DISCUSSION PAPER SERIES

DP15008

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DEVELOPMENT ECONOMICS

ECONOMIC HISTORY

ISSN 0265-8003

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Discussion Paper DP15008
Published 07 July 2020
Submitted 04 July 2020

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Abstract

The Messina-Reggio Calabria Earthquake (1908) was the deadliest earthquake and arguably the most devastating natural disaster in modern European history. It occurred when overseas mass emigration from southern Italy was at its peak and international borders were open, making emigration a widespread phenomenon and a readily available option for disaster relief. We use this singular event and its unique and important context to study the effects of natural disasters on international migration. Using commune-level data on damage and annual emigration, we find that, despite massive destruction, there is no evidence that the earthquake had, on average, a large impact on emigration or its composition. There were, however, heterogeneous and offsetting responses to the shock, with a more positive effect on emigration in districts where agricultural day laborers comprised a larger share of the labor force, suggesting that attachment to the land was an impediment to reacting to the disaster through migration. Nonetheless, relative to the effects of ordinary shocks, such as a recession in the destination, this momentous event had a small impact on emigration rates. These findings contribute to literatures on climate- and disaster-driven migration and on the Age of Mass Migration.

JEL Classification: F22, J61, O15, N3, Q54

Keywords: migration, Natural Disasters, Refugees, Italy, US Immigration, Age of Mass Migration

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Acknowledgements
For helpful comments, we thank Christina Gathmann, Gaia Narciso, Cormac Ó Gráda, Laura Panza, Dean Yang; seminar participants at Vanderbilt University, Trinity College Dublin, and the University of Heidelberg; and conference participants at the 2019 Economic History Workshop of the Associazione per la Storia Economica and the 2019 European Historical Economics Society Conference. We are grateful to Peg Zitko and the Statue of Liberty-Ellis Island Foundation for providing data. Christine Chang, Jongoh Kim, Elizabeth Nelson, Sarah Robinson, Claire Whittaker, and Danielle Williamson provided excellent research assistance. Gaspare Tortorici acknowledges funding from the Irish Research Council. Work on this paper was completed while Ariell Zimran was a W. Glenn Campbell and Rita Ricardo-Campbell National Fellow and the William C. Bark National Fellow at the

Hoover Institution, Stanford University; funding from the Hoover Institution is gratefully acknowledged. This material is based upon work supported by the National Science Foundation under Grant No. SES-1425598. Additional financial support was provided by the Northwestern University Economics Department's Eisner Fund, the Northwestern University Center for Economic History, the Balzan Foundation, and an Exploratory Data and Travel Grant from the Economic History Association.

International Migration Responses to Natural Disasters: Evidence from Modern Europe's Deadliest Earthquake

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1 Introduction

How do major natural disasters affect international migration? Interest in this question has grown recently, in part due to increased attention to the dangers of climate change. But the answer is both theoretically and empirically ambiguous (e.g., Berlemann and Steinhardt 2017; Black et al. 2013; Mahajan and Yang 2020). International migration can serve as an adjustment mechanism and provide relief in the face of negative economic shocks (e.g., Mahajan and Yang 2020; Ó Gráda 2019; Ó Gráda and O'Rourke 1997). On the other hand, disasters might hinder migration by tightening liquidity constraints (Cattaneo and Peri 2016), generating remittances or other financial inflows to affected areas (Yang 2008a), or creating exigencies or economic opportunities at home (Halliday 2006). Indeed, a number of studies have found that international migration may be unaffected or reduced by natural disasters (e.g., Beine, Noy, and Parsons 2019; Beine and Parsons 2015; Cattaneo and Peri 2016; Nawrotzki and DeWaard 2018). But this evidence comes almost entirely from studies of events occurring in recent decades—a period of stringent legal restrictions on international migration. A complete understanding of the effect of natural disasters on international migration in the absence of such barriers is still lacking.

In this paper we study, for the first time, the effect of a major natural disaster on international migration in a unique and historically important setting of open borders and pre-existing mass migration. The Messina-Reggio Calabria Earthquake of 1908 was the most deadly and destructive earthquake, and arguably the most devastating natural disaster of any kind, in modern European history,[1] killing as many as 120,000 people and causing massive destruction to buildings and infrastructure throughout Sicily and Calabria (Dickie 2008; Dickie and Sayer 2005; Parrinello 2015; Risk Management Solutions 2008). The historical importance of this shock is compounded by the unique setting in which it struck. The earthquake occurred at the peak of the Age of Mass Migration (1840–1914), during which over 50 million Europeans migrated to the New World (Abramitzky and Boustan 2017; Hatton and Ward 2019; Hatton and Williamson 1998), enabled by open borders and drawn by high expected returns (Abramitzky, Boustan, and Eriksson 2012).[2] Italy was a leading country in this movement, sending hundreds of thousands of emigrants each year to North and South America, as well as to other countries in Europe, in what amounted to one of the largest free flows of international migration in world history (Foerster 1919; Gomellini and Ó Gráda 2013; Spitzer and Zimran 2020). The earthquake-affected regions of Sicily and Calabria had just come to the forefront of

[1] Another candidate would be the 1755 Lisbon earthquake, which is estimated to have killed between 10,000 and 100,000 people, with most estimates in the lower range (Pereira 2009, p. 468).

[2] Of these, about 30 million were bound for the United States (Abramitzky and Boustan 2017; Hatton and Williamson 1998).

this movement, with average annual emigration rates of about 2.6 and 3.6 percent, respectively, in the four years prior to the earthquake. The region thus had sufficient prior exposure to migration to develop thick networks of prior migrants (Spitzer and Zimran 2020). These factors made international migration a familiar, attractive, and relatively easy option of disaster relief for the affected population. We ask whether and under what circumstances this option was used.

Our analysis is based on a dataset of annual emigration rates for every commune in Italy for the pre-World War I period, and we focus on the period 1905–1912.[3] This dataset is based on two complementary sources—passenger manifests of Italians arriving at the Port of New York (Spitzer and Zimran 2018) and official Italian emigration data (Spitzer and Zimran 2020). We combine these data with commune-level measures of damage from the earthquake (Guidoboni et al. 2007) and district-level data on the Italian labor force from the 1901 Italian census.[4] We use difference-in-differences and event study specifications to determine whether the emigration trends of severely damaged communes in Sicily and Calabria differed from those of other communes in those regions following the earthquake.[5]

Our main finding is that there is no evidence of a large impact of the earthquake on emigration from affected communes as a whole. Similarly, we find no evidence of an impact of the earthquake on the demographic composition (i.e., age and gender) of migrants. Our preferred point estimates suggest a small and transitory *decline* in emigration of about 8 percent in the first year after the shock in communes experiencing severe damage relative to other communes in Sicily and Calabria; in the four years after the earthquake, the average severely damaged commune experienced a decline in emigration of less than six percent. While limited statistical power prevents precise estimation of this effect, the standard errors of our estimates are sufficiently small to enable us to conclude that the impacts of the earthquake were, in fact, small as compared to some relevant benchmarks. For instance, the Panic of 1907, which led to a recession in the United States and sharp declines in US immigration, was associated with at least a 75-percent decline in emigration in the year prior to the earthquake. We can easily rule out such a magnitude for the estimated effect of the earthquake. Our estimates are also small when compared to the estimated impacts on migration of other natural and man-made disasters, such as modern hurricanes (Mahajan and Yang 2020), pogroms (Boustan 2007; Spitzer 2016), and the Dust Bowl (Long and Siu 2018).[6] This negligible impact is striking

[3]That is, the data areat the level of the Italian *comune*, of which there were approximately 8,000 in the study period.

[4]We use the term "district" to refer to the Italian units of *circondario* or *distretto*. These were the next highest administrative unit above the commune, and there were 284 such units in Italy in the study period. The earthquake-affected regions had only *circondari*.

[5]We also present analyses in which the sample includes all of Italy, and in which the unit of analysis is the district or province rather than the commune.

[6]We also compare our estimates to those of Ager et al. (2020), Boustan, Kahn, and Rhode (2012), Boustan et al. (2017), Lange, Olmstead, and Rhode (2009), and Sichko (2020), who study the effects of natural disasters on migration in other

in light of the extreme toll of the earthquake in lives and capital, the disruption of economic activity that it induced, the large (but short-lived) internal refugee movement that it created, the slow reconstruction that followed it, and the ubiquity of mass migration in the affected regions.

We do, however, find evidence of heterogeneous and offsetting effects of the earthquake on emigration from areas with different labor market compositions. In particular, we find that communes from districts with a greater share of the labor force employed as agricultural day laborers experienced a greater increase in emigration in response to the earthquake.[7] Though we cannot definitively rule out that this result reflects heterogeneity with respect to employment in agriculture more generally (rather than of employment in agricultural day labor specifically) on emigration responses, our finding of heterogeneous responses with respect to employment in agricultural day labor is robust to controlling for different earthquake reactions by areas with different shares of labor in agriculture of any form (i.e., owners, renters, sharecroppers, etc.). This result is consistent with the hypothesis that the earthquake generated migration by individuals who (among the agricultural classes) were most weakly attached to the land, but reduced it among individuals with a greater attachment, such that attachment to the land acted as an obstacle to adjusting to the shock through migration. This mechanism is also consistent with the "greater exigencies" explanation for reduced migration after natural disasters (Halliday 2006), which would tend to incentivize those more attached to the land to remain due to greater returns to labor devoted to reconstruction within the household or the commune.

This paper contributes to three main literatures. Most narrowly, it adds to the literature on the effects of the Messina-Reggio Calabria Earthquake. Given its significance in Italian history, this event has been the object of repeated scholarly investigations over more than a century (e.g., Dickie 2008; Dickie and Sayer 2005; Mercalli 1909). Debates continue regarding the toll of the earthquake in lives and damage, as well as on the magnitude of population movements in its wake (e.g., Caminiti 2009; Mortara 1913; Parrinello 2012; Restifo 1995). But to our knowledge, international migration in response to the disaster—a potentially important margin of response in this context given the high levels of migration prior to the shock—has not been studied. Understanding the reaction of international migration in response to the shock is fundamental to a complete history of this important event.

This paper also adds to the literature on the Age of Mass Migration, which has expanded in recent years as new data have been brought to bear on fundamental questions of the economics of migration.[8] However,

contexts.

[7]Although our analysis is at the commune level, the district is the finest level at which occupational distributions are available.

[8]See Abramitzky and Boustan (2017) and Hatton and Ward (2019) for surveys of this literature.

advances in understanding the determinants of migration in this context have been more limited (c.f., Gray, Narciso, and Tortorici 2019; Karadja and Prawitz 2019; Spitzer 2016; Spitzer and Zimran 2020). We advance the literature on this front by studying the role of sudden shocks to the home economy in generating emigration. This paper also contributes to the important but long-dormant debate over whether migration during the Age of Mass Migration was primarily shaped by push factors inherent to the home economy or by pull factors inherent to the destination (e.g., Gould 1979). By showing that even an enormously destructive shock to the origin had a small impact relative to business-cycle variation in the destination, we add to the body of evidence supporting the primacy of pull factors (e.g., Boustan 2007; Hatton and Williamson 1998; Jerome 1926; Kuznets 1958).

Finally, this paper contributes to the literature on the effects of natural and man-made disasters on migration, and thus to the broader literature on climate- and disaster-driven migration (Myers 2002). Our finding that a shock as cataclysmic as the Messina-Reggio Calabria earthquake had no meaningfully positive impact on international migration, despite the availability of this option and the absence of legal restrictions to migration, is an important addition to the recent accumulation of evidence demonstrating no or negative effects of natural disasters and other climatic shocks on international migration (e.g., Beine and Parsons 2015; Cattaneo and Peri 2016; Gröschl and Steinwachs 2017; Halliday 2006; Hunter, Murray, and Riosmena 2013). But our focus on a context of open borders and ubiquitous pre-shock mass migration enables us to conclude that this lack of an effect was likely the product of incentives and not of political or economic barriers to migration. Indeed, if ever there were a case in which a natural disaster would be expected to generate migration, it is in the context that we study of easy and widespread migration and a devastating shock. Our finding of the absence of a large effect is important in forming expectations regarding the potential for population movements after natural disasters, which is a particularly pressing question given the anticipated increase in the frequency of natural disasters due to climate change: the effects of these shocks may be more nuanced than simple intuition would suggest.

2 Background

2.1 The Earthquake and its Aftermath

The Messina-Reggio Calabria Earthquake struck on December 28, 1908. The magnitude 7.1 earthquake shook the Strait of Messina and its surroundings, including the twin cities of Messina and Reggio Calabria on either side. A severe tsunami hit the coastline shortly thereafter with waves as high as 40 feet (Risk

Management Solutions 2008). The scale of the damage was unprecedented, causing the earthquake to be regarded as one of the most destructive natural disasters in modern European history (Dickie 2008). The area's main cities, Messina and Reggio Calabria, were almost entirely destroyed (Baratta 1910); in Messina, for instance, over 90 percent of buildings were demolished (Dickie 2008). Estimates of the number of deaths caused by the earthquake and tsunami range from 90,000 to 120,000,[9] most of which were concentrated in the two urban centers along the Strait of Messina. In the municipality of Messina alone, an estimated 30,000 to 60,000 inhabitants were killed relative to a 1901 population of just under 150,000 (Dickie 2008).[10] Countless more were injured or lost their homes. The damage was so unprecedented in its severity that Giuseppe Mercalli, the renowned seismologist who created the widely used measure of material damage caused by an earthquake, added a new intensity degree to his eponymous scale to describe the damage—XI, *catastrofe* (e.g., Tertulliani 2014).

Outside of the major urban centers, many smaller communities were also reduced to rubble. Figures for Sicily are lacking, but detailed data are available on damage for all communes in the province of Reggio Calabria. In the average commune there (excluding Reggio Calabria itself), about 23 percent of buildings were completely destroyed and another 24 percent were heavily damaged, with more severe damage in the district of Reggio Calabria than in the districts of Palmi and Gerace Marina (Baratta 1910, pp. 198–207); see Figure 1 for a map of districts in the affected area. Some case studies for which more anecdotal information is available are illustrative. For instance, Palmi, a smaller Calabrian commercial center near the Tyrrhenian coast (pop. 13,346 in 1901), and Sant'Eufemia d'Aspromonte, a nearby uphill town (pop. 6,285 in 1901), were "dead," according to the Bishop of Palmi (Liberti 1993): Palmi had an estimated 700 dead and 1,000 wounded; out of 2,221 buildings, 445 houses were completely destroyed, 1,189 irreparably damaged, and 387 more lightly damaged; Sant'Eufemia d'Aspromonte had 839 dead; out of 1,200 buildings, only 100 survived (and were badly damaged) and the rest were destroyed (Baratta 1910, pp. 198–207).

The earthquake also led to considerable population displacement. At least 66,000 refugees are estimated to have left Messina in the immediate aftermath of the earthquake,[11] traveling mainly to other large Sicilian cities and to Naples: according to the official refugee census conducted in January and March 1909, there were about 20,000 refugees in Catania, 11,000 in Palermo, 2,600 in Syracuse, and 8,000 in Naples (Parrinello 2012). But there are indications that this flow was short-lived, as Restifo (1995, p. 562) reports that "immediately

[9] Caminiti (2009), Guidoboni and Mariotti (2008), Parrinello (2012), and Restifo (1995, 2008) provide a deeper investigation of these estimates. The uncertainty is primarily a result of the conflicting estimates of the death toll in Messina, which we discuss in further detail below.

[10] In comparison, the death toll caused by the 1906 San Francisco earthquake is estimated at around 3,000 individuals (Ager et al. 2020).

[11] Archivio Centrale dello Stato, Categoria 10, Fascicolo 31.

following the exodus from the scene of the disaster, a counter-exodus began." We discuss evidence below that supports this view of a rapid return to the affected area, and the ways in which internal displacement may affect the interpretation of our results.

Reconstruction after the earthquake proceeded slowly. The new anti-seismic urban regulation plans for the cities of Messina and Reggio Calabria were only approved in 1911. As a result, in 1911, more than 60,000 people in Messina still lived in temporary housing; even by 1922 this figure was more than 70,000 for people on either side of the Strait. Messina and Reggio Calabria were in many ways still large construction sites even after World War I (Farinella and Saitta 2019), and by the early 1920s, only about 1,500 buildings in Messina had been rebuilt (Saitta and Oriti 2013). Delayed reconstruction also appears to have been the norm in smaller towns in the area. In Palmi, for instance, there were difficulties in obtaining the materials to construct temporary shelters, and the distribution of reconstruction resources was reportedly stifled by a patronage system that was prone to misallocation. In some cases, the frustration with slow reconstruction led to protests and riots, which turned deadly in the case of the town of Sinopoli (Teti 2008).

Despite the sluggish reconstruction, the population of the cities of Messina and Reggio Calabria rebounded quickly (Parrinello 2012; Restifo 1995). According to census figures for 1911, their immediate population loss through deaths and refugee flight had been largely reversed. As shown in Table 1, Messina in 1911 had 126,557 inhabitants relative to 149,778 in 1901 and Reggio Calabria had 43,162 in 1911 relative to 44,415 in 1901. Thus, any immediate outflow of refugees appears to have returned relatively quickly. According to the traditional view of the Messinesi, this rapid recovery was largely due to an inflow of people from the hinterland attracted by the demand for reconstruction labor. Indeed, Messinesi call their hometown "a city without memory," in reference to the destruction of almost all historical buildings and to perceptions that internal migrants seeking reconstruction labor completely replaced the pre-earthquake population (Dickie and Sayer 2005). A more detailed examination of Italian census figures from 1901 and 1911, however, reveals that this local myth is untrue.[12] Table 1 presents data on the population of the cities of Messina and Reggio Calabria by place of birth from 1901 and 1911 population census data.[13] Two years after the disaster, 83.8 percent of Messina's 126,557 residents were listed as natives of the city, whereas only 6.2 percent were born elsewhere in the province of Messina (even less than their share in 1901), 4.9 percent were born elsewhere in Sicily, and 1.9 percent were born in the region of Calabria; figures for Reggio Calabria in Table 1 also indicate a general persistence of population, though the fraction locally born did decline from 83.7 percent

[12]We are not able to rule out a situation in which the residents of the city center were replaced by migrants from outlying *frazioni*, or villages, within the commune of Messina—that is, movement from the outer districts of the city to the city center.

[13]Unfortunately, similar data are not available for smaller towns in the affected areas.

in 1901 to 75.4 percent in 1911, indicating that internal migration was more important in Reggio Calabria than in Messina.[14]

These figures also indicate that any flow of internal migrants from Messina's hinterland after the earthquake into the city paled in comparison to the size of international emigration flows. In particular, even the stock of internal migrants in Messina was small when compared to an average of over 15,600 international emigrants per year from the province of Messina over the period 1905–1908 (of which over 13,000 per year were from communes other than Messina).[15] Thus, local folk history notwithstanding, internal migration and the demand for reconstruction labor in the two major cities of the area was not sufficiently large to absorb flows that would have constituted a positive international migration response had they been redirected abroad.

