economic role prior to the nineteenth 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. Indeed, we employ a comprehensive dataset, which combines various measures of early mafia diffusion across Sicilian municipalities with detailed information on natural resource endowments and a range of other geographical and socio-demographic characteristics. Third, in all our specifications we include area fixed effects, which allows us to identify our main effect from variations in sulphur endowment within small areas, which are plausibly homogeneous along several non-observable dimensions. Fourth, to account for possible spatial correlation in the mafia's emergence, we replicate our analysis using spatial regression methods. Finally, following Acemoglu *et al.* (2012), we perform additional tests of our hypothesis based on the comparison of pairs of neighbouring municipalities with different sulphur endowment.⁴

Our empirical findings provide strong support for our main hypothesis. In particular, we find that sulphur availability has a positive and significant effect on early incidence of mafia activity. 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 which, however, do not appear to find strong support in the data. In addition, none of the alternative explanations we test are clearly identifiable, so that we can spot, at most, correlations among early the mafia emergence and these supposed explanations. Although the focus of our analysis is on the mafia's emergence, in the last part of the article, we also document the existence of a strong correlation between historical and current mafia presence, and discuss the possibility of using historical sulphur availability as an instrument for the latter.

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.

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 organisations in various different parts of the world, where similar economic and institutional conditions may have occurred.⁵

The remainder of the article is organised as follows. Section 1 illustrates our theoretical framework and relates our work to the literature on mafia-type organisations and the resource curse. In Section 2 we discuss the socio-economic and political conditions of nineteenth century Sicily that favoured the mafia's emergence, with particular regard to the collapse of the Bourbon regime and the upsurge in sulphur's value. In Section 3 we present the data used in the empirical analysis, while in Section 4 we describe our empirical strategy and discuss our findings. Section 5 concludes.

1. On Mafia and Resource Curse

Our research first 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 favour the emergence of criminal organisations 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 (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.*, 2006*a, b*; Cabrales and Hauk, 2011).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 organisations 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.⁷

Our data structure, that exploits within-country variations in natural sources availability, has the advantage of downsizing a plausible effect of natural resources on institutions (a possible confound), since the latter are often designed at national level. Although studies that use this data structure (such as Caselli and Michaels (2013) and Naritomi *et al.* (2012), both using municipality-level data for Brazil) have to

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.

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

⁷ Dal Bó and Dal Bó (2011) emphasise different factor intensities to explain why price shocks to different commodities have different effects on social conflict. Dube and Vargas (2013) show evidence that in Colombia, price increases in agricultural product and in natural resources are associated to a decrease and to an increase in violence, respectively, because the former raise the opportunity cost of violence and the latter raise the incentive to appropriate rents through violence. Yet notice that in twentieth century Sicily both agriculture and extraction of natural resources were labour intensive.

renounce some degree of external validity, the possibility of pinning down the existing institutional framework is of great importance.

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 formalise the idea that the mafia should have been historically more active in towns where land was more fragmented and finds support for this hypothesis using qualitative data from an 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 the 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 mafia incidence across Sicilian areas, which is considered one of the most puzzling questions about the history of the Sicilian mafia.⁹

In more general terms, the results of this research complement the literature on the emergence of persistent social institutions as the consequence of what can be viewed as a 'historical accident' (Acemoglu *et al.*, 2001), which in the context of our study would be represented by the sudden rise in international demand for Sicilian sulphur. 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; Michalopoulos *et al.*, 2012; Nunn and Puga, 2012) 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 organisations (criminal ones in this case), which have persisted over time and continue to have relevant socio-economic effects.

2. Historical Background

Nineteenth century Sicily presented the two conditions that, according to the 'resource curse' argument discussed above, are conducive to the mafia's emergence: poor quality

⁸ The argument is based on the idea that the purchase of protection by 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 the mafia's potential profits. We present and discuss in detail in the data Section the parliamentary survey employed by Bandiera (2003) and the administrative jurisdictions in twentieth century Sicily.

⁹ This aspect has been discussed by historians, sociologists and economists alike. Some examples include Gambetta (1993), Lupo (1993), and Sylos Labini (2003).

of law-enforcement institutions and soaring value of domestic natural resources. In what follows we discuss some aspects of the nineteenth 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 production.

2.1. *Institutional Weakness and Economic Development*

Two major political transformations characterised the history of Sicily during the nineteenth 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 a heavy fiscal burden on them, 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 nineteenth century most of Sicilian municipalities were under the barons' direct jurisdiction; however, most feudal lords did not reside in their lands but in Palermo, the centre of the 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 the 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 cultivation (mainly cereals) and characterised by very low productivity and peasants' 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 produce 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.

Individuals specialised in the use of violence were abundant throughout Sicily. An increase in the demand for private protection could thus be easily met by potential suppliers, who had no difficulty in acquiring information and reputation, the key assets for private protection. In the countryside, *gabelloti* were surrounded by a

¹⁰ The port of Palermo was by far the busiest 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).

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 and Sonnino (1877), 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

2.2. Sulphur

The case of the sulphur 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. Sulphur mines were usually rented out employing *gabelloti*, as it happened in agrarian estates. Again, this was done to secure the right to exploit sulphur mines under the threat of violent attacks. Even if the kind of property and lending structure of sulphur mines was common to that of other productive assets, there are some specificities pertaining to the mining sector that lead us to hypothesise that the mining working environment was particularly conducive to violence. The absence of law enforcement, which characterised Sicily in the nineteenth century, was exacerbated in the underground life of sulphur caves, with controversies between workers usually solved using violence or its threat: a set of laws regulating within-mines penal responsibilities was approved only in 1893. Due to the lack of organised law enforcement, each miner had to protect his extraction from other miners, as raw material extracted by miners was usually paid only once a week and the material extracted each day was two or three times worth the daily wage of a worker. For the protection of their material, miners were supported by *carusi*, 10–15 year old boys who helped workers move extracted material and who, in this lawless environment, developed the specific characteristics of a mafioso: use of violence, non-cooperation with others, code of silence etc.¹²

Once extracted, sulphur 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 nineteenth century, international demand for sulphur soared, as this represented a fundamental intermediary input for industrial and chemical productions, which were quickly expanding both in Britain

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. Del Monte and Pennacchio (2012) show that there was a negative correlation between the intensity of brigandage and that of organised crime after the Italian Unification.