Finally, the figures in Table 1 make us skeptical of the higher range of the estimates for deaths in Messina. Table 1 shows that 84.8 percent of Messina's residents in 1901 were born in Messina. If the 60,000 deaths were randomly allocated by place of birth, this implies 50,880 deaths of Messina-born individuals, leaving 76,137 Messina-born individuals alive. Table 1 also shows that in 1911 there were 106,025 residents of Messina who were born in that commune—a gain of 29,888 individuals. This number is far too large to be explained by new births, particularly given the fact that there were only about 37,000 individuals aged 0–15 in Messina in 1911 and that subsequent deaths and the departure of refugees and emigrants have not been accounted for in this calculation.[16]

Surprisingly, very little is known about international migration as a response to the earthquake, despite the fact that the area was in the midst of an unprecedented mass emigration at the time of the shock. As we argue below, this option potentially provided cheap and readily available access for relief to the tens of thousands of inhabitants who had lost their homes and their livelihoods. Indeed, according to a survey of refugees from Messina in Naples in April 1909, half of the 1,000 respondents indicated an intention to migrate (either internally or overseas), "especially [to] the United States" (Parrinello 2012, p. 39). Importantly, there is no evidence that the earthquake itself posed a direct obstacle to migration by disrupting travel: although Messina was the sixth most important maritime hub in Italy in terms of yearly traffic, its importance as a point of embarkation for transatlantic migration paled in comparison to that of Palermo, Naples, and

[14]The *Movimento dello Stato Civile* also shows evidence of an increase in internal migration to the province of Reggio Calabria after 1908, but a decline in internal migration to the province of Messina.

[15]In Reggio Calabria, 75.4 percent of the 43,162 residents in 1911 were natives of the city, whereas 11.3 percent were born elsewhere in the province of Reggio Calabria, 1.7 percent were born elsewhere in Calabria, and 4.2 were born in Sicily, as compared to over 14,300 international emigrants per year over the period 1905–1908.

[16]Of course, this calculation cannot account for return migration from abroad and elsewhere in Italy, but the fact that the *Movimento dello Stato Civile* counts only 10,862 immigrants to the entire province of Messina from 1909–1911, suggests that such internal migration was of limited importance.

Genoa.[17] Whether the affected population responded to the disaster through this channel remains an open question with important implications for a complete understanding of this event and for the economics of disaster-induced migration.

2.2 Natural Disasters and Migration: Theory and Evidence

Natural disasters can affect migration incentives in a number of conflicting ways. Among other channels, disasters may affect the operation of markets for labor and goods; household decisions on consumption, saving, and insurance; financial flows; private and public investment; and technological change. Despite the simple intuition that negative shocks are bad for the local economy and therefore should strengthen push factors, economic theory does not clearly indicate either positive or negative effects of natural disasters on migration. Consequently, much of our understanding of the effects of natural disasters on migration depends on the empirical evidence, most of which comes from a literature motivated by the goal of understanding the effects of climate change on population movements in developing countries in recent decades (see surveys by Berlemann and Steinhardt 2017; Black et al. 2013). This literature has identified several important mechanisms by which natural disasters have been shown to affect migration and the evidence in the literature.

The simplest mechanism for an effect of natural disasters on migration is by augmenting push factors. By destroying productive capital, buildings, and infrastructure and by displacing labor, natural disasters hamper productive activity and trade. This can translate into a reduction in wages and household income in the place of origin (Baez and Santos 2008; Banerjee 2007; Cai et al. 2016; Gröger and Zylberberg 2016). More broadly, there is evidence that these shocks have persistent long-run negative effects on individual standards of living (Caruso 2017), on regional economic trajectories (Hornbeck 2012), and on national economic growth (Hsiang and Jina 2014; Skidmore and Toya 2002). The destruction of residential capital—probably the most notable feature of the Messina-Reggio Calabria Earthquake outside of the loss of life—is a shock to standards of living and a major wealth shock; moreover, it is a wealth shock that is shared within the community, which makes it harder to cope by employing local informal insurance mechanisms. With wages reduced, homes damaged or destroyed, and lacking the financial safety provided by the value of private residential real estate, the option of staying becomes less attractive. Indeed, there is ample evidence that natural disasters and climatic shocks have the capacity to cause massive displacement—short-term and short-distance internal migration—much like the well documented but short-lived stream of internal refugees in the wake of the Messina-Reggio Calabria Earthquake (e.g., Gray and Mueller 2012; Gröger and Zylberberg 2016; Penning-Rowsell, Sultana,

[17] From the Statue of Liberty-Ellis Island Foundation data that we describe below, were were able to determine that only about 4 percent of Italians arriving at Ellis Island between 1904 and 1908 embarked in Messina.

and Thompson 2013; Robalino, Jimenez, and Chacón 2015), and permanent long-distance internal migration (Boustan, Kahn, and Rhode 2012; Hornbeck 2012; Hornbeck and Naidu 2014; Sichko 2020). Some studies have also found similar positive effects on international migration (e.g., Drabo and Mbaye 2014; Reuveny and Moore 2009). The most comprehensive evidence for such a positive effect comes from a worldwide study of the effect of hurricanes on US immigration over the period 1980–2000 (Mahajan and Yang 2020).

However, it is far from clear that these positive effects on international migration are a common feature in all contexts of major natural disasters. A number of studies have found negative or no-migration effects, at least for large segments of the population (e.g., Beine and Parsons 2015; Cattaneo and Peri 2016; Gröschl and Steinwachs 2017; Halliday 2006; Hunter, Murray, and Riosmena 2013; Yang 2008b). This is a common finding even for internal migration (Cattaneo and Peri 2016; Gignoux and Menéndez 2016; Nawrotzki and DeWaard 2018; Paul 2005; Penning-Rowsell, Sultana, and Thompson 2013). This frequently observed lack of a positive effect of shocks on migration raises the notions of "trapped populations" (Nawrotzki and DeWaard 2018) and an "immobility paradox" (Beine, Noy, and Parsons 2019)—a state in which poor populations would have wanted to react by migration, but are locked in by liquidity constraints that are exacerbated by the shock. The role of liquidity constraints in masking or reversing an otherwise positive effect on migration is consistent with findings of heterogeneous effects of shocks on migration with respect to income, wealth, or human capital, with a greater increase in migration after a shock among better-off households, regions, or countries (Beine and Parsons 2017; Cattaneo and Peri 2016; Gröschl and Steinwachs 2017; Nawrotzki and DeWaard 2018; Sichko 2020; c.f., Halliday 2006).

Another possible mechanism that could counteract the push effect is that reconstruction may increase local labor demand after a shock and generate a negative or no-migration effect. Part of this effect would be realized through self-employment within the household. Consider the typical commune in the District of Reggio Calabria, where roughly half of the buildings were severely damaged or destroyed by the earthquake. For many households, repairing or rebuilding their own property would have been a high-net present value project. Such "greater exigencies" at home have been cited by Halliday (2006) as the most likely explanation for the negative effect of the 2001 El Salvador earthquakes on migration to the United States (although this is disputed by Yang 2008b). The effect might also come through changes in the labor market. Indeed, in the wake of earthquakes in Calabria prior to the one that we study, there is evidence of an increase in construction wages (Caputo 1908).[18] Moreover, reconstruction efforts are often fueled by remittances and other forms of

[18] Moreover, Pereira (2009) documents such a rise in wages after the 1755 Lisbon earthquake. Interestingly, however, Kirchberger (2017) finds that following the 2006 Yogyakarta earthquake in Indonesia, there was no overall change in wages in the worst hit places, but there was greater increase in wages and hours worked by workers who had previously been employed in agriculture, possibly due to a movement of workers from agriculture to construction. It is nevertheless puzzling that a labor

financial flows to the affected places (Bettin and Zazzaro 2018; David 2011; Mohapatra, Joseph, and Ratha 2009; Paul 2005; Yang 2008a; c.f., Lueth and Ruiz-Arranz 2008). Beyond the recovery period, post-disaster reconstruction may even produce positive economic effects that persist in the long run by bringing about a wave of (literal) creative destruction (Barone and Mocetti 2014; Gignoux and Menéndez 2016; Hornbeck and Keniston 2017), which may induce more people to stay by strengthening protections against similar future events (Boustan, Kahn, and Rhode 2012), or by hastening institutional reform (Pereira 2009).

Two issues in the rich literature on the relationship between natural shocks and migration highlight the contribution of our study of the Messina-Reggio Calabria Earthquake. First, as mentioned above, the literature has largely focused on climatic shocks. Most of these, such as extreme weather events, are relatively small in comparison to the scale of the devastation wrought by the Messina-Reggio Calabria Earthquake. Evidence on the effects of disasters at the scale of the Messina-Reggio Calabria Earthquake is scarce.[19] Second, virtually all studies dealing with international migration have explored events that have occurred since 1960—a period characterized by stringent restrictions on labor mobility across international borders (Hatton and Williamson 2005).[20] The Messina-Reggio Calabria Earthquake occurred in an area that was heavily exposed to overseas migration at a time in which the migration choice was unhindered by legal restrictions, and, moreover, could have been aided by large networks of prior migrants. If, for example, poorer populations are more likely to be incentivized to move overseas by a disaster, but are also less likely to be able to overcome the legal restrictions of migration, then the estimates on the effects on the underlying demand for international migration, which is the unobserved measure that really reflects incentives, will be downward biased. This raises the question of whether the "trapped populations" are not merely trapped by poverty or entrenched by shock-related incentives, but are in part also "banned" populations. Our case study is unique in focusing on a massive shock whose survivors were familiar with a relatively cheap option of overseas migration, were linked to a large proportion of their communities that had already relocated abroad and could assist their migration, and, in most cases, undoubtedly did have a legal path to migrate.

2.3 Italian Emigration

Italy was a latecomer to international mass migration. Whereas Britain, Germany, and Ireland were already the sources of large numbers of migrants as early as the 1840s, Italy, along with other countries in the

demand shock that originated in the construction sector would be more than offset by the ensuing transition of labor out of agriculture.

[19] The most obvious exceptions are the studies of earthquakes by Gignoux and Menéndez (2016), Halliday (2006), and Yang (2008b).

[20] Karadja and Prawitz (2019), who use frost shocks as part of an instrument for migration to the US from Sweden during the 1860s, provide evidence from a period of unrestricted migration, but the magnitude of the shock is considerably smaller.

southern and eastern European periphery, did not begin to experience large-scale international migration until the late 1880s (Hatton and Williamson 1994; Spitzer and Zimran 2020) even though the United States had maintained an effectively open border to European immigration throughout this period. Once Italian emigration began, however, it accelerated rapidly. The rate of emigration from the entire country exceeded 15 per thousand by 1901, and peaked in 1913 at over 25 per thousand (Hatton and Williamson 1998, p. 97).[21]

Italian migration was mostly divided between three major destinations—North America (primarily the United States), South America (primarily Argentina and Brazil), and Europe (primarily Austria-Hungary, Germany, Switzerland, and France). But the composition of destinations varied across the country, with northerners primarily traveling across the Alps and southerners to North America. In the regions of Sicily and Calabria, the rate of migration to North America regularly exceeded 20 per thousand after 1900. In total, 69 percent of migrants from these regions traveled to North America between 1900 and 1914. The next largest major destination was South America, with just under 24 percent of migrants from these regions.

Three important patterns characterized the Italian migration. First, a relatively large share of this flow consisted of repeat and temporary migrants, or "birds of passage" (Gomellini and Ó Gráda 2013). Bandiera, Rasul, and Viarengo (2013) argue that over 70 percent of Italian migrants to the United States between 1900 and 1910 returned to Italy.[22] Spitzer and Zimran (2018, Table 2, p. 231) find that 44.3 percent of Italians arriving at Ellis Island during the period 1907–1925 had already lived in the United States prior to the observed migration. This may be important in the context of a response to a natural disaster because there is reason to believe that temporary migration might be more responsive to a natural disaster than permanent migration (Bohra-Mishra, Oppenheimer, and Hsiang 2014).

The second feature, which was shared by migratory flows from virtually all European countries, was the considerable year-to-year fluctuation in migration rates in response to business cycles in the destination countries (Hatton and Williamson 1998, ch.4; Spitzer 2015). Most importantly in the context of the Messina-Reggio Calabria Earthquake, the Panic of 1907—a financial crisis in the United States that caused a recession in late 1907 and 1908—caused a decline in total immigration to the United States from nearly 1.2 million to under 700,000 between fiscal years 1907 and 1908. Immigration remained low in fiscal year 1909 before resurging to over 925,000 in fiscal year 1910 (Barde, Carter, and Sutch 2006). Italian emigration to the United States followed this trend, falling from over 300,000 in calendar year 1907 to about 130,000 in calendar year

[21] Ferenczi and Willcox (1929), Foerster (1919), Gomellini and Ó Gráda (2013), and Spitzer and Zimran (2020) also describe the trends in Italian migration.

[22] According to Hatton and Williamson (1998, p. 97), the national emigration rate from Italy net of returns was below 5 per thousand after 1901.

1908, before resurging to 289,000 in calendar year 1909.[23] To evaluate the effects of the earthquake on migration, it is crucial that we account for this volatility, which generated a nationwide surge in emigration in the year after the earthquake. This fluctuation in migration in response to the Panic of 1907 also provides a yardstick to which the effects of the earthquake can be compared.

The third important pattern in Italian migration is its spatial expansion (Gould 1980). Spitzer and Zimran (2020) show that mass migration from Italy to North America began in a few distinct districts in the late 1870s and early 1880s and spread from there in a process of spatial diffusion to the rest of Italy through immigrants' social networks.[24] In Sicily and Calabria, the nearest "epicenter" district was Corleone in the province of Palermo, from which the area experiencing mass migration expanded. By the time of the earthquake, the regions around the Strait of Messina had already achieved high rates of emigration. In a radius of 150 kilometers from the earthquake's epicenter, the average commune experienced an average annual emigration rate of over 35 per thousand in the period 1905–1908—an extraordinarily high rate by historical standards. We interpret this as having passed a point of saturation—a previous migrant stock large enough that it was likely that virtually all residents had a connection to prior migrants, and therefore had the option of migration and could be aided in migration by prior migrants.[25] Notably, however, southeastern Sicily (the provinces of Syracuse and Catania) lagged behind the rest of Sicily and Calabria, achieving saturation about a half decade later than the rest of the area. This meant that the emigration trend of this area was rising relative to others in the time period that we analyze (Spitzer and Zimran 2020). In other words, there was an external reason for differential trends in emigration in the regions affected by the earthquake, which is an important factor to consider in our difference-in-differences analysis.

The composition of the flow of Italian migration is also potentially important to understanding the impact of the earthquake. Roughly three-quarters of Italian migrants were male (Hatton and Williamson 1998, p. 102), an imbalance exceeding that of almost any other group of migrants during the Age of Mass Migration. Spitzer and Zimran (2018) show that migrants from southern Italy, including those from Sicily and Calabria, were largely positively selected into migration on the basis of average height, a proxy for human capital. This selection was particularly strong for Calabria (Spitzer and Zimran 2018, Fig. 2, p. 234). The flow of

[23]The Italian emigration statistics are from our transcription of the *Statistica della Emigrazione Italiana per l'Estero*, which we discuss in more detail below. In the original sources, the US data are reported in fiscal years whereas the Italian data are reported in calendar years. According to tne NBER measures, the contraction associated with the Panic of 1907 lasted from May 1907 to June 1908, approximately overlapping with fiscal year 1908 (National Bureau of Economic Research 2020).

[24]There were similar patterns for migration to South America and to Europe, but with different initial "epicenters" and starting points in time.

[25]Spitzer and Zimran (2020) show that connections to networks of prior migrants were the first-order determinant of mass emigration in Italy at the district and commune level from 1876–1920. Spitzer (2016) shows that pogroms in the Russian Empire did not push a significant number of Jews from the affected regions so long as they were not exposed to prior migration.

migration also consisted primarily of individuals employed in unskilled occupations (Federico et al. 2019; Pérez 2019; Spitzer and Zimran 2018). According to official Italian emigration statistics, in 1905–1908, 49.9 percent of Calabrian migrants and 38.1 percent of Sicilian migrants were employed in agriculture.[26] As we will show below, the occupational distribution of the affected areas bears heavily on their responses to the earthquake.

Internal migration within Italy may also have been an important margin of response to the earthquake, and would potentially constitute a substitute for international migration. However, at least in southern Italy, this was a far less common phenomenon than was international migration prior to the earthquake. As discussed above and as shown in Table 1, there is no evidence of a large inflow to the cities of Messina and Reggio Calabria. More generally, such flows were largely temporary and were dwarfed by international migration, especially after 1900 (Gallo 2012), probably because returns to migration and employment opportunities were far greater in overseas destinations. More broadly, the 1911 census indicates that 93.9 percent of Sicilan-born individuals living in Italy in 1911 and 94.1 percent of Calabrian-born individuals living in Italy in 1911 lived in their province of birth, of which 85.0 percent of Sicilians and 84.6 percent of Calabrians lived in their commune of birth.[27] There is little doubt that the primary outside option for the earthquake-affected population was overseas migration.

3 Data

3.1 Sources and Construction

Data on earthquake severity are taken from Guidoboni et al. (2007), a source based largely on descriptions of earthquake damage provided by Baratta's (1910) state-of-the-art study. This source reports Mercalli severity scores for various latitude-longitude pairs in the affected region. Whereas the more commonly referenced Richter scale is based on the actual shaking experienced during an earthquake, the Mercalli scale is defined on the basis of the damage suffered.[28] It ranges from I (not felt) to XII (extreme); in some cases, our data

[26] As we discuss in footnote 65 below, there is reason to believe that a substantial fraction of these were agricultural day laborers. In the relatively urbanized provinces of Reggio Calabria and Messina, however, the plurality of migrants were employed in construction, accounting for 43.0 percent and 45.5 percent of migrants from each province, respectively. For comparison, 28.3 percent of Sicilian migrants and 32 percent of Calabrian migrants in the period 1905-1908 were employed in construction. These figures are from Table IV of the 1904–1905, 1906–1907, and 1908–1909 volumes of the *Statistica della Emigrazione Italiana per l'Estero*.

[27] These figures are from Table IX.C of the 1911 Italian census. The district-level data from Table IX.B also support this notion, with the fraction of the population of each district that was born in its commune of residence ranging from 83.35 percent in Reggio Calabria to 90.19 percent in the district of Mistretta in the province of Messina.