¹² Since in the empirical part we find strong evidence of sulphur presence as predictor of mafia, as opposed to no effects of citrus cultivation, which shares similar commercialisation characteristics, we speculate that the real driver of the mafia’s emergence was the underground part of the story.

and France.¹³ For all of the nineteenth century and during the first decade of the twentieth century, Sicily represented the world's largest sulphur producer, accounting for up to 83% of world sulphur production in 1893.¹⁴

The increase in international demand for sulphur determined an increase in the value of its protection, favouring the mafia's emergence. As shown by the case of the Brotherhood of Favara mentioned in the Introduction, protection was not just delegated to *carusi*, but organised groups soon emerged and started to fight to control the market for sulphur protection, which after decades of growing demand had become highly profitable (indeed, the convicted affiliates to the Brotherhood of Favara belonged to two rival factions, which tried to consolidate their power in the market for sulphur protection).

To identify the effect of the increase in the value of sulphur endowments on the mafia's emergence, our empirical analysis exploits exogenous variations in the availability of sulphur across Sicilian municipalities. It is worth stressing that Sicilian sulphur was mainly on the surface (Squarzina, 1963; Cancila, 1995) and hence no considerable investment was required to find and extract it, so the information on the presence of sulphur mines proxies very well the presence of sulphur itself. Key to our identification strategy is the assumption that the presence of sulphur reserves was unimportant for local economic activity prior to the nineteenth century. Available evidence on Sicily's sulphur export is consistent with this view: as shown in Figure 1 Sicilian sulphur exports, virtually negligible at the beginning of the nineteenth century, reached almost 500,000 tons by the beginning of the nineteenth century, accounting for about 4% 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.¹⁵ According to Kutney (2009), sulphur in 1852 was the top export from Sicily (£392,000) before citrus fruits (£362,000), olive oil (£163,000) and wine (£106,000). Using information from Dimico *et al.* (2012), we obtain that in 1900 the value of export of Sicilian sulphur was at least three times the value of all exported Italian citrus products, testifying to a consolidated primacy of sulphur export over other commodities throughout the nineteenth century.¹⁶ All these factors contributed to an increase in sulphur producers' demand for protection both around the mines and possibly along the routes connecting them to the main ports.

¹³ In 1855 over 70% of Sicilian sulphur was exported to France and Great Britain (Squarzina, 1963). Sulphur 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 sulphur have been discovered and developed since the late 1840s, the use of sulphur gained momentum again because of its use in grape cultivation as a fungicide. In 1940 sulphur still accounted for 20% of Sicily's total export value (Pescosolido, 2010).

¹⁴ Sicilian sulphur production and export almost coincided since, throughout the nineteenth century, virtually no sulphur-intensive industries were active in the region, leaving aside its use in grape cultivation.

¹⁵ 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). The price was fluctuating also in the 1860–1900, according to Squarzina (1963). It went from 120 lira per ton in 1860 to a peak of 142 in 1874, then dropped to 65 in 1889 and recovered to 92 in 1900.

¹⁶ Dimico *et al.* (2012) report that Italian lemon exports amounted to around \$3M in 1900. The sulphur price was around 92 lira per ton and Sicilian exports peaked at 560,000 tons, that at an exchange rate of 5.5 liras per dollar amounts to \$9.4M.

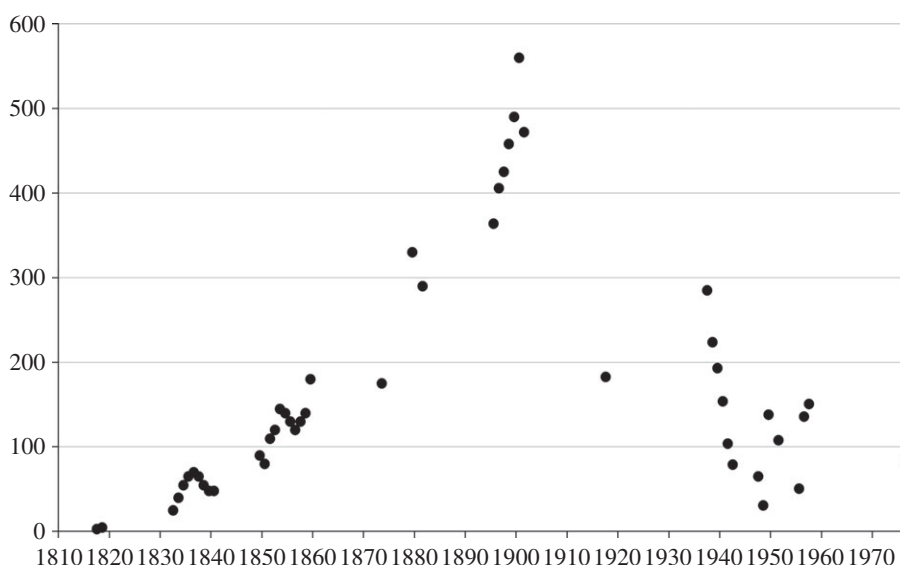


Fig. 1. *Export of Sicilian Sulphur*

Notes. Thousands of tons of sulphur exported from Sicily.

Source. Squarzina (1963), Cancila (1995) and various entries of Treccani Encyclopedia.