[28] For instance, an VIII (severe) on the Mercalli scale is defined as "Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned." An XI (extreme) is defined as "Few, if any, (masonry)

include intermediate measures such as IX–X or X–XI, which we score as 9.5 or 10.5. The description of actual damage is helpful in our case, as this is a more direct measure of the impact of the earthquake than the magnitude of shaking, which may translate differently into damage in different areas. Guidoboni et al. (2007) also provide information on the number of reported deaths at each latitude-longitude pair.[29]

To prepare these data for analysis, we first assigned the point-based severity measures to the communes into which they fall. Because we do not have a map of Italian communes for the early 20th century, we rely on a map of commune borders on January 1, 2018, which resulted in a small number of historical communes being combined with one another to form larger communes, primarily through the incorporation of adjacent communes into the city of Messina. In cases where a modern commune has multiple points of severity measures, we first attempt to identify the city center;[30] in other cases, we use the maximum severity recorded in the commune. Our benchmark treatment variable is a binary indicator for severe damage from the earthquake: we assign a commune to the "severe" group if its severity score is VIII or higher,[31] and assign all other communes to the "non-severe" group.[32]

We use two sources of migration data. The first is the Ellis Island arrival records database, which was provided by the Statue of Liberty-Ellis Island Foundation and is described in detail by Spitzer and Zimran (2018). This dataset contains the records of all passenger arrivals at the Port of New York for the period 1897–1924, comprising the vast majority of all arrivals in the United States during the latter decades of the Age of Mass Migration in general and in our study period in particular.[33] In total, there are records of 4.8 million passengers with Italian origin or nationality from the complete Statue of Liberty-Ellis Island Foundation database. The data are compiled from passenger manifests, which were completed by shipping companies upon passengers' embarkation in the port of origin, and which were subsequently verified by immigration agents at Ellis Island. In the case of Italian passengers, the information provided in these manifests is likely to be highly accurate as a result of the requirement by Italian authorities to travel abroad

structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly" (US Geological Survey 2019).

[29] As discussed above, these estimates remain the subject of debate to the present, particularly in the case of the city of Messina (e.g., Caminiti 2009; Parrinello 2012; Restifo 1995). Nonetheless, they provide the best estimates available of the death toll of the earthquake and subsequent tsunami, and so we present results below both using and not using these data. The total deaths figure that we use for Messina (which in our data includes some outlying towns that have since been incorporated into it) is 67,307.

[30] That is if there are several observations for Messina, we use the measure for the city of Messina itself rather than for surrounding *frazioni*, or villages, within the same municipality

[31] This is also the cutoff that corresponds to a Richter scale reading of 7.0 (US Geological Survey 2019).

[32] For communes with no severity measures, we use an inverse-distance-weighted imputation of Mercalli scores. In practice, all communes for which we impute a severity measure fall into the non-severe category (i.e., their imputed Mercalli scores are below VIII), which is consistent with the lack of severity information indicating little or no earthquake damage and with the inclusion of all severely affected areas in the damage data.

[33] Spitzer and Zimran (2018, Table D.1) compare the total inflows in this source to those of official statistics of arrivals of Italians to the United States, finding that the coverage of the Ellis Island passenger manifests is nearly complete.

with a passport, which was an official document identifying migrants' communes of origin.[34]

To identify the last place of residence of each passenger arriving at Ellis Island, we used an automated geo-location algorithm, previously used by Spitzer and Zimran (2018), which converted the textual (and often misspelled or incomplete) transcription of the last place of residence in the dataset into latitude and longitude pairs. Spitzer and Zimran (2018) show that this algorithm is highly accurate (i.e., in at least 92 percent of cases in which an individual is assigned to a location that location is correct), that at least 79.3 percent of records with complete information could be geo-located (with a higher probability of successful geo-location after 1900), and that this subset of individuals whose location could be determined from the algorithm is representative of all passengers. In total, the data include 1,879,365 individuals arriving in the United States in the years 1905–1912 with a listed last place of residence that was determined to possibly be in Italy. Specific latitude and longitude coordinates could be assigned to 1,445,096 passengers and were linked to a commune of last residence. For the same reason discussed above, we assigned individuals to the modern commune (as of January 1, 2018) in which their coordinates fall. We then used a variety of sources to determine the historical district and province to which this modern commune belongs.[35] The ultimate product is an annual count of passengers from each commune. The passenger lists also contain a limited number of individual migrant characteristics, including age and gender.[36] We use these data to construct each commune-year's average emigrant characteristics, as well as a count of prime-aged male passengers (i.e., males 18–65), who may have been more responsive to the labor market consequences of the shock.

Our second and complementary source of migration data is the official commune-level emigration counts published in the *Statistica della Emigrazione Italiana per l'Estero*.[37] This source, which was digitized and described in detail by Spitzer and Zimran (2020), indicates the number of international emigrants from each commune based on the issuance of passports, which were compulsory for international travel after 1901 (Foerster 1919; Hatton and Williamson 1998). Although these data add information relative to the Ellis Island records and provide coverage of all destinations (rather than just the United States) and ports of entry (rather than only New York), there are some disadvantages. First, they do not enable us to determine

[34] On the Italian passport system, see Foerster (1919, pp. 10–22).

[35] More details of this component of the data cleaning process are presented in Online Appendix B.

[36] The records contain additional personal information, such as height and occupation. But these variables were not digitized for the entire collection of passenger records. Spitzer and Zimran (2018) digitized a sample that enables cross-province comparisons, but the additional transcription required to enable a cross-commune-year comparison of individuals characteristics is infeasibly large. Therefore, we restrict our analysis to the variables that are available for all individuals.

[37] We keep these data at the level of the historical commune at which they are reported, which leads to some minor differences relative to the Ellis Island data described above; however, their geographic location (and thus their earthquake severity) is based on modern borders. This is particularly relevant in the case of communes that have been incorporated into other communes over time; in such cases, the location is based on the location of the modern commune to which they have been incorporated. More details of this data cleaning are provided in Online Appendix B and by Spitzer and Zimran (2020).

the type of migrant (e.g., age or gender) or the destination of the migrant. Second, data for the districts of Palmi (in the province of Reggio Calabria) and Messina (in the province of Messina) for the fourth quarter of 1908 were destroyed by the earthquake and were imputed based on 1907 figures.[38] There is also the possibility that the earthquake may have disrupted travel plans, leading to a discrepancy between passport issuances and actual emigration. Therefore, we use the Ellis Island data for our benchmark specification, while reporting the same results using the alternative emigration data. The two sources are largely consistent with each other, and so are the outcomes of the empirical analysis.

One concern with both sources of migration data is whether internal refugees who eventually migrated were reported as coming from their hometowns or from their place of refuge. Unfortunately, we cannot be certain that displaced persons were indeed listed according to the town in which they had been living at the moment the earthquake struck. We are reassured, however, by the evidence that refugees rapidly returned to affected areas (Restifo 1995) and that internal migration rates as documented in the 1911 census were low. Further reassurance is provided by sampling and inspecting passenger lists for a mismatch between the last place of residence and the place of birth.[39] This search yields no systematic evidence of Messina-born individuals listing somewhere else as the last place of residence.[40]

Finally, we use data from the 1901 Italian census of population. This source provides commune-level population counts (the last before the earthquake),[41] which enable us to compute rates of emigration. It also provides district-level occupational distributions. Most of the workers were employed in agriculture, and we are particularly interested in the distribution of the different types of their contractual attachment to the land. The least attached were the agricultural day laborers (*giornalieri di campagna*). Other categories include sharecroppers (*mezzadri*), contracted laborers (*contadini obbligati*), renters, lessees, and owner-occupiers. We use these data to compute two measures—the fraction of the male labor force in the district employed in agriculture (of all types of tenure) and the fraction of the male labor force employed as agricultural day laborers. We focus on the latter group because they were the least attached to the land and we therefore suspect that they may have been more responsive to shocks than others.[42]

[38] The original source states, "Per gli emigranti partiti dai comuni del circondario di [Messina/Palmi] mancano i dati del quarto trimestre 1908, perchè il registro dei passaporti andò disperso nel disastro causato dal terremoto; si è perciò completata la statistica, sostituendovi i dati relativi al quarto trimestre 1907."

[39] The latter field is available in the original manuscripts, but was not transcribed, and so this comparison requires a manual examination.

[40] We randomly sampled a small number of individuals and manifest pages in the passenger manifests emigrating in January, February, and March 1909 whose last place of residence was in the province of Catania, which was the closest and most significant refuge for the displaced Messinesi. We then manually inspected these records and found no instance of a Messina-born individual listed as a resident of Catania.

[41] The data that we use are originally from the 1901 census, but were reported in the *Statistica della Emigrazione Italiana per l'Estero*.

[42] We also obtained data on employment in construction, which we use in supplemental analyses.

3.2 Summary Statistics

Table 2 presents summary statistics for severely damaged and non-severely damaged communes in Calabria and Sicily, as well as for the whole of Italy. The data for the non-severely damaged communes in Sicily and Calabria are shown for all communes (columns 2, 5, and 7) and for communes within 150 kilometers of the earthquake epicenter (column 3).[43] The Table first presents data on the damage caused by the Earthquake. Unsurprisingly, severely damaged communes were closer to the epicenter of the earthquake, and by definition they experienced more damage as measured by the Mercalli score. By contrast, the average non-severely damaged commune in the regions of Sicily and Calabria had a Mercalli severity of about VI ("Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.").[44] Severely damaged communes also registered considerably more deaths per capita, though the average was still far lower than Messina's 44 percent death rate, which was the exception rather than the rule. Figure 2 maps the data on damage from the earthquake. Panel (a) presents the Mercalli score for each commune (excluding those without data in Guidoboni et al. 2007). Panel (b) maps the indicator for whether each commune experienced damage of a Mercalli severity of VIII or greater, along with a circle indicating a 150-kilometer radius from the earthquake epicenter. As expected, the communes experiencing a severe shock are those closer to the epicenter (indicated by the large dot).

Table 2 also presents various measures of emigration. The rates of emigration according to the Ellis Island data are approximately half those according to the official data, reflecting the incomplete coverage of the Elis Island data in terms of international destinations (e.g., migration to South America is not captured by the Ellis Island data) and ports of entry to the United States. Reassuringly for treatment balance, the pre-earthquake emigration rates in the severely and non-severely affected communes in Sicily and Calabria were similar, though there is some imbalance within regions. We provide a formal study of pre-trends in our main results below.

Figure 3 presents the spatial distribution of our main outcome variable—average annual emigration rates at the commune level according to the Ellis Island data.[45] Panel (a) reports average annual emigration rates for the pre-earthquake period 1905–1908. The main pattern evident from this panel is the lower emigration rates from southeastern Sicily relative to the rest of the island and relative to Calabria, consistent with the late arrival of mass migration in this area, as discussed above and by Spitzer and Zimran (2020). Panel (b)

[43] The farthest severely damaged commune from the epicenter of the earthquake was 101.6 kilometers.

[44] Put another way, US Geological Survey (2019) maps a Mercalli severity of VI to a maximum Richter scale reading of 5.9, and a severity of VIII to a minimum Richter scale reading of 7.0—a greater-than-10-fold difference in intensity.

[45] Online Appendix Figure A.1 presents analogous figures based on the Italian official statistics,

reports the change in emigration after the earthquake (the ratio of the average annual emigration rates for 1909–1912 relative to those for 1905–1908). Consistent with the expansion of migration to the southeast of Sicily, the greatest increase over time appears to have been in these areas with previously low migration rates.[46] There is little apparent evidence of an impact from the earthquake, apart from a decline in emigration rates in the cities of Messina and Reggio Calabria and some of their adjacent communes.[47]

Figure 4 further reinforces the view of a limited impact of the earthquake relative to other forces affecting migration. Using both the Ellis Island (panel a) and the official emigration data (panel b) for the period 1905–1912, this Figure plots the ratio of the post-to-pre emigration rates against the pre-earthquake average annual emigration rates, separating the severely damaged and non-severely damaged communes. These figures both show that any impact of the earthquake was of secondary importance as compared to the patterns of convergence in emigration rates. There is, however, a clear downward slope in the plots, reflecting β-convergence in migration rates. This pattern is present in both the severe and non-severe group, with little difference between the lines for the two groups.[48]

Figure 5 provides additional support for the view that any effect of the earthquake was of second-order relative to other causes of emigration, plotting the average annual commune-level emigration rate over the period 1905–1912 for four different subsets of communes in the sample—severely damaged, not severely damaged, not severely damaged within 150 kilometers of the epicenter, and all of Italy. Panel (a) uses the Ellis Island data and panel (b) uses the official emigration statistics. The dominant pattern in these trends is the large decline in average emigration rates in 1908 in response to the Panic of 1907, from over 15 per thousand to about 5 per thousand in the Ellis Island data and from over 40 per thousand to about 20 per thousand in the official statistics over 1906–1908. Conversely, the trends for both the severely damaged and other communes in Sicily and Calabria appear similar both before and after the earthquake at the end of 1908, further suggesting that on average, the effect of the earthquake on a severely damaged commune's emigration rate was minimal, and certainly so relative to temporal fluctuations in migration.

[46] In the official emigration statistics, the average annual emigration rates for the southeastern provinces of Syracuse and Catania in the period 1905–1908 were 24.6 and 22.7 per thousand—high by external standards, but the lowest of any provinces in Sicily or Calabria in this period. While Catania (along with every other province in the area except Syracuse) experienced a decline in average annual migration rates in the period 1909–1912, Syracuse experienced an increase in average annual emigration rates by a factor of 1.16 over this period.

[47] This decline is not mirrored in the official statistics of Online Appendix Figure A.1.

[48] Spitzer (2016) and Spitzer and Zimran (2020) perform similar analyses. There is a natural concern that the negative correlation comes from the fact that the pre-earthquake emigration rate appears on the x-axis and also inversely on the y-axis. To address this concern, we follow Spitzer (2016) and Spitzer and Zimran (2020) in also reporting the correlation between the ratio and the post-earthquake emigration rate. If the negative relationship were solely mechanical, then we would expect a positive correlation in this case of the same magnitude as the negative correlation. As evident in the notes to the figures, there is such a positive correlation, but it is smaller than the negative correlation between the ratio and the pre-earthquake emigration rates. Thus, there is evidence that some but not all of the negative relationship in Figure 4 is spurious.

Were severely damaged communes similar to the non-severely damaged ones? The descriptive statistics in Table 2 show that there were some differences between the treatment and the control group. It appears that within 150 kilometers of the epicenter, severely damaged communes were somewhat more populous than others in 1901, likely reflecting the greater exposure of the two main urban areas in the area of the Strait of Messina. There was also a slightly lower share of agricultural day laborers and employment in agriculture in severely damaged communes, though the differences are small. Table 2 also presents information from the Ellis Island data on pre-earthquake average migrant characteristics. The severely damaged communes had, on average, older and more male migrants, but restricting the radius of attention to within 150 kilometers of the earthquake epicenter blunts this difference. Such imperfect balance is an issue that we will directly address in our analysis by including commune fixed effects in all regressions and by explicitly examining pre-trends.

4 Empirical Strategy

Our empirical analysis is based on emigration data at the commune-year level for the period 1905–1912. Because the earthquake occurred in the last days of 1908 (December 28), it is natural to define 1908 as the last year of the pre-treatment period and 1909 as the first year of the post-treatment period. The length of the period that the analysis covers is motivated by the prior expectation that the impact of the earthquake might evolve over several years. Our event study specifications explore the sensitivity of the findings to changing the duration of the experiment window. We limit our benchmark sample to communes in the regions of Sicily and Reggio Calabria, in which the affected communes are located. We also include results in which we limit attention to communes within 150 kilometers of the epicenter to more closely focus on the affected region, as well as specifications including all communes in Italy.

Our benchmark empirical approach is the generalized difference-in-differences equation with non-parametric province-specific time trends,

$$\log(e_{it}) = \alpha_{pt} + \alpha_i + \beta(s_i \times q_t) + \gamma(d_i \times q_t) + \varepsilon_{it}, \tag{1}$$

where e_{it} is the emigration rate of commune i in year t, α_{pt} are province-year fixed effects, and α_i are commune fixed effects. The commune fixed effects capture time-invariant differences in emigration rates across communes. The province-year fixed effects capture province-specific year-to-year variations, addressing annual volatility in migration rates and the potential variability of this volatility across the study area. The coefficient of interest in these regressions is β, which is the coefficient on the interaction of an indicator for whether a commune was severely damaged by the earthquake (s_i) and an indicator for years 1909 and later (q_t). We cluster standard errors at the district level, which captures the possibility of spatial correlation between the errors of nearby communes, even across different years. Equation (1) also includes an interaction of the logarithm of distance from Corleone (d_i)—the nearest emigration "epicenter" from which migration spread—and the "post" indicator q_t. We include this interaction in all of our difference-in-differences analyses to account for differential trends stemming from distance from the early sources of emigration, which, as discussed above, is an important source of potentially non-parallel trends.[49] Identification is based on the degree to which severely damaged communes deviated in the post-treatment period from the trend of other communes in the same province, beyond deviations implied by their distance from Corleone. We also use this specification with alternate outcomes reflecting the average migrant characteristics of each commune-year.

In all of our analyses we weight each commune equally rather than by its population, its share of aggregate emigration, or some other measure of size. Each commune thus constitutes a separate instance. Importantly, this implies that the cities of Messina and Reggio Calabria, despite their large population, death toll, and refugee streams, are treated as just two of many communes. Weighting by population would cause us to derive much of our identification from the cities of Messina and Reggio Calabria, in which the effects of the earthquake may have been idiosyncratic and unrepresentative.[50] This approach corresponds to the motivation to understand how a typical commune was affected by the earthquake rather than to quantify the total effect of the earthquake.

Our preferred emigration outcome variable is the logarithm of the emigration rate as measured in the Ellis Island data. We also examine alternative outcome variables, representing different aspects of emigration. These alternatives include an Ellis Island-based measure of migration of prime-aged (18–65) males, which we take as the group that was the most likely to react to labor market incentives, and total emigration rates from the Italian official statistics. We also estimate specifications in which we adjust the emigration rate in

[49]For the all-Italy specifications, we control for year-specific functions for the logarithm of the distance from the nearest emigration "epicenter" for migration to North America as identified by Spitzer and Zimran (2020). These are Corleone in the province of Palermo, Sala Consilina in the province of Salerno, Isernia in the province of Campobasso, Pozzuoli in the province of Naples, and Chiavari and Albenga in the province of Genoa.

[50]Because of their importance in the economy of the affected area and the extent of the damage, much of the attention of the authorities at the time of the disaster, and subsequently of the historical literature and of the popular memory of the event, has focused on the experience of these cities, and especially of Messina. But these cities were just two of the many affected (and 109 severely damaged) communities, whereas the responses of the remaining smaller communes is poorly documented and understood. Shedding more light on the aftermath of the earthquake beyond the major cities is an additional contribution of this paper.

the post-earthquake period according to the estimated death toll.[51]

Finally, to provide a test of the parallel trends assumption inherent in equation (1), to better understand the dynamics of the response (if any) to the earthquake, and to determine if the results are driven by the definition of the experiment window, we also adapt equation (1) into an event study specification. Specifically, we estimate an equation of the form

$$\log(e_{it}) = \alpha_{pt} + \alpha_i + \beta_t s_i + \gamma_t d_i + \varepsilon_{it}, \tag{2}$$

where all terms are defined analogously to equation (1) and the coefficients β and γ are permitted to vary by year.