It is important to mention that the export of Sicilian sulphur rapidly declined over the first part of the twentieth 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 open cast sulphur mines.

3. 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 nineteenth 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.

3.1. *Mafia*

Our primary source of data on the early diffusion of the mafia in Sicily is represented by the work of Cutrera (1900). A former law-enforcement official and one of the major experts of the phenomenon at the time, Cutrera collected detailed information on the intensity of mafia activity in 285 Sicilian municipalities in the last decades of the nineteenth 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).¹⁷ 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 under the newly unified state.¹⁸ 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*).¹⁹ 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 the one used by Cutrera.²⁰

We believe that Cutrera's data are preferable to Damiani-Jacini's for several reasons. First, unlike Damiani-Jacini, 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 sulphur 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 mafia activity in their jurisdiction, introducing a measurement error. As discussed in Pazzona (2010), the problem would be even more severe if such factors were themselves correlated to 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 mafia activity in different municipalities. On the other hand, given his position of being an 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 mafia activity). 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. Although our empirical

¹⁷ 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.

¹⁸ 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 20 May 1883. A complete version of the questionnaire can be found at page V, volume XIII, tome II, fascicle IV of the official inquiry report.

¹⁹ Post-unification Sicily was characterised 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.

²⁰ 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 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.).

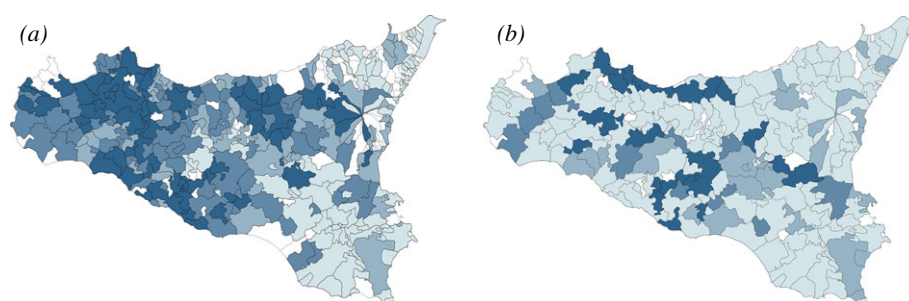


Fig. 2. *Geographic Distribution of the Sicilian Mafia in the Late Nineteenth Century*

Notes. The Figure reports the assessment of the intensity of mafia activity according to Cutrera (left) and Damiani-Jacini (right), with darker greys indicating more intense mafia 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, for example for municipalities created in the twentieth century.

analysis primarily relies on Cutrera's data, we also test the robustness of our findings using the Damiani-Jacini 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 nineteenth century, based respectively on Cutrera's and Damiani-Jacini's data, is depicted in Figure 2. Relative to Damiani-Jacini, Cutrera's data indicates that the mafia had more presence 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 (Lupo, 1993; Sylos Labini, 2003; among others), is further reassuring on the accuracy of Cutrera's data.

3.2. *Sulphur and Other Geographical and Historical Variables*

With regard to the presence of sulphur, comprehensive municipal data are available from Squarzina (1963). These include information on the number of sulphur mines in each Sicilian municipality in 1886 – that is, around the peak of Sicily's sulphur 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 nineteenth century – we consider both mines that were still operating in 1886 as well as those that were already exhausted by then. It is worth emphasising, once again, that Sicilian sulphur was generally on the surface so that its extraction was relatively unchallenging and did not require considerable investment; as a consequence, at the peak of Sicily's sulphur export boom, virtually all major sulphur reserves on the island had been tapped (Squarzina, 1963). In light of this fact, the presence of sulphur mines can be considered a good proxy for the exogenous distribution of sulphur reserves, which is ultimately our variable of interest. Our key explanatory variable is the number of sulphur mines in each municipality (labelled sulphur henceforth), that is summarised in Figure 3.

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

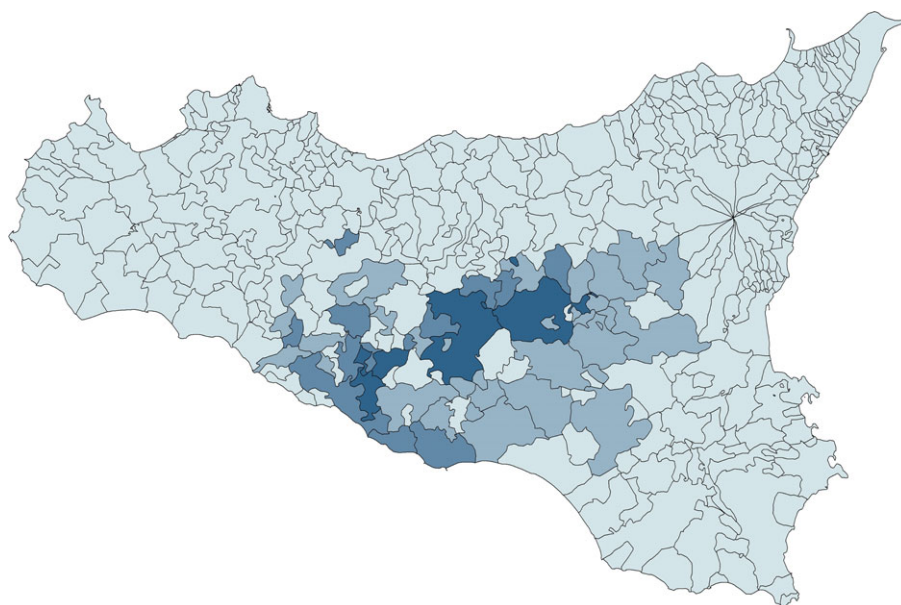


Fig. 3. *Geographic Distribution of Sicilian Sulphur Mines (1886)*

Notes. The Figure reports the number of sulphur mines (both active and exhausted) recorded in each Sicilian municipality in 1886 on a four-level scale: 0 (lighter grey), 1–10, 11–30, more than 30 (darker grey).

influenced the demand and supply of mafia services and, at the same time, may be correlated with the presence of sulphur, in order to be sure that our variable of interest reflects the effect of sulphur availability on the mafia's emergence and is not merely proxying for other characteristics.