5 Results

5.1 Aggregate Effects of the Earthquake

Our benchmark results point toward the null hypothesis, that there was no meaningful effect of the earthquake on subsequent emigration flows. Table 3 presents the results of estimating the generalized difference-in-differences specification of equation (1) for a variety of geographic scopes and definitions of the outcome.[52] Our preferred estimates, which use the Ellis Island data with no adjustments and include all of Sicily and Calabria, are in column (1) of Panel A. The estimated coefficient of -0.056 is statistically insignificant and points to a small decline in emigration from affected areas of less than six percent.[53] The remaining specifications of Table 3 show that this qualitative result of a small and statistically insignificant effect is not driven by the choice of dependent variable or geographic scope; almost all of the estimated treatment effects are negative, small, and statistically insignificant.

[51] Specifically, we compute the alternative emigration rate $\tilde{e}_{it}$ as

$$\tilde{e}_{it} = \begin{cases} \frac{E_{it}}{N_i} & t \leq 1908 \\ \frac{E_{it}}{N_i - D_i} & t \geq 1909 \end{cases},$$

where E_{it} is the number of emigrants from commune i in year t, N_i is the 1901 population of commune i, and D_i is the death toll in commune i according to Guidoboni et al. (2007).

[52] In Online Appendix A, we include several alternative versions of these results. Online Appendix Table A.1 repeats the results using the actual Mercalli score or an imputation where the score is not available as the measure of treatment rather than the discrete severe-not severe indicator. We do not prefer this dose-response specification because there is no reason to believe that the Mercalli scores are cardinal and because there is little basis on which to believe that the imputation of Mercalli scores is correct (though as discussed above it does appear that all severely damaged communes were included in the survey). Online Appendix Table A.2 uses the negative of the logarithm of the distance from the epicenter as the measure of treatment. In all cases the results are qualitatively similar to those in Table 3

[53] That is, a decline in the average annual emigration rate from about 15 per thousand (the pre-earthquake average, as shown in Table 2) to about 14 per thousand.

Figure 6 presents year-specific treatment effects from the event study specification of equation (2) with a variety of dependent variables. As in Panel A of Table 3, the sample includes all communes in Sicily and Calabria. First, these specifications provide a clear test of the parallel trends assumption underlying the difference-in-differences analysis. They also show how any effect of the earthquake in the post-earthquake period evolved over time. Our preferred results are presented in panel (a), which uses emigration counts from Ellis Island with no adjustments. Although the standard errors for each year's treatment effect are naturally larger, the point estimates show no evidence of meaningfully different behavior of severely affected and other communes prior to the earthquake, as evidenced by the small magnitude of the coefficients in the pre-treatment period. After the shock, there was a slight (just under 0.08 log points) but statistically insignificant decline in emigration in the severely damaged communes in 1909, the first year after the earthquake. This decline then disappeared within a year, and in subsequent years the severely damaged communes followed the same trends as the unaffected communes. The lack of a clear impact of the earthquake is not due to an idiosyncrasy of our choice of how to measure emigration: the results using alternative outcome variables are largely similar, though the precise magnitudes and patterns differ between them. On the whole, based on these results and those of Table 3, there appears to have been no statistically significant effect of the earthquake, and at most, the point estimates indicate a small and short-lived decline in emigration from affected communes.[54]

To evaluate the effect of the earthquake on the demographic composition of emigration, we repeat the estimation of equation (1) using some simple characteristics of migrants, presenting the results in Table 4. This estimation asks whether the average immigrant characteristic of a commune was affected by the earthquake. For all four characteristics—age, male, prime-aged male, and child (i.e., less than 16 years old)—and all five geographic scopes that we study, we find no evidence of a statistically significant effect of the earthquake. The point estimates are small and relatively precisely estimated. For instance, column (2) of panel A indicates that there was a 1.5 percentage-point decline in the fraction of migrants who were male in response to the shock relative to a pre-earthquake mean of over 85 percent in the severely damaged communes. These results further strengthen the conclusion that there is no evidence of a strong effect of the earthquake on migration.

[54] Online Appendix C provides additional evidence of little to no effect of the earthquake based on a linkage of passenger records to a census of refugees.

5.2 Statistical Power and Economic Significance

A challenge to our interpretation of these results as indicating a lack of an effect of the earthquake is that the estimates for the effects on migration rates are statistically imprecise. In our preferred specification in column (1) of Panel A of Table 3, the 95-percent confidence interval for the earthquake effect ranges from a decrease in emigration of 0.33 log points to an increase of 0.22 log points. This raises the question of whether we can rule out that an economically significant response to the earthquake occurred. In part, this is a matter of how to define economic significance. To be sure, a 20-percent response may not be negligible, but it is important to keep in mind the magnitude of the disaster, which was among the worst in centuries of European history, and the ubiquity of international migration in the affected region. If there were any case in which we expect a clear and large effect of a natural disaster on emigration, it is this one.

Moreover, even the extremes of the confidence interval of our estimates allow us to rule out several important benchmark magnitudes for the effect of the earthquake. One yardstick is the decline in emigration resulting from the Panic of 1907, just one year before the earthquake. There is a wide agreement in the literature that this short-lived recession greatly reduced US immigration from all European origin countries (Hatton and Williamson 1998, ch. 4), and southern Italy was no exception. Communes severely damaged by the earthquake experienced a decline in average migration rates from 1907 to 1908 from 15 per thousand to 4 per thousand (panel a of Figure 5)—a decline of 1.293 log points.[55] Our 95-percent confidence interval for the impact of the earthquake can easily rule out a decline of this magnitude.[56] Conversely, the maximum range of the confidence interval also allows us to rule out a change of the magnitude of the aggregate change in migration from 1908–1909, when recovery from the recession led to a resurgence of emigration of almost the same magnitude as the prior decline. It follows *a fortiori* that the effect implied by our point estimate is extremely small relative to this benchmark effect of US business cycle fluctuations.

This particular comparison also bears on the "push-pull" debate of migration (e.g., Gould 1979; Hatton and Williamson 1998; Jerome 1926; Kuznets 1958), which considers whether the size of migratory flows was primarily determined by conditions in the origin or destination countries. Although this specific case does not permit the drawing of more general conclusions, the small impact of an undoubtedly cataclysmic event in Italy on migration, in particular as compared to the much larger effect of a transient shock outside Italy in

[55] In the official data, the decline over 1906-1908 is from over 45 per thousand to just over 20 per thousand—a decline of 0.79 log points. Over 1907–1908, the decline is from about 34 per thousand to just over 20 per thousand, a decline of 0.49 log points. But the confidence interval for the estimated effect of the earthquake on emigration rates is also smaller when using the official statistics, ranging from a decline of 0.21 log points to a rise of 0.10 log points.

[56] The 1907–1908 change also exceeds the bounds of our confidence interval for the one-year impact of the earthquake, as evident in panel (a) of Figure 6.

the form of a US recession, points strongly to pull factors in the United States as being key drivers of the size of the migratory flow from Italy to the United States. Notably, the small impact of the earthquake relative to that of the business cycle is similar to Boustan's (2007) finding that the Russian Jewish emigration to the United States was primarily determined by the state of the US economy and that pogroms had at most a second-order effect.

Other useful yardsticks can be derived from prior studies estimating the effects of natural and man-made disasters in other contexts. The Age of Mass Migration provides a few such examples. Spitzer (2016) estimates the effect of a pogrom on the emigration of Russian Jews from another "migration-saturated" region—the Pale of Settlement in the Russian Empire around 1905. He finds that exposure to a pogrom led to an increase in emigration of about 20 percent. Although this estimate is within the bounds of our 95 percent confidence interval for the effect of the earthquake, it is close to the upper extreme, allowing us to be reasonably confident that the Messina-Reggio Calabria earthquake did not have a larger impact. The Great Irish Famine of 1846–1850 is another useful comparison, in the sense that it was a disaster that had had an immense toll in lives and has been linked to subsequent mass migration (Ó Gráda 2019; Ó Gráda and O'Rourke 1997). Although the effect of the famine has not been formally quantified, the large impact of the shock is evident in the fact that the number of Irish immigrants to the United States more than doubled between 1846 and 1847 (Barde, Carter, and Sutch 2006) when the famine intensified, even as the base population declined dramatically. We can easily rule out changes of this magnitude in our context.

Another analysis of the link between natural disasters and international migration is provided by Mahajan and Yang (2020), who focus on the effects of hurricanes on migration to the United States. The benchmark estimate that they provide is that a so-called "one-standard-deviation" hurricane (a smaller shock than the Messina-Reggio Calabria Earthquake) increased migration by 11.8 percent of the mean—an estimate within the bounds of our confidence interval. Mahajan and Yang (2020) also find that the effect of a hurricane on migration is increasing in the size of the existing migrant stock from the country of origin in the United States. We estimate that in 1908, the Italian migrant stock in the United States was about 3.8 percent of the Italian population.[57] This estimate provides a lower bound on the previous migrant stock in the United States of the earthquake-affected region, where emigration rates to the United States were considerably higher: in the period 1900–1914, the emigration rate to North America from Sicily and Calabria was about 2.4 times that

[57] In 1900, the stock of Italian-born individuals in the United States was 484,027; by 1910, this figure was 1,343,125 (Haines 2006). To estimate the stock in 1908, we use information from Barde, Carter, and Sutch (2006) on Italian arrivals in the United States. Based on the fact that 1,830,340 arrivals in 1901–1909 corresponded to an increase in population of 859,098 from 1900 to 1910, we assume that the 1,647,122 arrivals from 1901–1908 corresponded to a (proportional) population increase of 773,102, making our estimated stock of Italians in the United States after 1908 1,257,129, which is 3.8 percent of the 1901 Italian population of 32,965,504.

of Italy as a whole, implying that a previous migrant stock of as much as 9 percent in the United States is not unreasonable.[58] According to the estimates of Mahajan and Yang (2020, Table 1), a previous migrant stock of 3.8 percent corresponds to an estimated effect of a "one-standard-deviation" hurricane of about 10 percent of the mean; this estimate is again within the bounds of our confidence interval, though if we accept an estimate of a prior migrant stock of 9 percent, the implied estimate is at the extreme of our confidence interval. Arguably, the most appropriate comparison given the open borders of the period we study, however, is Mahajan and Yang's (2020) estimate of the effect of a hurricane conditional on the stock of US citizens (rather than simply prior migrants) from the country of origin. This is because these individuals are able to support migration of individuals from their country of origin with the least interference of policy, as would have been the case for Italians in the United States in the open border period of the Age of Mass Migration. Applying the estimates of Mahajan and Yang (2020, Table 3) to a citizen stock of 3.8 percent of the origin population yields an estimated effect of a shock of 43.9 percent of the sample mean—well outside the bounds of our confidence interval.

Instances of disaster-induced internal migration in the United States also provide useful points of comparison. A close analog to the event that we study is the San Francisco Earthquake of 1906, which, despite its salience as a shock of the same type, was far less destructive than the Messina-Reggio Calabria earthquake. Ager et al. (2020, Table 1) find that this earthquake had no impact on out-migration rates. Importantly, however, whereas southern Italy in 1908 was the center of mass *emigration*, the American west in 1906 was the destination of many *in*-migrants from abroad and from the rest of the United States. Ager et al. (2020, Table 1) find that a one-standard deviation increase in earthquake intensity reduced the in-migration rate over the period 1900-1910 by 11 percentage points relative to a mean of about 52 percent, or about a 20 percent decline. This magnitude is close to the upper bound of the confidence interval of our estimate, making it unlikely that the effect of the Messina-Reggio Calabria Earthquake was equal or stronger.

Another important natural disaster in US history was the Dust Bowl of the 1930s. Long and Siu (2018, Table 2, p. 1009) show that Dust Bowl counties experienced an increase in inter-county emigration rates from 47.2 percent to 51.6 percent from the 1920s to the 1930s while the rest of the country experienced a decline in inter-county migration rates. Though this is a crude comparison, this increase of about 23 percent is at the upper extreme of our confidence interval.[59] In another natural disaster in the United States, Lange, Olmstead, and Rhode (2009, pp. 713–714) find that the boll weevil caused a decline of population

[58] A lack of information on within-country place of origin in US censuses prevents us from performing a similar calculation to that of footnote 57 regarding the stock of prior migrants for the earthquake-affected region.

[59] A crude difference-in-differences that compares this increase to the decline in migration in the rest of the country only strengthens this conclusion.

of 30 percent in five years (i.e., an average annual out-migration rate of 6 percent or higher from areas that previously were not engaged in considerable internal migration) in the counties most reliant on cotton prior to the shock. More generally, Boustan et al. (2017) study natural disasters in the United States in the 20th century. They find that a "super-severe" disaster in a county led to an increase in its out migration rate by 3 percentage points relative to an average out migration rate of 1 percentage point (Boustan et al. 2017, Tables 1 and 2)—substantially larger than the one that we estimate.

In sum, although our estimates are statistically imprecise, hindering our ability to definitively conclude that there was no meaningful effect of the earthquake on international migration, our standard errors are nevertheless sufficiently small to conclude that any effect that may have existed was small as compared to those of similar or weaker shocks that have been studied in prior research.

5.3 District- and Province-Level Analysis

The preceding analysis has focused on the commune as the unit of analysis. While studying the smallest administrative unit in Italy is appealing and provides more observations, a concern is that the no-spillovers assumption inherent in the difference-in-differences and event study analyses may be violated if, for instance, the shock to the urban labor markets of Messina and Reggio Calabria changed the migration incentives for individuals in communes that were not severely damaged. If these spillovers led the unaffected communes' emigration to be affected in the same direction as that of affected communes, this bias would push our estimates toward zero, limiting our ability to conclude that any effect of the earthquake on migration was small. To gauge whether such spillover effects biased the magnitude of the estimated effects, we expand the unit of analysis to the district (of which there were 284 in Italy, including 11 in Calabria and 24 in Sicily) or the province (of which there were 69, including 3 in Calabria and 7 in Sicily). Specifically, we estimate versions of equation (2) in which the unit of observation is the district-year or the province-year, the province-year fixed effects are replaced with region-year fixed effects (there were 15 regions, or *compartimenti*), and the control for distance from Corleone is removed.[60] An important caveat in this analysis is that focusing on larger administrative units considerably reduces the number of observations. For this reason we focus on a specification that includes all Italian districts or provinces in the sample.

We classify a district or province as "treated" if at least 40 percent of its population lived in a commune that was severely damaged by the earthquake. In practice, this results in the five closest districts to the epicenter (Castroreale and Messina in Sicily and Gerace Marina, Palmi, and Reggio Calabria in Calabria) and

[60] The reduced granularity of the data and the greater importance of non-US destinations in a country-level analysis limits the degree to which we can capture diffusion.

the two closest provinces to the epicenter (Messina and Reggio Calabria) being treated. The small number of treated units in such an analysis raises issues of inference (MacKinnon and Webb 2020). To address this concern, we use a randomization inference approach that builds on the one used by Arthi, Beach, and Hanlon (2019). We randomly chose 500 points in Italy, assigned the five closest districts or the two closest provinces as treated, and estimated the adapted versions of equation (2). We then ask whether our estimates using the actual treated areas stand out relative to those with these alternative treated areas.

We focus these results, which are presented in Figure 7, on the unadjusted official statistics because they provide more complete coverage of areas outside of southern Italy, which are included in these specifications. In these areas, migration to destinations other than the United States was considerably more important,[61] implying that the loss of information arising from focusing only on migration to the United States—as the Ellis Island data require—may be more severe.[62] In these results, there is no evidence of differential pre-trends between affected and unaffected districts, at least from 1906. The point estimates for 1909 are consistent with a transient effect, if any, of the earthquake on emigration, this time a positive one. In all cases, any difference between affected and unaffected districts or provinces vanishes by 1910. Moreover, the randomization inference bands indicate that the documented increase in emigration from affected districts and provinces does not stand out relative to the placebo effects from the 500 randomly placed "epicenters." Although these results are limited by the small number of observations available to analyze trends at the province and district level, we view them as providing supportive evidence for our findings above that any aggregate effect of the earthquake on emigration was minimal and short-lived.

5.4 Labor Force Composition and Heterogeneous Responses to the Earthquake

Focusing on aggregate impacts of the earthquake may mask heterogeneous and offsetting responses across communes. These responses might have been meaningful in magnitude and duration in many places; yet given the results above, any such heterogeneous responses evidently cancelled each other out in the aggregate. As discussed above, there could be several factors that might make a prospective migrant more or less responsive to the shock. The size of the network, typically measured as a function of past migration, is surely a crucial factor (Mahajan and Yang 2020). In Online Appendix D, we explicitly check for heterogeneous responses according to a commune's pre-1908 stock of prior migrants but find no evidence for its existence.[63] This

[61] In the northern regions of Piedmont, Lombardy, Veneto, and Emilia Romagna, over 77 percent of migrants in the period 1900–1914 traveled to other European countries.

[62] Results for alternative dependent variables are presented in Online Appendix Figures A.2 and A.3.

[63] We also check for heterogeneity according to exposure to another earthquake in 1905 and according to a commune's district-level share of labor in construction in 1901. There is no clear evidence of heterogeneity in this dimension.

finding is consistent with Mahajan and Yang's (2020) finding of an interaction between the *level* of migration and the stock of past migrants because we have specified the outcome variable in logarithmic terms, which makes the estimated effect proportional to the base rate of migration.

Another obvious suspect for a potential source of heterogeneity in response to the earthquake is an individual's socio-economic status. Unfortunately, we do not have sufficient individual-level data to study changes in migration by occupation.[64] But we do have data on the composition of the local labor force by industry at the level of the district, and in particular on the share of agricultural workers, who were about 60 percent of the labor force (Table 2). More specifically, we observe the shares of different types of agricultural workers, divided into several categories. The different types of agricultural workers differed in both their standards of living and in their level of attachment to the land. Renters, lessees, and owner-occupiers, who had a stake in cultivating the land to which they were attached, could not abandon it costlessly on short notice and would have experienced the "greater exigency" of an incentive to rebuild after the shock. Day laborers, who were about half of the agricultural labor force (Table 2) may or may not have been more likely to migrate in general,[65] but relative to other agricultural workers, they were unfettered by contractual obligations or vested capital and, for this reason, potentially were more prone to quickly react to unexpected shocks. To evaluate the heterogeneity of the response with respect to socio-economic status and to the degree of attachment to the land, we test whether in fact areas where agricultural day laborers were a greater share of the labor force were more responsive to damage from the earthquake.