To account for differences 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 (1993) emphasises the importance of the towns' 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 1 km).²¹ However, we also control for difference in elevation within a given area, a variable which has been

²¹ The GLOBE data set has superseded the GTOPO30 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).

identified in the literature as imposing significant limitations on both agriculture and breeding activities (Lupo, 1993; Grigg, 1995; Michalopoulos, 2012). In particular, we use data on the maximum difference in altitude in a given municipality available from the Italian Institute of Statistics (ISTAT).

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 and sumac) were high-value export goods which might demand a degree of protection similar to that of sulphur. To account for this aspect, we include in our regression measures of land suitability for the three most widespread crop categories in nineteenth 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 assigned 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 minimise concerns of possible reverse effects of the mafia's presence on the prevalence of particular crops.²³ 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, labelled as postal roads, indicates whether, at the beginning of the nineteenth century, a municipality had direct access to one of the postal roads which connected Sicily's largest towns. The data are derived from the digitalisation and geo-referencing of a detailed historical map of Sicily in the late eighteenth century (Cary, 1799), hence prior to the steady rise in sulphur'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).²⁴

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

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 Durante (2009), Nunn and Qian (2011) and Michalopoulos (2012).

²³ In the online Appendix, to test one of the alternative hypothesis about the mafia's emergence, we use information on the proportion of land devoted to the cultivation of citrus fruits in each municipality, available from the Damiani-Jacini inquiry.

²⁴ Sicily's main commercial ports were: Mazara del Vallo, Porto Empedocle, Trapani, Siracusa, Catania, Palermo and Messina.

et al., 2012), we control for a measure of population density (density) based on data on municipal population from the 1861 census.²⁵ However, to control for possible differences between rural and urban areas, we also define a dummy variable, *urban*, indicating whether a municipality is located within a 10 kilometre distance from one of Sicily's then five largest cities.²⁶

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 inquiry, in which mayors were 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 the value one for municipalities 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 allows us to include in all our regressions department fixed effects, which capture the political and historical background common to all municipalities in the same department. In particular, since in the period under examination, the Sicilian administrative, judicial and law-enforcement systems were organised at the department level, the inclusion of 24 department fixed effects allow us to estimate the effect of sulphur on mafia by comparing municipalities characterised by a fairly homogeneous level of institutional quality. Descriptive statistics on all variables are reported in Table 1.

4. Empirical Analysis

This Section presents the empirical assessment of how geographical variations in sulphur endowment contributed to the emergence of the Sicilian mafia. As discussed above, over the nineteenth century, Sicily experienced the collapse of the Bourbon Kingdom and a generalised situation of weak law enforcement. Over the same century, international demand for sulphur soared and most of the world supply came from Sicily. Municipalities with sulphur reserves thus experienced a boom in the value of their natural resources.²⁷ We exploit the exogenous distribution of sulphur reserves to identify the effects of such boom on the mafia's emergence. We document a resource

²⁵ 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 square 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 1861 of 0.95. Palermo, the capital, was Sicily's largest and densest city, with a population of 185,000 inhabitants and a density of 1,000 inhabitants per square kilometer, comparable to that of current mid-size Italian cities.

²⁶ These include: Palermo, Catania, Trapani, Messina and Girgenti.

²⁷ As already shown in Figure 1, sulphur exports from 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 sulphur demand. Sulphur exports were negligible at the beginning of the nineteenth century, peaked at the end of that century (reaching 540,000 tons in 1901) and sharply declined in the twentieth century (by 1976, it was only 85,000 tons).

Table 1
Descriptive Statistics

Variable	Observations	Mean	SD	Minimum	Maximum
<i>maf_c</i>	285	1.435	1.138	0	3
<i>maf_d</i>	158	0.689	1.064	0	3
Sulphur	282	1.965	7.064	0	61
Sulphur dummy	282	0.165	0.373	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
Different elevation	282	796.837	519.126	48	3,232
Postal roads	282	0.550	0.498	0	1
Distance to river	282	9.279	7.247	0.992	42.075
Distance to port	282	37.924	19.371	0.132	83.919
Urban	282	0.124	0.330	0	1
Population density	282	132.412	126.861	4.856	1,177.986
Land fragmentation	237	0.759	0.428	0	1

Notes. 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.

curse, by which valuable natural resources fostered protection demand and extortion opportunities, thus favouring the emergence of organised crime.

As a preliminary check, we present some evidence corroborating the idea that sulphur did not play any relevant economic role before the nineteenth century, so that any *ex ante* differences between sulphur-rich and sulphur-poor municipalities are not driven by sulphur presence. Before 1800, the Sicilian economy was arguably characterised by a Malthusian regime, in which development is meaningfully proxied by population growth. For all municipalities for which we have population data for the eighteenth and the nineteenth centuries, Table 2 reports OLS regressions of average population growth on initial population (in logarithms) and on sulphur.²⁸ The three columns refer to population growth in each century and in the whole period, respectively. Sulphur is never significant, confirming its irrelevance for previous economic development. Together with the already documented fact that sulphur exports were negligible at the beginning of the nineteenth century, this evidence is our first and preliminary step to tackle the issue of *ex ante* similarity of municipalities with and without sulphur. In the following analysis, we tackle such issues in many additional ways.