Our empirical approach is to adjust the difference-in-differences specification of equation (1) to the form

$$\log(e_{it}) = \alpha_{pt} + \alpha_i + \beta(s_i \times q_t) + \gamma(d_i \times q_t) + \delta(x_i \times q_t) + \pi(s_i \times x_i \times q_t) + \varepsilon_{it}, \tag{3}$$

where x_i is some characteristic of commune i and π is the interaction coefficient of interest. Similarly, we adjust the event study specification of equation (2) to the form

$$\log(e_{it}) = \alpha_{pt} + \alpha_i + \beta_t s_i + \delta_t x_i + \pi_t(s_i \times x_i) + \gamma_t d_i + \varepsilon_{it}. \tag{4}$$

[64]Spitzer and Zimran (2018) transcribed occupation and literacy data for a limited sample of migrants in the Ellis Island passenger lists, but this sample is too small to analyze changes in commune-year averages.

[65]There is reason to believe that agricultural day laborers made up the bulk of the flow of immigrants from Italy as a whole, although it is impossible to positively verify this. In Spitzer and Zimran's (2018) sample, 47.8 percent of male migrants over age 22 reported an unskilled job, with another 37.1 percent reporting a farming occupation. However, given the age distribution, it is very likely that some or even most of those listed as farmers were, in fact, farm laborers. That farmers were the shortest occupational group (Spitzer and Zimran 2018, Table A.2, p. 243) is consistent with this. Moreover, it is very likely that those listing an occupation of "laborer" were in fact farm laborers; see also Pérez's (2019, pp. 13–14) argument that the distinction between farmers and unskilled laborers in passenger manifests is not particularly informative.

We begin by focusing on results with x_i as the 1901 district-level share of employment as agricultural day laborers, which we adjust to have mean zero and standard deviation one in the sample.

Table 5 presents the results of estimating equation (3) for unadjusted emigration data for Sicily and Calabria.[66] Columns (1)–(4) use the Ellis Island data while columns (5)–(8) use the official statistics. Columns (1) and (5) repeat results from Table 3 for comparison. Our main results for heterogeneity by employment in agricultural day labor are in columns (2) and (6). These results indicate a small and statistically insignificant reaction of communes at the mean to the earthquake. But they also show that there is a statistically significant relationship between a district's share of employment in agricultural day labor and the response of communes in that district to the earthquake shock. In column (2), we find that a commune with an agricultural day labor share one standard deviation above the mean experienced an increase in emigration of over 35 percent in response to the earthquake shock. It is important to note, however, that even this relatively large response of areas with a higher agricultural day labor share was small relative to the fluctuation in migration rates in response to the Panic of 1907.

To more easily see the different reaction of communes with different agricultural day labor shares to the earthquake, Figure 8 estimates equation (4) over the same sample using an indicator for being above the sample median in terms of the agricultural day labor share as x_i. Panel (a), which uses the Ellis Island data, shows clear evidence of a differential reaction to the earthquake in terms of the composition of local labor force. Whereas communes in both above- and below-median districts show no pre-trend, there is a readily apparent (and statistically significant) divergence in the effect of the earthquake on affected districts.[67] Communes in districts with an above-median share of agricultural day laborers show an increase in emigration in response to the earthquake of 23 percent in 1909, whereas communes with a below-median share show a decrease in 1909 of 46 percent. After 1909, there remains a divergence between the two groups of communes, though the difference is smaller—an increase of about 10 percent and a decrease of about 17 percent in 1911, both statistically insignificant. The event-study results with the official statistics in panel (b) are less dispositive, however, requiring us to treat these results with some skepticism.[68]

Was this heterogeneity indeed linked to the structure of the agricultural labor force, or merely to its size relative to that of other sectors? In columns (3) and (7), we estimate equation (3) with the share of a district's male labor force employed in agriculture in 1901, standardized to have mean zero and standard deviation one in the sample, as x_{ip}. In column (3), the coefficient is weaker than for the purely unattached agricultural labor

[66] Results for other dependent variables and geographic scopes are presented in Online Appendix Table A.3.

[67] As with our analysis of the aggregate effects above, there is concern that spillovers may lead to a bias in this analysis. But these spillovers would tend to work against our finding in this section of an effect of the earthquake.

[68] Results for alternative dependent variables are presented in Online Appendix Figure A.4.

force, but is still large and statistically significant;[69] in column (7), the estimate is similar to that for column (6). Columns (4) and (8) allow for heterogeneous earthquake responses by both characteristics, effectively "horse-racing" the two.[70] In column (4), the coefficient on the interaction with general agricultural labor is considerably reduced relative to column (3) and is statistically insignificant. Conversely, the coefficient on the interaction with the share in agricultural day labor is only slightly reduced and remains statistically significant. This suggests that the positive effect is indeed specific to the unattached agricultural labor.

Again, performing the same exercise with the official statistics (column 8) gives less conclusive results. In this case, neither the interaction with the agricultural day laborer share nor with the general agricultural labor share is statistically significant, though the magnitude of the coefficient on the interaction of the agricultural day laborer share remains similar, but is less precisely estimated, as compared to column (6). Thus, the results of column (8) cannot definitively differentiate between the role of general and unattached agricultural labor. On the whole, however, we conclude that the results of Table 5 and Figure 8 show strong evidence of a heterogeneous impact of the earthquake on emigration according to employment in agriculture, and suggest that it is specifically the unattached portion of the agricultural labor force that is associated with a positive migration response to the disaster.

5.5 Discussion

In light of the devastation wrought by the Messina-Reggio Calabria Earthquake and the ubiquity of mass migration in Sicily and Calabria at the time of the shock, our finding that there was no discernible positive impact on migration from the average commune is surprising. It is, however, consistent with economic theory and with findings of no effect or a negative effect of natural disasters on migration in other contexts (e.g., Beine, Noy, and Parsons 2019; Beine and Parsons 2015; Cattaneo and Peri 2016; Gröschl and Steinwachs 2017; Halliday 2006; Hunter, Murray, and Riosmena 2013; Nawrotzki and DeWaard 2018; Yang 2008b), though unlike these cases, our results cannot be attributed to legal restrictions on international migration.

This literature has proposed a number of explanations for this so-called "immobility paradox." The main explanation is that the devastation from the disaster led to a tightening of liquidity constraints. While we do not have the data with which to directly test for this mechanism, the lack of a sustained decline in migration rates in severely damaged areas—either relative to other areas (Figure 6) or relative to pre-existing trends (Figure 5)—is on its face inconsistent with such a mechanism. Moreover, since day laborers were likely the poorest of the agricultural classes, an increase in migration where they were most common is inconsistent

[69] Results for other geographic scopes and dependent variables are presented in Online Appendix Table A.4.

[70] Full results are presented in Online Appendix Table A.5.

with the tightening of liquidity constraints as a factor affecting migration in response to the earthquake.

A rise in reconstruction labor demand as the explanation for our results is also inconsistent with the lack of a significant inflow of labor from the hinterland to the heavily damaged cities (Table 1) and with the delays in reconstruction documented above. It is also inconsistent with our findings of higher responsiveness of areas with more agricultural day laborers. These individuals, instead of migrating abroad, could have migrated to the urban areas in search of reconstruction labor, but evidently did not do so. However, a lack of detailed data on internal migration and wages prevent us from formally testing this mechanism.[71]

Another possible explanation for the lack of a migration response is that natural disasters are one-time shocks that do not affect the long-term attractiveness of a location.[72] But the lack of a response to the Messina-Reggio Calabria Earthquake cannot be explained in this way. As described above, the effects of the earthquake on the affected areas were long lasting, with reconstruction continuing even after World War I. The earthquake thus *did* constitute a long-term change to the attractiveness of areas along the Strait of Messina.[73] A lack of networks in potential destinations (e.g., Mahajan and Yang 2020; Spitzer 2016) may also have limited the ability of individuals to respond to the earthquake through overseas emigration. However, as discussed above, extremely high rates of migration prior to the earthquake imply that this cannot be an explanation for a lack of response to a shock. Additionally, Bohra-Mishra, Oppenheimer, and Hsiang (2014) suggest that temporary migration may be more responsive than permanent migration to shocks. As discussed above, however, the largely temporary nature of the Italian migration also rules out this potential explanation. Finally, Bettin and Zazzaro (2018), David (2011), Mohapatra, Joseph, and Ratha (2009), Paul (2005), and Yang (2008a) attribute such results to remittance flows and other financial inflows to the affected area. We have not been able to locate data on remittances that would enable us to test this mechanism. But there is evidence from the historical literature that governmental financial inflow to the area, though initially present,[74] were limited. For instance, only 866 of 30,000 businesses that applied were granted subsidies in the first four months after the earthquake (Di Paola and Savasta 2005), and the head of the relief committee forbade the allocation of funds to individuals (Bosworth 1981).

Instead, the explanation for a lack of response of migration to this shock may lie in our findings on

[71] Arcari (1936) provides province-level information on wages of various classes of agricultural workers, including agricultural day laborers beginning in 1905 (see also Federico, Nuvolari, and Vasta 2019). There is a general upward trend in wages in Messina, with no discernible deviation after the earthquake. However, the lack of more geographically detailed data prevents any stronger conclusion.

[72] There is stronger evidence in some settings of an effect of changing temperatures—a longer-term change in the attractiveness of a location—on emigration (e.g., Bohra-Mishra, Oppenheimer, and Hsiang 2014; Cattaneo and Peri 2016) than of an effect of single shocks.

[73] In Online Appendix D, we also show that the evidence of responsiveness to repeated earthquake shocks is limited.

[74] Parrinello (2015) indicates that the equivalent of about 82 million current Euros by the end of February 1909.

the heterogeneous response of areas of different labor market compositions, that there were effects that differed across parts of the affected area and offset one another. That these effects varied on the basis of the share of employment in agricultural day labor is consistent with the "greater exigencies" theory, as the agricultural day laborers, not owning or occupying any land, would be least affected by the new incentive for reconstruction of damaged property. This finding indicates that attachment to the land may have been an important determinant of responsiveness to such shocks.

6 Conclusion

How does a large shock to an area already experiencing mass migration affect migration? Does migration provide relief, as in many other cases? Or does the damage, destruction, and recovery hinder emigration? This paper answers these questions in the context of the most devastating earthquake to strike modern Europe, and arguably the most destructive natural disaster in modern European history, which occurred in the midst of the Age of Mass Migration in one of the areas most affected by this phenomenon. Using a dataset of emigration rates at the commune level for the period 1905–1912 (Spitzer and Zimran 2018, 2020), we find that on aggregate there was no more than a negligible and short-lived effect of the earthquake on emigration from affected communes. But this does not imply that the earthquake had no effect at all on emigration. Instead, we find that weaker attachment to the land was associated with increased migration—a result consistent with the "greater exigencies" mechanism of natural disasters reducing migration, and with attachment to the land acting as a barrier to responding to shocks through migration.

The results of this paper add to the large recent literature on the Age of Mass Migration, and to the debate over the impact of push and pull factors on migration in this context (Gould 1979; Hatton and Williamson 1998), pointing to a weak role for push factors relative to pull factors. More importantly for current international migration, we shed light on the question of how migration is affected by natural and man-made disasters. As a changing climate has increased the likelihood of natural disasters (Intergovernmental Panel on Climate Change 2012), in particular in the developing world, concern has grown over the degree to which individuals will be displaced (World Bank 2018). It remains an open question whether and under what circumstances individuals in the affected region can find relief through migration, and moreover whether such shocks will lead to an influx of refugees to developed countries. However, the results of this paper show that in areas with a high rate of pre-disaster migration struck by a devastating shock need not produce migration in response, even when borders are open.

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Tables

Table 1: Population of the cities of Messina and Reggio Calabria by birthplace, 1901 and 1911

	Messina		Reggio Calabria	
Birthplace	1901	1911	1901	1911
Same commune	127,017	106,025	37,175	32,530
Other commune in same province	9,888	7,838	3,927	4,872
Elsewhere in Sicily	4,244	6,167	824	1,826
Elsewhere in Calabria	3,833	2,386	668	755
Total	149,778	126,557	44,415	43,162

Notes: The "Total" row includes births elsewhere in Italy and abroad; for this reason, the first four rows of each column do not sum to the figure in the "Total" row.
Sources: For 1901, the data are from the 1901 Italian census of population, Volume II, Table V.A, pages 357–8. For 1911, the data are from the 1911 Italian census of population, Volume VI, Table IX.A, pages 78 and 85.

Table 2: Summary statistics

	Sicily and Calabria			Calabria		Sicily		Italy
	Severe	Not Severe		Severe	Not	Severe	Not	All
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	All	All	150 km	All	All	All	All	
Earthquake Exposure								
Distance to Epicenter (km)	39.034	138.958	98.106	39.361	128.971	38.209	148.714	640.389
	(20.977)	(56.769)	(32.527)	(22.613)	(45.797)	(16.474)	(64.339)	(326.519)
Mercalli Intensity	8.368	5.764	6.324	8.404	6.108	8.276	5.429	1.159
	(0.707)	(1.345)	(1.186)	(0.739)	(0.980)	(0.621)	(1.555)	(2.327)
Deaths per thousand	18.739	0.011	0.020	19.923	0.011	15.759	0.011	0.380
	(59.504)	(0.118)	(0.157)	(48.086)	(0.103)	(82.543)	(0.132)	(8.817)
Emigrants per Thousand Population								
Ellis Island, 1905–1908	14.753	14.925	14.533	13.722	14.213	17.276	15.598	8.236
	(16.496)	(14.627)	(13.498)	(16.782)	(12.479)	(15.560)	(16.377)	(12.234)
Ellis Island, 1909–1912	12.458	13.907	14.013	10.864	13.320	16.526	14.456	7.337
	(12.925)	(11.640)	(11.473)	(12.566)	(10.785)	(12.989)	(12.365)	(9.609)
Ellis Island, Prime, 1905–1908	10.882	9.043	9.415	10.703	9.312	11.319	8.789	5.260
	(11.943)	(8.931)	(9.057)	(12.587)	(8.646)	(10.242)	(9.188)	(7.905)
Ellis Island, Prime, 1909–1912	8.540	8.004	8.649	7.934	8.670	10.086	7.380	4.492
	(8.353)	(7.027)	(7.484)	(8.530)	(7.314)	(7.705)	(6.691)	(6.128)
Official, 1905–1908	34.146	36.296	36.136	35.196	38.948	31.030	33.710	27.614
	(19.560)	(21.662)	(21.634)	(19.579)	(19.194)	(19.242)	(23.545)	(26.933)
Official, 1909–1912	31.899	34.195	34.536	30.740	37.742	35.340	30.735	26.343
	(18.184)	(19.185)	(20.028)	(17.328)	(17.778)	(20.200)	(19.871)	(26.674)
Migrant Characteristics, 1905–1908								
Age	26.572	25.253	25.559	27.227	25.721	24.969	24.813	25.666
	(3.989)	(3.815)	(3.793)	(4.280)	(3.971)	(2.549)	(3.608)	(5.577)
Male	0.873	0.773	0.799	0.896	0.807	0.818	0.742	0.797
	(0.136)	(0.173)	(0.166)	(0.135)	(0.173)	(0.122)	(0.167)	(0.228)
Prime-Aged Male	0.750	0.635	0.663	0.786	0.673	0.664	0.599	0.677
	(0.183)	(0.216)	(0.207)	(0.173)	(0.212)	(0.179)	(0.214)	(0.278)
Child	0.117	0.181	0.165	0.100	0.157	0.158	0.204	0.139
	(0.109)	(0.141)	(0.136)	(0.106)	(0.134)	(0.103)	(0.143)	(0.171)
Commune Characteristics								
Population (1901, 1,000)	6.185	6.896	5.714	4.854	3.284	9.538	10.437	5.433
	(16.529)	(15.593)	(9.847)	(8.950)	(3.224)	(27.627)	(21.134)	(17.928)
District Agricultural Day Laborer Share (1901)	0.301	0.309	0.305	0.315	0.320	0.267	0.297	0.170
	(0.056)	(0.077)	(0.065)	(0.037)	(0.075)	(0.078)	(0.078)	(0.102)
District Agricultural Employment Share (1901)	0.616	0.647	0.658	0.648	0.698	0.535	0.597	0.628
	(0.114)	(0.108)	(0.093)	(0.081)	(0.044)	(0.145)	(0.126)	(0.140)
Distance to Emigration Epicenter (km)	208.854	126.033	162.783	221.824	157.449	176.205	95.343	137.673
	(25.576)	(60.239)	(39.159)	(15.243)	(47.371)	(14.815)	(55.507)	(85.020)
Observations	804	4,790	2,715	574	2,322	230	2,468	38,299
Communes	109	629	356	80	308	29	321	6,505

Notes: Standard deviations in parentheses. Observations are at the commune-year level. Mercalli measures are imputed where missing. Observation numbers are the minimum with observations for all variables in the Ellis Island-based dataset. Commune numbers are the number of distinct communes among these observations. Emigration rates are expressed per thousand population for clarity, but we use the (logarithm of the) decimal rate for analysis.

Table 3: Difference-in-differences results

	Ellis Island				Official Data	
			Prime-Age Only			
	(1) All	(2) Deaths	(3) All	(4) Deaths	(5) All	(6) Deaths
Panel A: Sicily and Calabria	−0.056	−0.040	−0.077	−0.060	−0.056	−0.026
	(0.142)	(0.137)	(0.140)	(0.134)	(0.079)	(0.080)
Observations	5,610	5,610	5,547	5,547	6,109	6,109
R-squared	0.752	0.752	0.741	0.742	0.610	0.609
Panel B: Italy	−0.058	−0.041	−0.077	−0.061	−0.057	−0.027
	(0.142)	(0.137)	(0.140)	(0.135)	(0.084)	(0.085)
Observations	39,717	39,717	37,494	37,494	61,164	61,164
R-squared	0.798	0.798	0.794	0.794	0.772	0.772
Panel C: Sicily and Calabria (150 km)	−0.052	−0.036	−0.075	−0.059	−0.082	−0.051
	(0.129)	(0.125)	(0.131)	(0.126)	(0.084)	(0.083)
Observations	3,528	3,528	3,490	3,490	3,928	3,928
R-squared	0.744	0.744	0.745	0.745	0.628	0.626
Panel D: Calabria (150 km)	−0.022	−0.017	−0.030	−0.025	0.007	0.012
	(0.061)	(0.060)	(0.058)	(0.057)	(0.056)	(0.057)
Observations	2,079	2,079	2,060	2,060	2,391	2,391
R-squared	0.742	0.742	0.731	0.730	0.546	0.539
Panel E: Sicily (150 km)	−0.025	−0.008	−0.039	−0.022	−0.101	−0.071
	(0.302)	(0.292)	(0.286)	(0.276)	(0.157)	(0.145)
Observations	1,449	1,449	1,430	1,430	1,537	1,537
R-squared	0.741	0.742	0.747	0.747	0.679	0.679

Significance levels: [a] p<0.01, [b] p<0.05, [c] p<0.1

Notes: This table presents difference-in-differences coefficients for severe-times-post. Standard errors clustered on the district level are in parentheses. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post, except for the results for all of Italy, which include log distance from the nearest emigration epicenter times post. Observations limited to 1905–1912.