4.1. Municipality-level Estimates

Table 3 provides our first clear evidence of the importance of sulphur for the mafia's emergence. It reports municipality-level OLS estimates of our preferred mafia measure (*maf_c*) on the number of sulphur mines (sulphur). The different columns gradually

²⁸ Data for population of Italian towns between 1300 and 1861 are available from Paolo Malanima at: http://www.paolomalanima.it/DEFAULT_files/Page646.htm

Table 2
Growth Regressions

Dependent variable: population growth			
	(1) 1600–1700	(2) 1700–1800	(3) 1600–1800
Ln(population 1600)	−0.1660*** (0.0576)		−0.0900** (0.0404)
Ln(population 1700)		−0.0761 (0.0608)	
Sulphur	0.0003 (0.0030)	−0.0002 (0.0028)	−0.0002 (0.0022)
Observations	47	56	50
R ²	0.159	0.029	0.097

Notes. 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 *Sulphur*, the number of sulphur 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.

increase the number of control variables.²⁹ Column 1 shows that, in a univariate regression (including a constant, as all regressions in all Tables), the estimated coefficient on sulphur, significant at the 1% level, is equal to 0.033, implying that a one standard deviation increase in sulphur leads to an increase in *maf_c* by more than one sixth of a standard deviation.³⁰ In light of the distribution of *maf_c* and sulphur, this effect appears important in magnitude (although, as one should expect, not huge) and it is highly significant. Moreover, as shown in the rest of this Section, it is very robust and stable both in magnitude and in significance. Given the clear identification provided by the exogenous shock in the value of sulphur resources we claim our findings to be causal. Column 2 adds department fixed effects. This is our first step in tackling the issue of whether differences in sulphur endowment pick up differences in other variables, which may matter for the mafia's emergence. Such fixed effects control for any characteristics that were common within a department. As previously mentioned, the administration of justice and law enforcement in Sicily were organised at the level of departments, so that these fixed effects are meant to capture heterogeneity also along this dimension.³¹ The result shows that, even within each department, municipality-level variations in sulphur endowment are positively and significantly associated to variations in early mafia presence (the point estimate is 0.022 and it is again significant at the 1% level).

²⁹ Since *maf_c* is an ordinal variable, we also estimate an ordered probit model; when doing so we obtain analogous results (available upon request).

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

³¹ Replicating the entire analysis of Table 3 using standard errors clustered at the level of departments delivers similar results, i.e. sulphur always enters with a positive and significant coefficient. A more accurate way of clustering standard errors using spatial techniques is presented later in this Section.

Table 3
Baseline Estimates

Dependent variable: Cutrera's index of early mafia presence (<i>maf_c</i>)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sulphur	0.0328*** (0.0105)	0.0224*** (0.0082)	0.0237*** (0.0089)	0.0228** (0.0091)	0.0234** (0.0092)	0.0239*** (0.0089)	0.0549*** (0.0127)
Citrus suitability			-0.0251* (0.0150)	-0.0155 (0.0151)	-0.0235 (0.0163)	-0.0227 (0.0166)	-0.0293 (0.0180)
Cereals suitability			0.0235** (0.0108)	0.0223** (0.0108)	0.0224** (0.0107)	0.0224** (0.0110)	0.0296*** (0.0111)
Olive suitability			-0.0037 (0.0119)	-0.0039 (0.0119)	0.0009 (0.0131)	-0.0016 (0.0129)	-0.0001 (0.0145)
Water scarcity			0.1267 (0.1986)	-0.0460 (0.1990)	-0.0231 (0.1923)	0.0057 (0.1933)	-0.0548 (0.2010)
Ruggedness				-0.0011 (0.0008)	-0.0010 (0.0008)	-0.0011 (0.0008)	-0.0006 (0.0009)
Different elevation				0.0004*** (0.0001)	0.0004*** (0.0001)	0.0005*** (0.0001)	0.0006*** (0.0002)
Postal roads					0.0811 (0.1008)	0.0975 (0.1002)	0.1470 (0.1127)
Distance to river					0.0101 (0.0092)	0.0045 (0.0094)	0.0091 (0.0101)
Distance to port					-0.0087 (0.0060)	-0.0034 (0.0069)	-0.0022 (0.0080)
Urban						0.1855 (0.1898)	0.0925 (0.2133)
Population density						0.0013*** (0.0005)	0.0012** (0.0005)
Land fragmentation							0.0961 (0.1315)
Department FEs	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	285	285	282	282	282	282	237
R ²	0.042	0.567	0.577	0.594	0.601	0.618	0.659

Notes. 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 nineteenth 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 *Sulphur* is the number of sulphur 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. In columns 1 and 2 the number of observations is 285, while in columns 3–7 it drops to 282 due to the fact that for three municipalities information for at least one of the control variables included in the regressions is missing. 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.

To minimise the risk that within-department variations in sulphur 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, transport and communication, socio-demographic variables and land fragmentation (always including department fixed effects). No matter which controls we include, sulphur remains highly significant and the magnitude of the coefficient is barely affected, suggesting that our main result is not driven by any omitted variable.³²

³² The coefficient on sulphur is only raised when we add land fragmentation to the controls. Yet, note 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.

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 the mafia's emergence was related to citrus cultivation (Gambetta, 1993; Lupo, 1993; Dickie, 2004; Del Monte and Pennacchio, 2012; Dimico *et al.*, 2012) and also to the mafia's possibility of controlling scarce water resources and thus having 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 development was related to citrus cultivation. Column 4 adds two geographic controls: average ruggedness and difference in elevation (Nunn and Puga, 2012; Michalopoulos, 2012). 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. 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 (Glaeser and Sacerdote, 1999; Buonanno *et al.*, 2012). In line with the literature, we find that population density is positively and significantly related to the mafia's emergence. Finally, column 7 adds land fragmentation, which according to Bandiera (2003) should be relevant to the mafia's emergence but we find no support for her thesis.