Table 4: Difference-in-differences results for migrant characteristics

	(1) Age	(2) Male	(3) Prime	(4) Child
Panel A: Sicily and Calabria	−0.324	−0.015	−0.010	0.002
	(0.310)	(0.013)	(0.017)	(0.010)
Observations	5,623	5,621	5,621	5,623
R-squared	0.243	0.470	0.470	0.384
Panel B: Italy	−0.322	−0.015	−0.010	0.002
	(0.310)	(0.013)	(0.016)	(0.010)
Observations	40,269	40,280	40,260	40,290
R-squared	0.246	0.322	0.325	0.283
Panel C: Sicily and Calabria (150 km)	−0.266	−0.018	−0.014	0.004
	(0.325)	(0.012)	(0.015)	(0.009)
Observations	3,539	3,537	3,537	3,539
R-squared	0.253	0.444	0.441	0.333
Panel D: Calabria (150 km)	-0.700^{c}	−0.014	−0.022	0.011
	(0.378)	(0.022)	(0.019)	(0.008)
Observations	2,082	2,080	2,080	2,082
R-squared	0.215	0.385	0.404	0.301
Panel E: Sicily (150 km)	0.056	−0.012	0.011	0.003
	(0.415)	(0.016)	(0.020)	(0.018)
Observations	1,457	1,457	1,457	1,457
R-squared	0.235	0.415	0.408	0.319

Significance levels: ^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1

Notes: This table presents difference-in-differences coefficients for severe-times-post. Standard errors clustered on the district level are in parentheses. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post, except for the results for all of Italy, which include log distance from the nearest emigration epicenter times post. Observations limited to 1905–1912.

Table 5: Heterogeneous responses to the earthquake

	Ellis Island				Official			
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severe x Post	−0.056	0.014	0.017	0.022	−0.056	−0.081	−0.020	−0.060
	(0.142)	(0.090)	(0.087)	(0.087)	(0.079)	(0.080)	(0.050)	(0.056)
Severe x Post x Ag Lab Share		0.341^a		0.308^a		0.133^b		0.119
		(0.085)		(0.101)		(0.064)		(0.135)
Severe x Post x Ag Share			0.196^b	0.021			0.153^a	0.086
			(0.073)	(0.082)			(0.054)	(0.104)
Observations	5,610	5,592	5,592	5,592	6,109	6,109	6,109	6,109
R-squared	0.752	0.752	0.752	0.752	0.610	0.614	0.611	0.615

Significance levels: ^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1
Notes: Sample includes all communes in the regions of Sicily and Calabria. Dependent variable is unadjusted emigration rate relative to 1901 population from the source listed in the column header. Standard errors clustered on the district level are in parentheses. Ag Share is defined as the fraction of the 1901 male labor force in agriculture at the district level, and is standardized to have mean zero and standard deviation one. Ag Lab Share is the share of the 1901 male labor force in agricultural day labor (*giornalieri di campagna*) at the district level and is standardized to have mean zero and standard deviation one in the sample. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post. Observations limited to 1905–1912.

Figures

Figure 1: Map of districts in the affected area

Note: Districts in the provinces of Messina and Reggio Calabria are labeled. The earthquake epicenter is indicated by the large dot.

(a) Mercalli Scores

(b) Severity Indicator

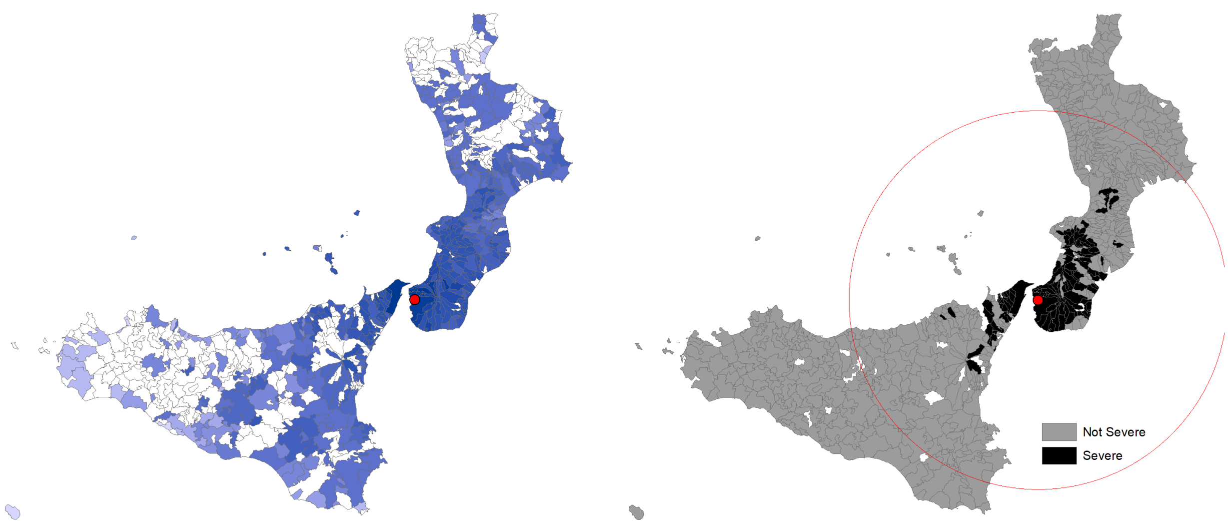


Figure 2: Earthquake damage

Note: The large dot indicates the earthquake epicenter. Panel (a) presents the Mercalli scores derived from Guidoboni et al. (2007), as described in text. Darker colors indicate higher Mercalli severity; white communes have no data. Panel (b) presents the severity indicator, which takes a value of one for communes with Mercalli severity of at least VIII. Communes with no Mercalli data have their severity based on an inverse-distance-weighted imputation; in practice all missing communes have an imputed Mercalli score less than VIII and thus are not considered "severely damaged." The red circle in panel (b) marks a radius of 150 kilometers from the earthquake epicenter.

(a) Average Annual Emigration Rates 1905–1908 (b) Ratio of 1909–1912 to 1905–1908 Emigration Rates

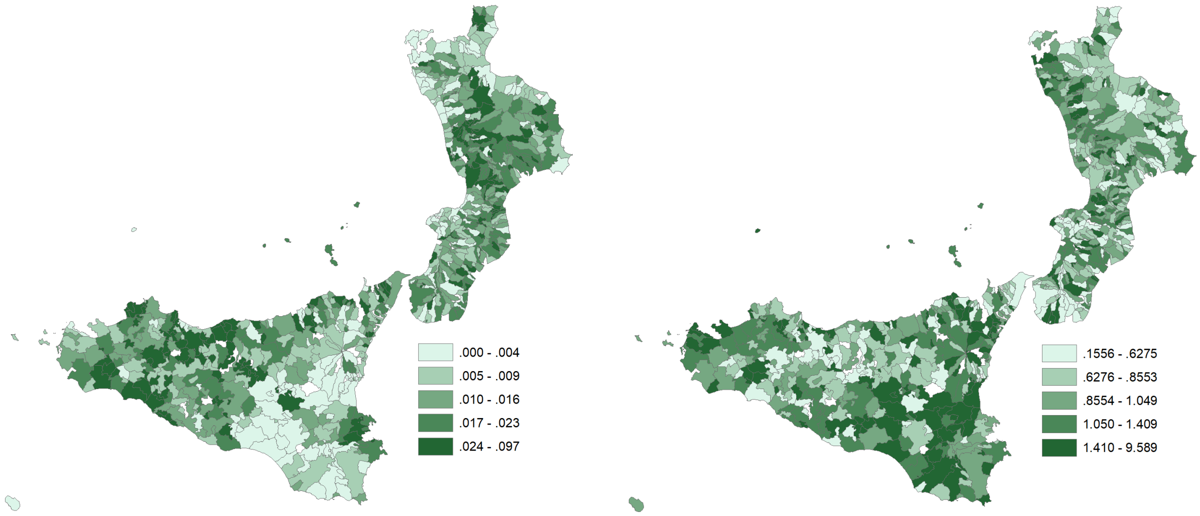


Figure 3: Commune-level emigration rates

Note: Data are from Ellis Island. Panel (a) shows average annual emigration rates for 1905–1908. Panel (b) shows the ratio of the average annual emigration rate for 1909–1912 to that for 1905–1908. Both map scales are based on quantiles of the distribution.

(a) Ellis Island (b) Official

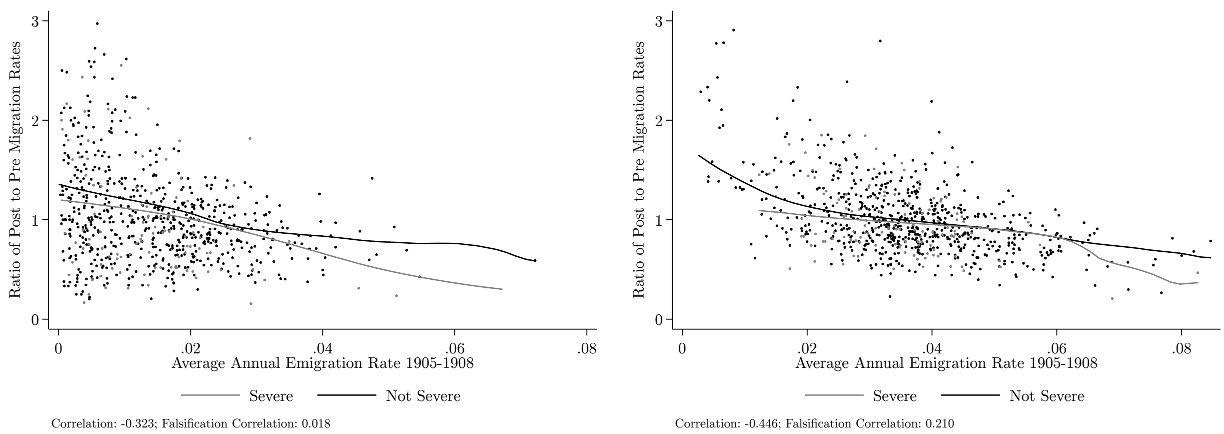


Figure 4: β-convergence in emigration rates

Note: "Severe" indicates communes experiencing severe damage from the earthquake. "Not Severe" indicates all communes in Sicily and Calabria not experiencing severe damage from the earthquake. This figure plots the change in emigration rates over the period 1905–1908 to 1909–1912 (i.e., the ratio of the latter to the former) against the average annual emigration rate for 1905–1908 at the commune level using data from Ellis Island. Communes that more than tripled their migration (27 in panel a and 2 in panel b) are omitted from the scatterplots (but not the non-parametric regressions) for clarity. One commune in panel (a) with a 1905–1908 migration rate over 0.08 is also omitted from the scatter plot for clarity.

(a) Ellis Island

(b) Official

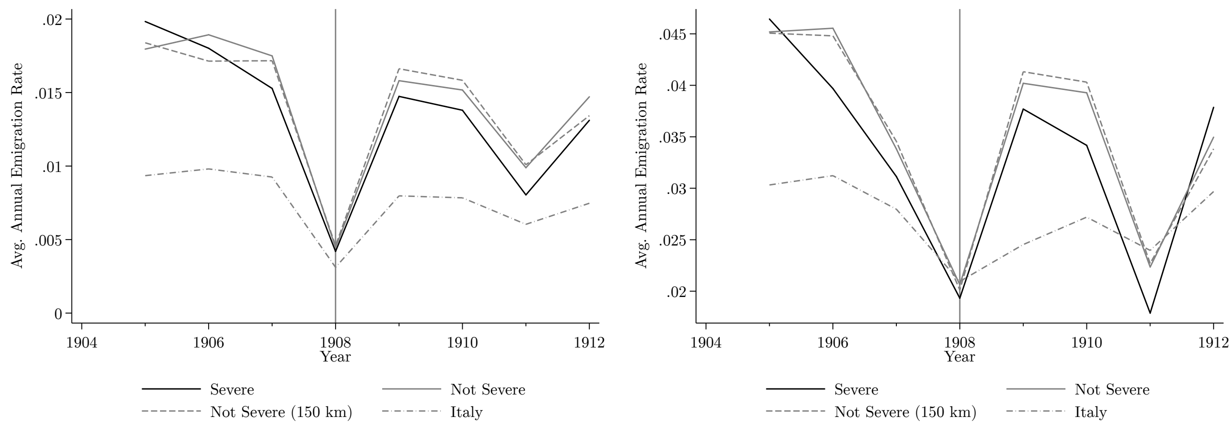


Figure 5: Emigration Trends for Sicily and Calabria

Note: "Severe" indicates communes experiencing severe damage from the earthquake. "Not Severe" indicates all communes in Sicily and Calabria not experiencing severe damage from the earthquake. "Not Severe (150 km)" is the same as the previous, but is limited to communes within 150 kilometers of the earthquake epicenter. "Italy" is the trend for all of Italy. These are average annual emigration rates for communes (i.e., they are not weighted by commune population).

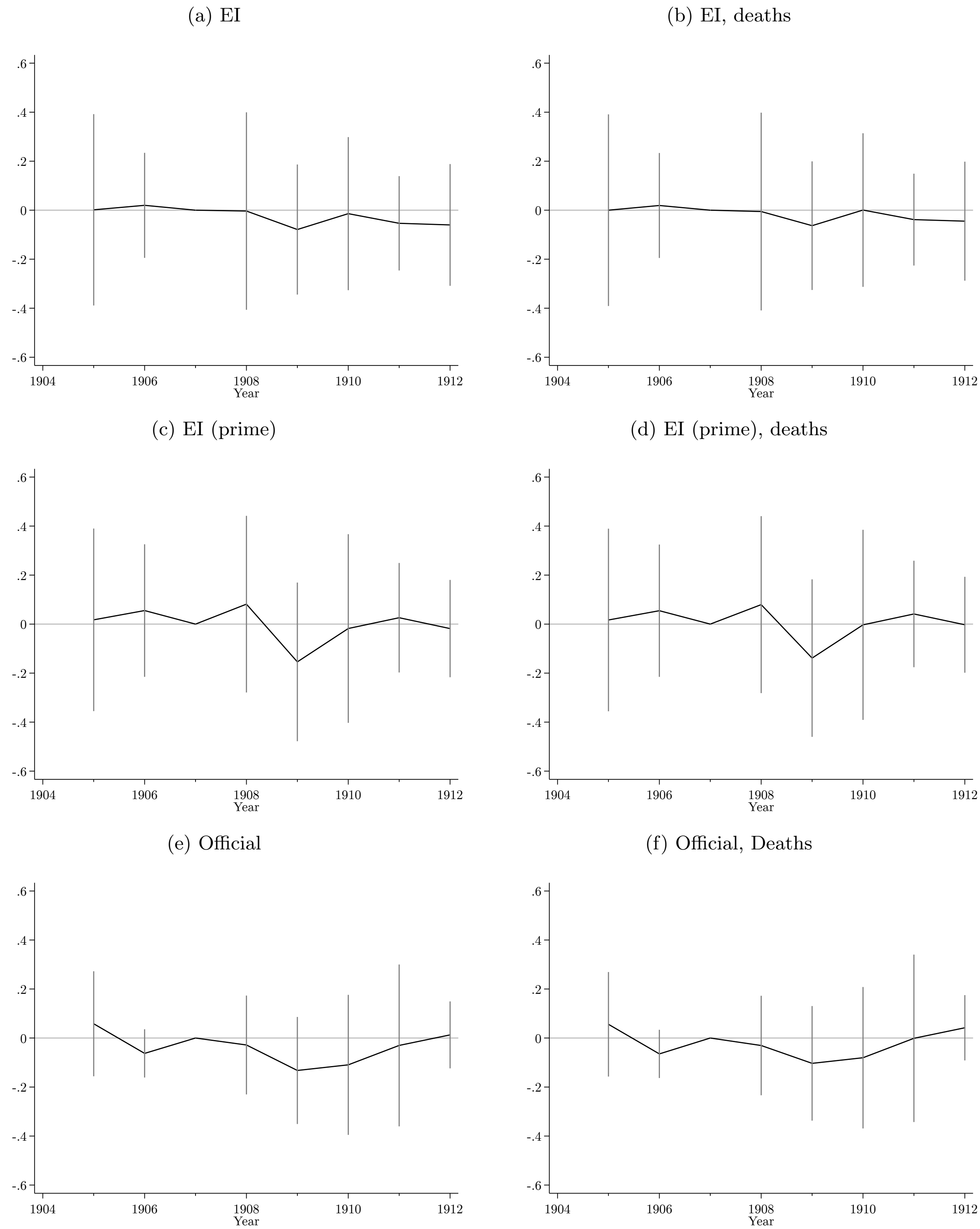


Figure 6: Event studies for the effect fo the earthquake on migration

Note: Sample includes all communes in the regions of Sicily and Calabria. All event studies control for a year-specific function of distance from Corleone and have 1907 as the base year. Bars indicate 95 percent confidence intervals clustered on the district level. The measure on the y-axis is the effect in log points.

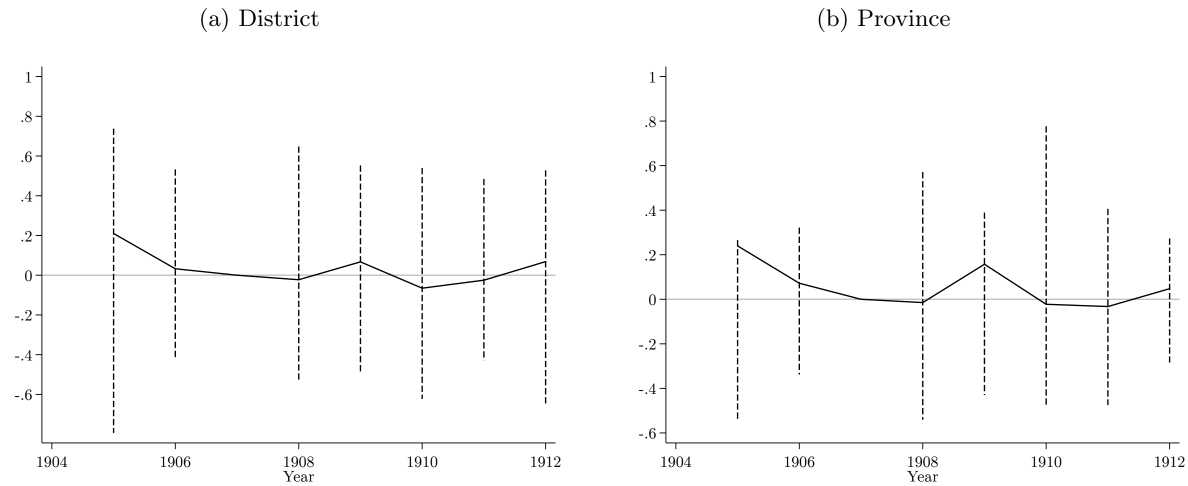


Figure 7: Event studies at higher levels of geographic disaggregation

Note: Sample includes all districts or provinces in Italy. Dotted lines represent 95% ranges of estimates from the randomization inference exercise described in text with 1907 as the base year. The measure on the y-axis is the effect in log points.

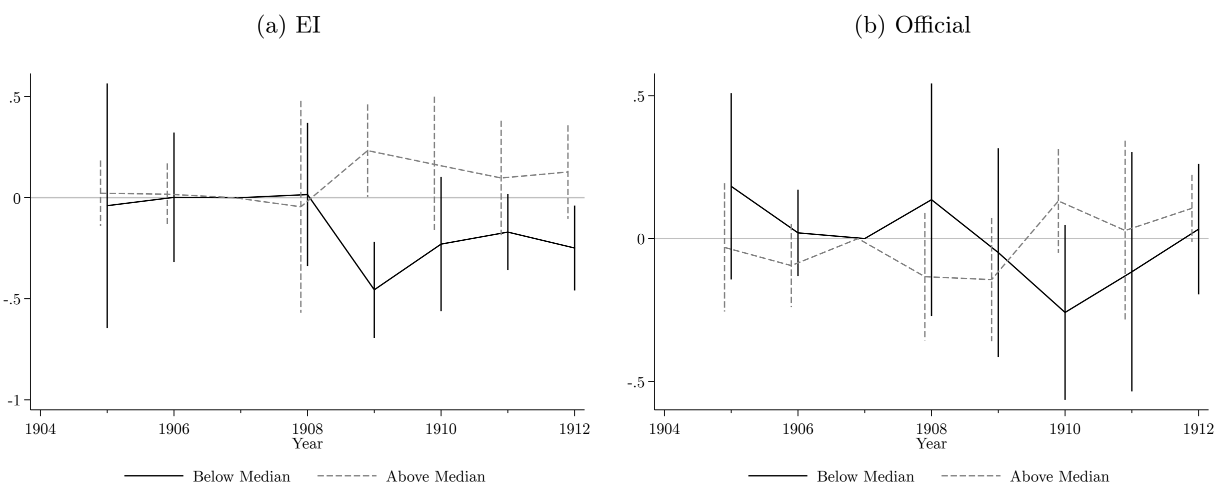


Figure 8: Event studies divided by share of district employment in agricultural day labor

Note: Sample includes all communes in the regions of Sicily and Calabria. All event studies control for a year-specific function of distance from Corleone and have 1907 as the base year. Bars indicate 95 percent confidence intervals clustered on the district level. The division into "below median" and "above median" is based on the distribution of the share of employment in agricultural day labor in the sample. The measure on the y-axis is the effect in log points.

A Additional Tables and Figures (For Online Publication)

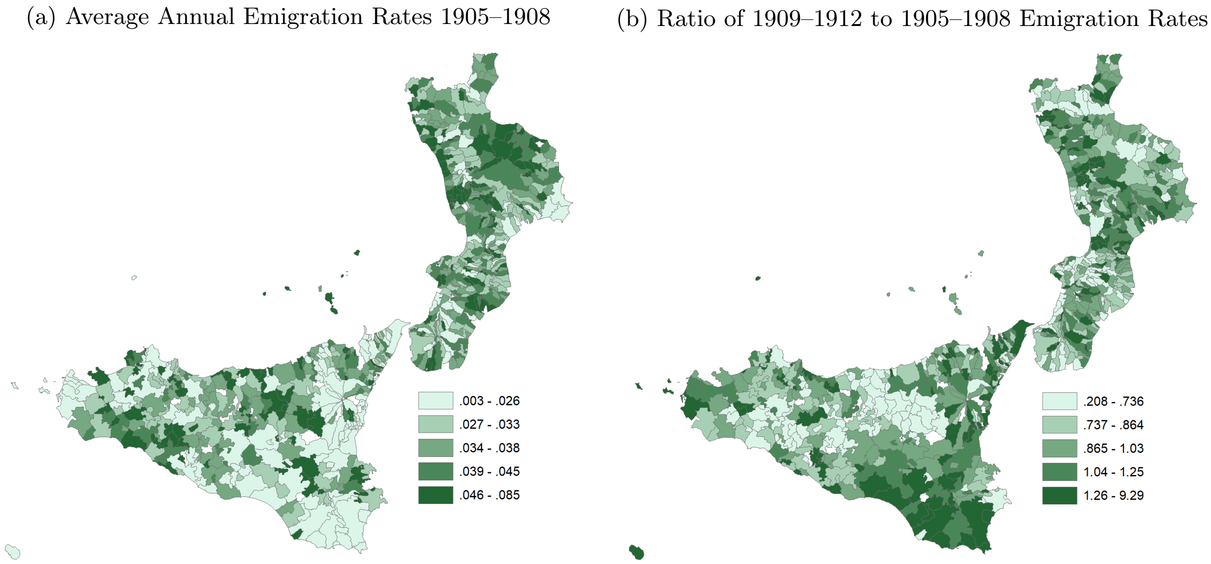


Figure A.1: Commune-level emigration rates

Note: Data are from Italian official statistics. Panel (a) shows average annual emigration rates for 1905–1908. Panel (b) shows the ratio of the average annual emigration rate for 1909–1912 to that for 1905–1908. Both map scales are based on quantiles of the distribution.

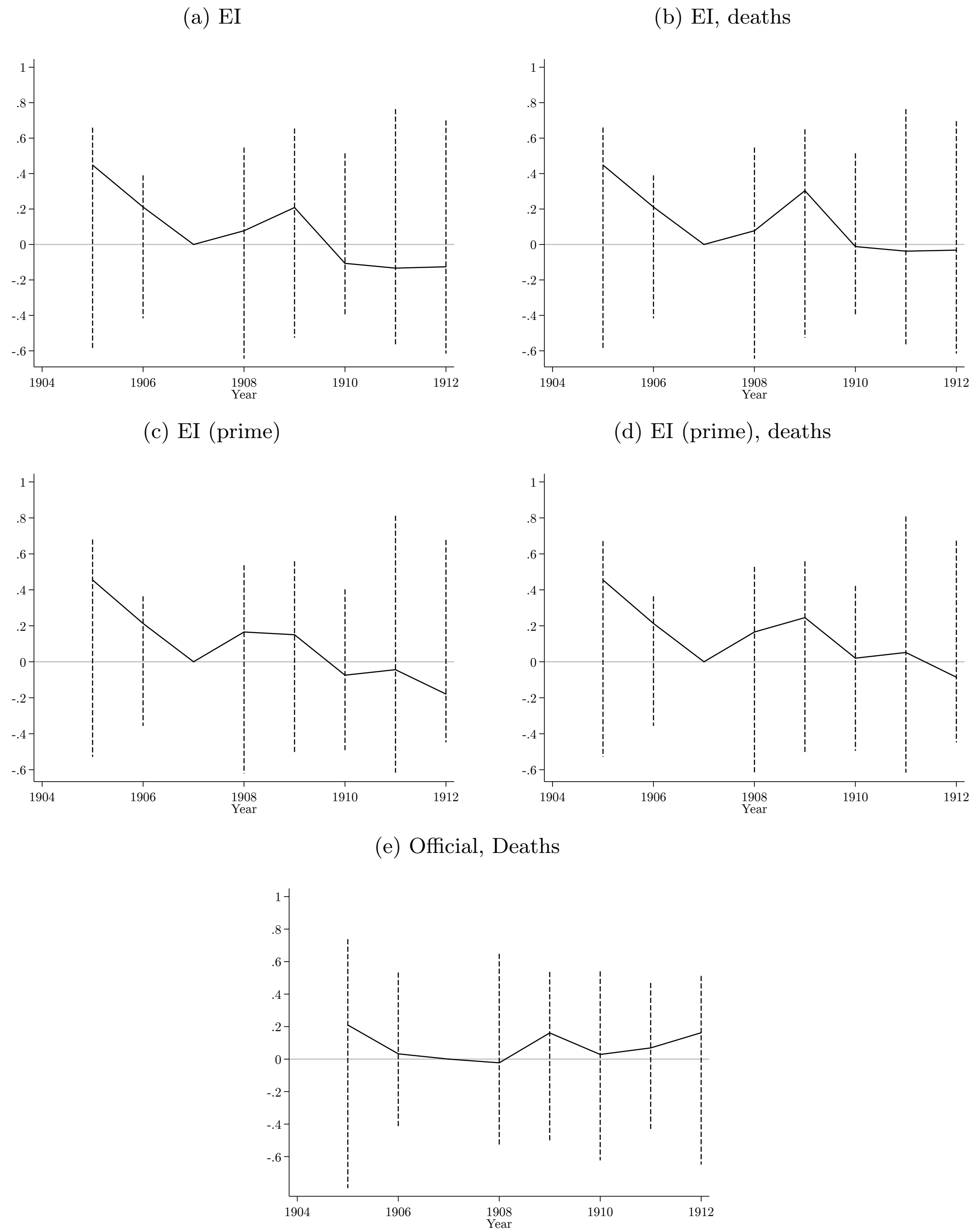


Figure A.2: Event studies at the district level

Note: Sample includes all districts in Italy. Dotted lines represent 95% ranges of estimates from the randomization inference exercise described in text with 1907 as the base year. The measure on the y-axis is the effect in log points.

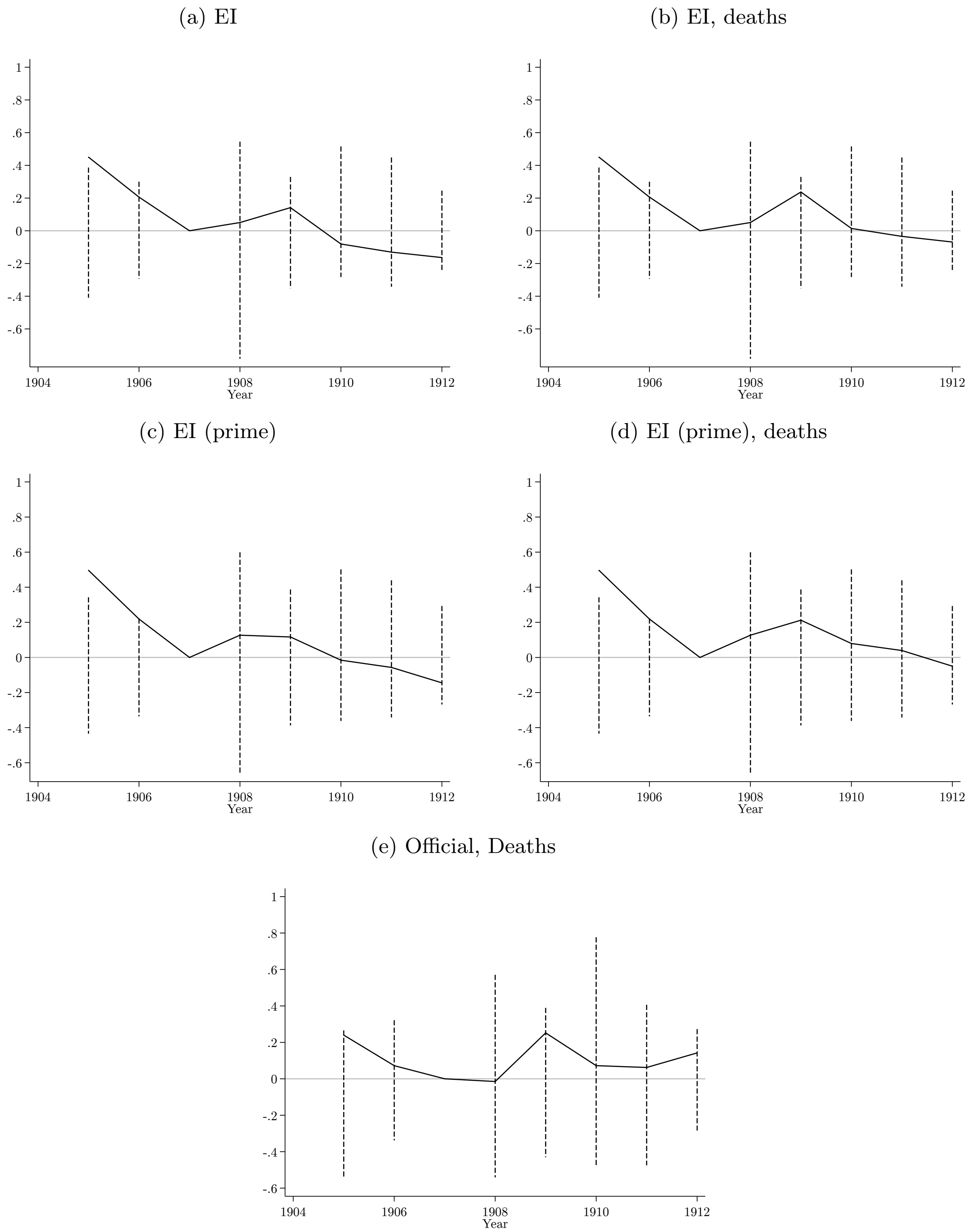
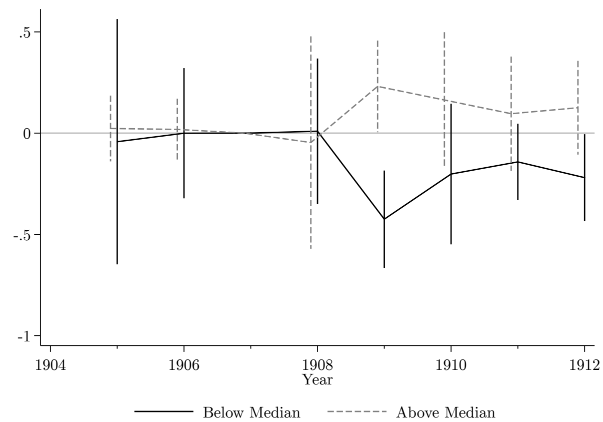


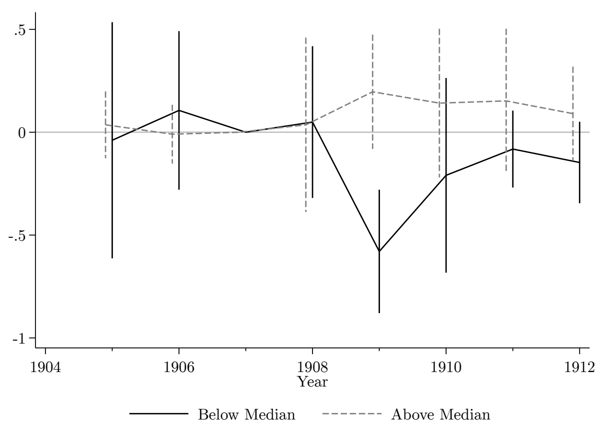
Figure A.3: Event studies at the province level

Note: Sample includes all provinces in Italy. Dotted lines represent 95% ranges of estimates from the randomization inference exercise described in text with 1907 as the base year. The measure on the y-axis is the effect in log points.

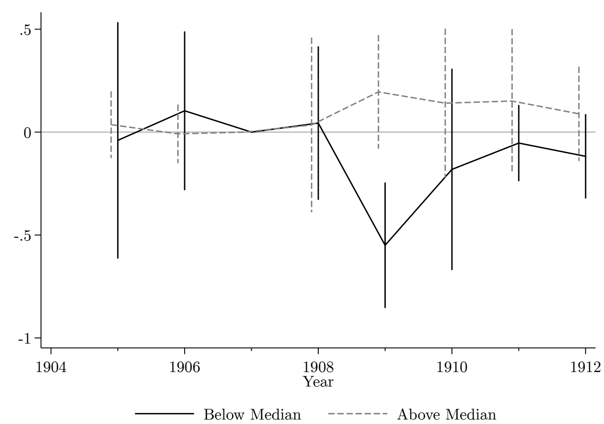
(a) EI, deaths



(b) EI (prime)



(c) EI (prime), deaths



(d) Official, Deaths

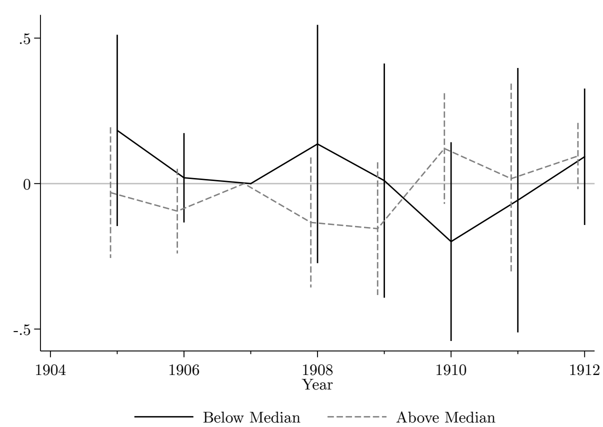


Figure A.4: Event studies divided by share of district employment in agricultural day labor

Note: Sample includes all communes in the regions of Sicily and Calabria. All event studies control for a year-specific function of distance from Corleone and have 1907 as the base year. Bars indicate 95 percent confidence intervals clustered on the district level. The division into "below median" and "above median" is based on the distribution of the share of employment in agricultural day labor in the sample. The measure on the y-axis is the effect in log points.

Table A.1: Difference-in-differences results with Mercalli scores

	Ellis Island				Official Data	
			Prime-Age Only			
Variable	(1) All	(2) Deaths	(3) All	(4) Deaths	(5) All	(6) Deaths
Sicily and Calabria	−0.049	−0.040	−0.054	−0.046	−0.021	−0.004
	(0.032)	(0.029)	(0.033)	(0.030)	(0.025)	(0.026)
Observations	5,555	5,555	5,493	5,493	6,053	6,053
R-squared	0.753	0.753	0.742	0.742	0.610	0.609
Italy	-0.061^{b}	-0.055^{b}	-0.064^{b}	-0.058^{b}	−0.036	−0.023
	(0.025)	(0.023)	(0.026)	(0.024)	(0.023)	(0.025)
Observations	9,205	9,205	9,052	9,052	10,015	10,015
R-squared	0.785	0.785	0.772	0.772	0.795	0.794
Sicily and Calabria (150 km)	-0.074^{c}	−0.058	-0.079^{c}	−0.063	−0.048	−0.018
	(0.040)	(0.036)	(0.044)	(0.041)	(0.037)	(0.043)
Observations	3,473	3,473	3,436	3,436	3,872	3,872
R-squared	0.745	0.745	0.746	0.746	0.628	0.625
Calabria (150 km)	−0.064	−0.050	−0.057	−0.044	−0.013	0.014
	(0.043)	(0.039)	(0.039)	(0.035)	(0.039)	(0.052)
Observations	2,055	2,055	2,036	2,036	2,367	2,367
R-squared	0.742	0.741	0.732	0.731	0.543	0.537
Sicily (150 km)	−0.103	−0.084	−0.102	−0.082	−0.054	−0.024
	(0.068)	(0.057)	(0.078)	(0.069)	(0.050)	(0.050)
Observations	1,418	1,418	1,400	1,400	1,505	1,505
R-squared	0.746	0.746	0.750	0.750	0.683	0.682

Significance levels: ^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1

Notes: This table presents difference-in-differences coefficients with continuous treatment intensity using Mercalli intensity, which is imputed where it is not observed. Standard errors clustered on the district level are in parentheses. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance to Corleone-times post, except for the all-Italy regressions which include log distance to the nearest epicenter of emigration-times-post. Observations limited to 1905–1912.