A common concern in the resource curse literature is that results may be driven by outliers. To address this aspect we replicate our econometric analysis excluding the two municipalities with a disproportionately high number of sulphur mines and, alternatively, using a robust estimator which down-weights observations with large residuals using the Huber weight function. In both cases, the magnitude of the coefficient on sulphur increases and is estimated even more precisely, which suggests that, if anything, our results are tempered by the presence of outliers.³³ As an additional robustness check, we estimate our baseline regression using instead of the number of sulphur mines (*sulphur*) a dummy (*sulphur_d*) that equals one for those municipalities with at least one sulphur mine. Using *sulphur_d* is important because we do not have information on the quantity of sulphur 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 sulphur. Table 4 reproduces the same specifications of Table 3 but it substitutes *sulphur_d* (the dummy for the presence of at least a sulphur mine in a municipality) for *sulphur*. For the sake of space, we only report the coefficient of *sulphur_d*. Results show that, even if we neglect the information on the intensive margin of sulphur extraction and only rely on the extensive margin, the presence of sulphur is still significant to explain the mafia's emergence. Yet, the slight decrease in significance levels also suggests that the intensive margin was relevant as well.

As an additional check we control for possible spatial effects. There is no reason to believe that the mafia's activity follows the administrative boundaries of municipalities.

³³ Both sets of results, not shown here, are available upon request. The two municipalities are Enna and Caltanissetta which display respectively 61 and 52 sulphur mines.

Table 4
Baseline Estimates with Sulphur Dummy

	Dependent variable: Cutrera's index of early mafia presence (<i>maf_c</i>)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sulphur dummy	0.5532*** (0.1762)	0.3594 (0.2193)	0.4501** (0.2286)	0.3968* (0.2370)	0.4165* (0.2449)	0.4916** (0.2237)	0.4550*** (0.2168)
Department FEs	No	Yes	Yes	Yes	Yes	Yes	Yes
Suitability and water	No	No	Yes	Yes	Yes	Yes	Yes
Geomorphological	No	No	No	Yes	Yes	Yes	Yes
Distances	No	No	No	No	Yes	Yes	Yes
Sociodemographic	No	No	No	No	No	Yes	Yes
Land fragmentation	No	No	No	No	No	No	Yes
Observations	285	285	282	282	282	282	237
R ²	0.033	0.559	0.570	0.587	0.593	0.613	0.639

Notes. 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 nineteenth 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, Sulphur dummy, is a dummy taking value one if the number of sulphur 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. In columns 1 and 2 the number of observations is 285, while in columns 3–7 it drops to 282 due to the fact that for three municipalities, information for at least one of the control variables included in the regressions is missing. 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.

Mafia lords may indeed offer protection and practise extortion in neighbouring 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 activity in a municipality just because the mafia is active in neighbouring municipalities. There may therefore be relevant spatial spillovers from a municipality to its neighbours. 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 generalised spatial two stage least squares (GS2SLS) estimator of Kelejian and Prucha (1998). Results are presented in Table 5, which reproduces the same specification of column 6 of Table 3 in panel (a) (i.e. using sulphur as an explanatory variable) and the same specification of column 6 of Table 4 in panel (b) (i.e. using sulphur dummy as an explanatory variable). We employ both a non-standardised (columns 1 to 3) and a row-standardised (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).

Allowing for a spatial structure in our data does not alter our baseline estimates: independently of how we specify the spatial model, the coefficient of sulphur (and sulphur dummy) is extremely stable in magnitude and is always highly significant. While the coefficients on the spatial structure do not show a stable and consistent pattern across specifications, they are often significant when using the row-standardised contiguity matrix, suggesting that mafia activity in neighbouring municipalities might indeed be relevant and thus spatial estimates are justified. Looking at the full model reported in column 6, in both panels the positive coefficient on the spatial error is in line with intuition, while the negative coefficient of the spatial lag is consistent with mafia families endogenously locating at a sufficiently large distance from other families.

4.2. 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 3, with the same specification, but substituting *maf_d* for *maf_c*. Since estimates exploit district-level information on mafia 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 regressions, the estimated coefficient on sulphur is strongly significant and is extremely stable, suggesting that our results are not driven by either the specific mafia measure used or 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 other contributions. In particular, Bandiera

Table 5
Spatial Estimates

Dependent variable: Cutrera's index of early mafia presence (<i>maf_c</i>)						
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel (a)</i>						
Sulphur	0.0229*** (0.0072)	0.0230*** (0.0071)	0.0227*** (0.0072)	0.0211*** (0.0071)	0.0227*** (0.0071)	0.0231*** (0.0066)
λ	0.0062 (0.010)		0.0043 (0.010)	0.4337*** (0.131)		0.5776*** (0.115)
ρ		0.0257 (0.022)	0.0188 (0.025)		0.1151 (0.102)	-0.4495*** (0.149)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	280	280	280	280	280	280
<i>Panel (b)</i>						
Sulphur dummy	0.4680*** (0.1811)	0.4774*** (0.1807)	0.4654*** (0.1816)	0.4417** (0.1791)	0.4618*** (0.1798)	0.4896*** (0.1694)
λ	0.0103 (0.010)		0.0084 (0.010)	0.4082*** (0.135)		0.5326*** (0.122)
ρ		0.0304 (0.021)	0.0175 (0.025)		0.1254 (0.099)	-0.3848*** (0.153)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	280	280	280	280	280	280

Notes. This Table presents the results of a spatial model estimated by means of the generalised 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 3. Columns 1 to 3 employ a non-standardised contiguity matrix, while a row-standardised 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 the nineteenth 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 in panel (a), Sulphur, is the number of sulphur mines as collected by Squarzina (1963), while the other control variables are described in the main text (excluding the fragmentation index). In panel (b), the main explanatory variable is a dummy taking value one when Sulphur is positive. 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 6
District-Level Estimates

Dependent Variable: Damiani-Jacini's Index of Early Mafia Presence (<i>maf_d</i>)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sulphur	0.0354*** (0.0080)	0.0318*** (0.0115)	0.0325*** (0.0116)	0.0327*** (0.0117)	0.0326*** (0.0121)	0.0347*** (0.0122)	0.0322** (0.0127)
Citrus suitability			0.0413 (0.0315)	0.0483 (0.0324)	0.0444 (0.0344)	0.0399 (0.0351)	0.0378 (0.0352)
Cereals suitability			-0.0034 (0.0193)	0.0024 (0.0188)	0.0022 (0.0196)	0.0042 (0.0197)	0.0016 (0.0201)
Olive suitability			-0.0203 (0.0180)	-0.0203 (0.0177)	-0.0212 (0.0198)	-0.0207 (0.0199)	-0.0155 (0.0210)
Water Scarcity			0.2763* (0.1678)	0.2842 (0.1730)	0.2669 (0.1711)	0.2365 (0.1720)	0.2078 (0.1820)
Ruggedness				0.9873 (2.1534)	1.2538 (2.2252)	0.9421 (2.2031)	0.6733 (2.1898)
Different elevation				0.0002 (0.0002)	0.0002 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)
Postal roads					0.2210 (0.1906)	0.2877 (0.1947)	0.2680 (0.1993)
Distance to river					0.0026 (0.0177)	-0.0022 (0.0182)	-0.0040 (0.0184)
Distance to port					-0.0009 (0.0126)	0.0016 (0.0145)	0.0002 (0.0144)
Urban						-0.1216 (0.4075)	-0.1115 (0.4097)
Population density						0.0014* (0.0008)	0.0014* (0.0008)
Land fragmentation							-0.1847 (0.2467)
Department FEs	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	158	158	158	158	158	158	158
R^2	0.105	0.232	0.249	0.259	0.266	0.283	0.288

Notes. 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 on a 0 to 3 scale (0 is no mafia activity, 3 is large mafia activity). The main explanatory variable *Sulphur* is the number of sulphur 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.

(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 favoured the 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 3, based on 237 municipalities, do not support their arguments.

4.3. Neighbour-pair Fixed Effects

So far we have presented consistent and robust findings, documenting the significant effect of the presence of sulphur on the mafia's origins. Since sulphur is not randomly

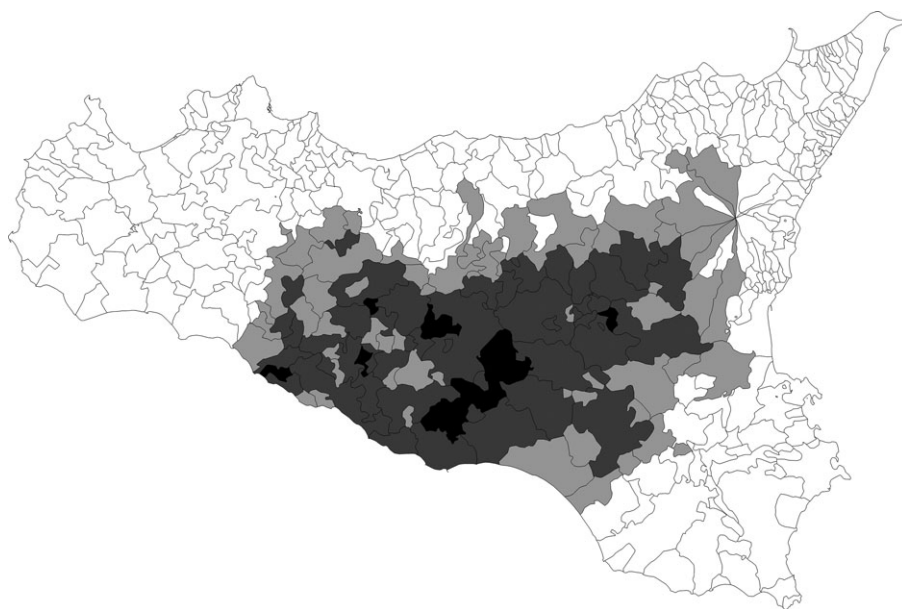


Fig. 4. *Municipalities with Sulphur Mines and their Neighbours*

Notes. White municipalities are excluded from the analysis because both they and their neighbours do not host sulphur. Light grey municipalities are those 54 without sulphur that have neighbouring municipalities with sulphur (the 35 in dark grey). Black municipalities are excluded because, even if endowed with sulphur, they do not neighbour any non-sulphur municipality.

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 sulphur endowment do not pick up the effects of some other characteristics, which may be relevant for mafia emergence. In this Section, we go even deeper and, rather than comparing municipalities with different sulphur endowments within a given department, we follow Acemoglu *et al.* (2012) and exploit variations in sulphur endowments across direct neighbours.

In particular, we restrict our analysis to the 48 municipalities which have sulphur mines and the 54 municipalities without sulphur mines which are adjacent to them.³⁴ As in Acemoglu *et al.* (2012), we implement the neighbour-pair fixed effects estimator, very similar to a matching methodology and to a regression discontinuity design, comparing each sulphur-mining municipality to each of its direct neighbours without sulphur. Figure 4 visually presents municipalities with sulphur mines and their neighbours.

This empirical strategy makes it possible to control directly for unobservables that are common across adjacent municipalities by including neighbour-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,

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

Table 7
Neighbour-pair Fixed Effect Estimates

Dependent variable: Cutrera's index of early mafia presence (<i>maf_c</i>)						
	(1)	(2)	(3)	(4)	(5)	(6)
Sulphur	0.0206*** (0.0061)	0.0172** (0.0073)	0.0231** (0.0093)	0.0216** (0.0094)	0.0196** (0.0094)	0.0207*** (0.0055)
Neighbour-pair FEs	No	Yes	Yes	Yes	Yes	Yes
Suitability and water	No	No	Yes	Yes	Yes	Yes
Geomorphological	No	No	No	Yes	Yes	Yes
Distances	No	No	No	No	Yes	Yes
Sociodemographic	No	No	No	No	No	Yes
Observations	162	162	162	162	162	162
R ²	0.054	0.637	0.667	0.672	0.681	0.795

Notes. 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 sulphur and its neighbour 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 the nineteenth 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 *Sulphur* is the number of sulphur mines as collected by Squarzina (1963), while the other control variables are described in the main text. Neighbour pair 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.

labour market, geography) and are likely to be very similar across any other unobservables. Within the neighbour pair, we claim that the exogenous source of variation in mafia activity is the presence of sulphur mines.

Formally, we define with S the subset of municipalities with sulphur mines and with $N(s)$ all the adjacent municipalities without sulphur mines of each element of S . We use s and i to index municipalities with and without sulphur mines, respectively. We estimate the following model by means of OLS:

$$maf_c_s = \beta sulphur_s + \gamma \mathbf{X}'_s + \psi_{si} + v_s \quad s \in S, \quad (1)$$

$$maf_c_i = \beta sulphur_i + \gamma \mathbf{X}'_i + \psi_{si} + v_i \quad i \in N(s) \quad (2)$$

where \mathbf{X}'_t collects municipality-level controls, ψ_{si} represents common unobservables for the neighbour pair (s, i) and v_t represents municipality-specific unobservables ($t = s, i$). Neighbour-pair fixed effects estimates are presented in Table 7. For simplicity, we only present the coefficient on sulphur but, consistently with Table 3, we progressively add all the controls described in the previous Section. The coefficient of sulphur in the neighbour-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 sulphur endowment in the mafia's emergence.

4.4. Mafia Persistence

Although the main purpose of our research is to shed light on the historical determinants of the mafia's emergence, we are also interested in understanding to what extent these factors have had persistent effect on the presence of the mafia today.

Table 8
Persistence

	Council	Real estates	Firms	Theft	Burglary	Car theft	Robbery
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<i>maf_c</i>	0.0706*** (0.0187)	0.1477*** (0.0325)	0.1524*** (0.0277)	-183.9049*** (52.9439)	3.1591 (10.1428)	-28.3848*** (9.4874)	-2.2930 (2.0695)
Observations	282	282	282	282	282	282	282

Notes. This Table presents the results of instrumental variable estimates in which the first stage is specification presented in column 2 of Table 3 (i.e. *maf_c* regressed on sulphur 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 was dissolved due to mafia infiltration over the period 1991 to 2011 (source: Ministero dell'Interno), Real estate 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 equal 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.

In particular, we analyse 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's 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 if the municipality council was dissolved due to mafia infiltration over the period 1991 to 2011 (source: Ministero dell'Interno) and two dummies equal to one respectively, if at least a firm and at least a real estate/property have been seized by the Italian judicial authority in the municipality by the end of 2011 (source: Agenzia del Demanio).³⁵ It is worth noting that over the considered period more than 10% of Sicilian municipalities were dissolved and firms and real estate properties were seized in more than 23% and 44% of Sicilian municipalities respectively. Moreover, 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 might 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 we regress current day mafia (and other crime rates) on instrumented historical mafia. In particular, the first stage is the specification presented in column 2 of Table 3 (i.e. *maf_c* regressed on sulphur and department fixed effects) and the second stage is a measure of crime today regressed on the instrumented measure of historical mafia (i.e. *maf_c*). Instrumental variable estimates, presented in Table 8, show a strong effect of early mafia on today's mafia presence, confirming the persistence of the phenomenon

³⁵ 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 organisations.

over time. Moreover, other crime rates (i.e. theft, burglary, car theft and robbery) are in some cases negatively affected by the mafia's historical presence, suggesting that the mafia's territorial and social control acts as a deterrent of non-mafia-related crimes.

5. Conclusions

Under weak institutions, a boom in the value of natural resources may raise both the demand for private protection and the opportunities for rent appropriation through extortion, thus favouring the emergence of mafia-type organisations, since they have a competitive advantage in such activities, and thus translating in a resource curse with potentially persistent consequences. We investigate the validity of this argument empirically for the specific case of the origins of the Sicilian mafia, which emerged in the mid-nineteenth century, when the widespread power vacuum created by the collapse of the Bourbon Kingdom coincided with the soaring international demand for Sicilian sulphur. Our evidence, based on a newly collected municipality-level dataset, shows a significant and robust effect of sulphur endowments on early mafia activity. We claim this effect to be causal, since sulphur is exogenously distributed as any natural resource, it is easily discoverable in Sicily since it is mainly superficial, and until the beginning of nineteenth century it was almost commercially useless. Our findings are robust to the inclusion of several controls, including fixed effects for small areas, to the use of mafia measures at different aggregation levels, allowing for a well-defined spatial structure of the data and even to the inclusion, in an Regression Discontinuity Design fashion, of fixed effects for pairs of adjacent municipalities, with and without sulphur mines.

In addition to documenting the causal effect of sulphur endowments on the origins of the Sicilian mafia, we review and further test the effect of alternative factors that have been proposed as possible determinants of the emergence of the mafia; we show that, when appropriately accounting for local fixed effects and other municipal controls, none of them appear to display an empirically robust effect.

University of Bergamo
Sciences Po
University of Bologna
University of Bologna

Additional Supporting Information may be found in the online version of this article:

Appendix A. Role of Citrus Cultivation.

Data S1.

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