Table A.2: Difference-in-differences results with log(distance from epicenter)

	Ellis Island				Official Data	
			Prime-Age Only			
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	All	Deaths	All	Deaths	All	Deaths
Sicily and Calabria	−0.138	−0.110	−0.159[c]	−0.131	−0.068	−0.015
	(0.098)	(0.095)	(0.087)	(0.085)	(0.057)	(0.062)
Observations	5,610	5,610	5,547	5,547	6,109	6,109
R-squared	0.753	0.753	0.742	0.742	0.611	0.609
Italy	−0.130	−0.105	−0.144[c]	−0.120	−0.100	−0.053
	(0.088)	(0.086)	(0.081)	(0.078)	(0.062)	(0.069)
Observations	39,717	39,717	37,494	37,494	61,164	61,164
R-squared	0.798	0.798	0.794	0.794	0.772	0.772
Sicily and Calabria (150 km)	−0.185[b]	−0.151[c]	−0.190[b]	−0.156[c]	−0.083	−0.022
	(0.089)	(0.088)	(0.086)	(0.086)	(0.076)	(0.082)
Observations	3,528	3,528	3,490	3,490	3,928	3,928
R-squared	0.745	0.745	0.745	0.745	0.628	0.626
Calabria (150 km)	−0.243[c]	−0.170	−0.212	−0.142	0.134[a]	0.245[a]
	(0.111)	(0.112)	(0.125)	(0.126)	(0.039)	(0.043)
Observations	2,079	2,079	2,060	2,060	2,391	2,391
R-squared	0.742	0.742	0.731	0.731	0.547	0.543
Sicily (150 km)	−0.745[b]	−0.684[b]	−0.613[b]	−0.551[b]	−0.498[b]	−0.403[c]
	(0.251)	(0.237)	(0.235)	(0.220)	(0.195)	(0.219)
Observations	1,449	1,449	1,430	1,430	1,537	1,537
R-squared	0.745	0.745	0.749	0.749	0.683	0.682

Significance levels: [a] p<0.01, [b] p<0.05, [c] p<0.1

Notes: This table presents difference-in-differences coefficients with continuous treatment intensity defined by negative log distance from the epicenter. Standard errors clustered on the district level are in parentheses. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post, except for the all-Italy results, which include log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table A.3: Additional difference-in-differences results with share of district employment in agricultural day labor

	Ellis Island				Official Data	
			Prime-Age Only			
Variable	(1) All	(2) Deaths	(3) All	(4) Deaths	(5) All	(6) Deaths
Panel A: Sicily and Calabria						
Severe x Post	0.017	0.029	−0.008	0.004	−0.020	−0.000
	(0.087)	(0.085)	(0.085)	(0.083)	(0.050)	(0.054)
Severe x Post x Ag Lab Share	0.341^a	0.322^a	0.324^a	0.305^a	0.133^b	0.093
	(0.085)	(0.084)	(0.076)	(0.075)	(0.064)	(0.061)
Observations	5,592	5,592	5,531	5,531	6,109	6,109
R-squared	0.752	0.752	0.742	0.742	0.611	0.610
Panel B: Italy						
Severe x Post	−0.593^a	−0.547^a	−0.608^a	−0.562^a	−0.406^b	−0.307
	(0.117)	(0.116)	(0.093)	(0.092)	(0.189)	(0.190)
Severe x Post x Ag Lab Share	0.456^a	0.430^a	0.454^a	0.428^a	0.236^b	0.185^c
	(0.120)	(0.118)	(0.104)	(0.103)	(0.100)	(0.098)
Observations	37,846	37,846	35,689	35,689	61,164	61,164
R-squared	0.799	0.799	0.795	0.795	0.772	0.772
Panel C: Sicily and Calabria (150 km)						
Severe x Post	0.030	0.043	0.003	0.015	−0.034	−0.011
	(0.079)	(0.078)	(0.078)	(0.076)	(0.054)	(0.060)
Severe x Post x Ag Lab Share	0.226^a	0.210^a	0.223^a	0.207^a	0.113^a	0.080^c
	(0.072)	(0.071)	(0.067)	(0.067)	(0.039)	(0.041)
Observations	3,519	3,519	3,482	3,482	3,928	3,928
R-squared	0.745	0.745	0.747	0.747	0.630	0.627

Significance levels: ^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1

Notes: Standard errors clustered on the district level are in parentheses. Ag Lab Share is the share of the 1901 male labor force employed in agricultural labor (giornalieri di campagna) at the district level, and is standardized to have mean zero and standard deviation one. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post, except in Panel B, which uses log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table A.4: Additional difference-in-differences results with share of district employment in agriculture

	Ellis Island				Official Data	
			Prime-Age Only			
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	All	Deaths	All	Deaths	All	Deaths
Panel A: Sicily and Calabria						
Severe x Post	0.014	0.023	−0.008	0.002	−0.081	−0.065
	(0.090)	(0.090)	(0.092)	(0.091)	(0.080)	(0.082)
Severe x Post x Ag Share	0.196^b	0.178^b	0.185^a	0.168^b	0.153^a	0.117^b
	(0.073)	(0.074)	(0.067)	(0.068)	(0.054)	(0.049)
Observations	5,592	5,592	5,531	5,531	6,109	6,109
R-squared	0.752	0.752	0.742	0.742	0.614	0.612
Panel B: Italy						
Severe x Post	−0.004	0.007	−0.021	−0.010	−0.069	−0.043
	(0.094)	(0.094)	(0.096)	(0.096)	(0.085)	(0.087)
Severe x Post x Ag Share	0.240^b	0.218^b	0.226^b	0.204^b	0.110^c	0.062
	(0.103)	(0.106)	(0.091)	(0.093)	(0.057)	(0.050)
Observations	37,846	37,846	35,689	35,689	61,164	61,164
R-squared	0.799	0.799	0.795	0.795	0.772	0.772
Panel C: Sicily and Calabria (150 km)						
Severe x Post	0.039	0.047	0.012	0.020	−0.084	−0.071
	(0.094)	(0.094)	(0.093)	(0.094)	(0.066)	(0.070)
Severe x Post x Ag Share	0.137^b	0.122^c	0.141^b	0.126^b	0.149^b	0.119^c
	(0.060)	(0.061)	(0.058)	(0.058)	(0.059)	(0.059)
Observations	3,519	3,519	3,482	3,482	3,928	3,928
R-squared	0.744	0.744	0.746	0.746	0.630	0.628

Significance levels: ^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1

Notes: Standard errors clustered on the district level are in parentheses. Ag Share is the share of the 1901 male labor force employed in agriculture at the district level, and is standardized to have mean zero and standard deviation one. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post, except in Panel B, which uses log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table A.5: Additional difference-in-differences results with agricultural employment shares

	Ellis Island				Official Data	
			Prime-Age Only			
Variable	(1) All	(2) Deaths	(3) All	(4) Deaths	(5) All	(6) Deaths
Panel A: Sicily and Calabria						
Severe x Post	0.022	0.032	−0.003	0.007	−0.060	−0.042
	(0.087)	(0.086)	(0.085)	(0.085)	(0.056)	(0.054)
Severe x Post x Ag Lab Share	0.308[a]	0.317[a]	0.297[a]	0.305[a]	0.119	0.139
	(0.101)	(0.104)	(0.090)	(0.094)	(0.135)	(0.132)
Severe x Post x Ag Share	0.021	−0.001	0.016	−0.005	0.086	0.039
	(0.082)	(0.083)	(0.073)	(0.075)	(0.104)	(0.101)
Observations	5,592	5,592	5,531	5,531	6,109	6,109
R-squared	0.752	0.752	0.742	0.742	0.615	0.614
Panel B: Italy						
Severe x Post	−0.542[a]	−0.546[a]	−0.571[a]	−0.574[a]	−0.498	−0.510[c]
	(0.176)	(0.179)	(0.154)	(0.158)	(0.308)	(0.303)
Severe x Post x Ag Lab Share	0.419[a]	0.431[a]	0.429[a]	0.441[a]	0.297	0.324[c]
	(0.132)	(0.137)	(0.119)	(0.124)	(0.196)	(0.193)
Severe x Post x Ag Share	0.023	−0.006	0.009	−0.019	−0.039	−0.102
	(0.101)	(0.104)	(0.088)	(0.091)	(0.143)	(0.138)
Observations	37,846	37,846	35,689	35,689	61,164	61,164
R-squared	0.799	0.799	0.795	0.795	0.772	0.772
Panel C: Sicily and Calabria (150 km)						
Severe x Post	0.036	0.044	0.006	0.015	−0.069	−0.055
	(0.085)	(0.085)	(0.083)	(0.082)	(0.054)	(0.055)
Severe x Post x Ag Lab Share	0.220[b]	0.225[b]	0.210[b]	0.215[b]	0.049	0.059
	(0.084)	(0.086)	(0.082)	(0.084)	(0.073)	(0.074)
Severe x Post x Ag Share	−0.001	−0.019	0.009	−0.008	0.127	0.092
	(0.068)	(0.069)	(0.066)	(0.066)	(0.088)	(0.089)
Observations	3,519	3,519	3,482	3,482	3,928	3,928
R-squared	0.745	0.745	0.747	0.747	0.633	0.631

Significance levels: [a] p<0.01, [b] p<0.05, [c] p<0.1

Notes: Standard errors clustered on the district are in parentheses. Ag Share is the share of a district's 1901 male labor force employed in agriculture, and is standardized to have mean zero and standard deviation one. Ag Lab Share is the share of the 1901 male labor force in agricultural day labor (giornalieri di campagna) at the district level and is standardized to have mean zero and standard deviation one. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times post, except in Panel B, where we include log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

B Additional Details of Data Cleaning (For Online Publication)

The data that we created by geo-locating Ellis Island passengers to modern communes required standardization before analysis. The main issue in this case was the fact that some individuals were assigned to communes that were created after 1901, when our population data were taken.[75] Without any correction, it would not be possible to compute emigration rates for these communes because of the lack of a denominator. To address this issue, we manually scoured a variety of sources, such as the *Comuni e Loro Poplazione ai Censimenti dal 1861 al 1951*, published by ISTAT in 1960, which lists border histories to 1951. (In cases where communes were founded after 1951, other sources were consulted, such as official websites of each commune.) These sources enabled us to determine which historic commune these new communes were a part of in the early 20th century. We can then simply use the population of that historic commune as the denominator and the total number of emigrants from any component of the historic commune as the numerator.

For the official statistics, the difficulty was in geo-locating communes that no longer exist because they were merged into modern communes. If the communes no longer exist, we do not have the ability to determine their severity, distance from the epicenter, or distance from Corleone. To address this issue, we used the *Comuni e Loro Popolazione* and related sources to determine the commune into which they were combined. We then used the centroid of the modern commune as the location of all historic communes now making up the modern commune. This approach is necessarily imperfect, but is the best approach available to us given the absence (to our knowledge) of a map of historic communes.

[75]This would occur if an individual listed a village within a commune as his last place of residence and this village later separated to become a separate commune.

C Evidence from Refugee Censuses (For Online Publication)

Another source published in the wake of the earthquake enables us to perform an additional test of the effect of the earthquake on emigration. In particular, in the initial weeks after the earthquake, refugees from Messina were resettled in various cities throughout Italy. We have been able to locate and digitize a census taken in the aftermath of the earthquake listing all refugees resettled in the city of Catania, on Sicily's southeastern coast. In total, 20,673 individuals are listed in this source.

To determine whether there was a change in emigration after the earthquake, we link the individuals listed in this source to the Ellis Island passenger manifest from which our emigration data were derived. We perform this linkage using a procedure based on that described by Collins and Zimran (2019), which is also used by Collins and Zimran (2020). This procedure derives from Ferrie's (1996) pioneering record linkage approach. It is most similar to that used by Beach et al. (2016) and also shares strong similarities with the method used by Abramitzky, Boustan, and Eriksson (2014) and described in further detail by Abramitzky et al. (2019). Relative to this procedure, we make the following adjustments. First, we include both men and women. Whereas the Ellis Island manifests list the passenger's gender, the refugee census does not; we impute gender by assigning a female gender to any individual whose first name ended in "a."[76] Second, we require that the absolute difference in the age-implied birth years of individuals in the two sources be no more than two years (as opposed to four). Third, we do not include a preliminary step in which we match the sources to themselves and remove potential duplicates. In the Ellis Island data, we do this because it was common for individuals to travel multiple times, and we thus expect there to be cases in which the same individual appears multiple times. In the case of the refugee census, the small sample means that such a linkage would not necessarily eliminate common names. Fourth, after linking we limit the sample to individuals listed in the refugee census as being between the ages of 18 and 30 in 1909. Finally, we do not require a unique match. Instead, we eliminate any case in which a record has no more than five matches in the opposite source. Given these looser linkage conditions than are common in the literature on linked data, this exercise amounts to asking what the trend in emigration was among individuals in the Ellis Island manifest whose approximate names and birth years appear in the refugee census. It is thus at best supportive evidence to supplement our more definitive evidence presented in the main text.

Figure C.1 presents the results. In panel (a), we present two time trends. The first, labeled "Linked," is the number of passengers in the Ellis Island manifest who were linked to an individual in the refugee census. The second, labeled "Total," is the total number of passengers in the source. In panel (b), we present

[76] Of course, there are some Italian male names that end in "a," but this approach provides a simple but useful approximation.

analogous results limiting the data to passengers listing a last place of residence in the province of Messina. We do not perform any formal testing given the small sample, but the basic result is evident in the figures.

First, the fact that we have a large number of links in 1908 and earlier—years in which, in principle, all individuals in the refugee census were living in Italy, suggests that our linkage is characterized by a large degree of false matches. Second, the continued similarity of the trends after 1908 supports our findings of no effect of the earthquake on migration. In principle, an increase in migration by these refugees could have led to a surge of the linked line above the trend of the total line after 1908 (but not before), or vice versa. But no such effect is evident in this case, suggesting that the representation of individuals with names appearing in the refugee list did not increase after the earthquake.

(a) All Passengers (b) Messina Passengers

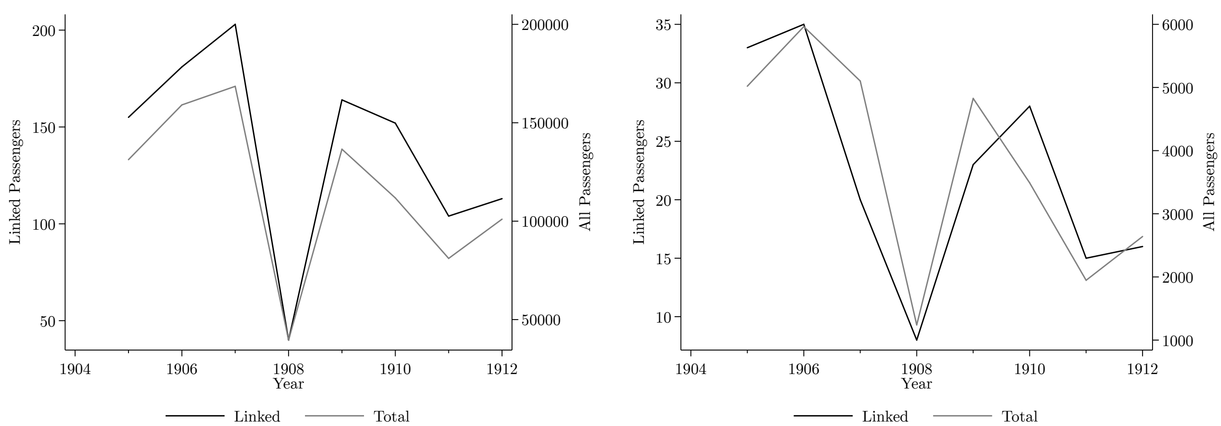


Figure C.1: Patterns in linked data

D Heterogeneous Responses to the Earthquake (For Online Publication)

One possible reason for a lack of response to a shock such as an earthquake is its transient nature. Whereas the devastation inflicted by the earthquake was substantial, it was also a transient shock and may not have led potential migrants to update their beliefs regarding the long-run utility of remaining in Italy.[77] However, in an area prone to seismic shocks, an accumulation of earthquakes may have had a stronger effect than a single shock, however large. Indeed, Calabria was also affected by a magnitude 7.2 earthquake in 1905. Although the Richter intensity of this earthquake was greater than the one that we study, it was far less destructive, causing at most 2,500 deaths. Guidoboni et al. (2007) also provide Mercalli severity scores for this earthquake. The communes severely affected by this earthquake, indicated in Figure D.1, overlap somewhat with those severely affected by the 1908 earthquake, enabling us to test this dual-earthquake hypothesis.

The results of this test are presented in Table D.1, which shows the results of estimating equation (3) with x_i taking a value of one for communes severely affected by the 1905 earthquake and zero otherwise. Our preferred specification continues to be the one using unadjusted Ellis Island data and focusing on the entirety of the regions of Sicily and Calabria. We find that communes unaffected by the 1905 earthquake had a somewhat smaller (but still imprecisely estimated) response to the 1908 earthquake (the severe × post coefficient) at a decline of 4.8 log points. We also find a negative coefficient on severe × post × severe 1905, indicating a more negative response to the 1908 earthquake among communes that also experienced the 1905 earthquake severely. Communes experiencing both earthquakes had an estimated decline in migration in response to the 1908 earthquake of 21 percent—a considerably larger estimate than in Table 3. There is no statistically significant evidence of a difference in the response of doubly affected communes—likely due to the fact that there were only 21 such communes—though the sum of the two interaction coefficients is statistically significant.

A commune's response to the shock may also have been shaped by the network of prior migrants from that commune in the destination country (Hatton and Williamson 1998; Spitzer and Zimran 2018, 2020). In particular, more prior emigrants from a commune may have been able to support disaster victims seeking to emigrate. Indeed, Mahajan and Yang (2020) find that this is an important source of variation in response to migration rates, though our specification of the dependent variable in logarithms addresses this. Table

[77] Even still, the largely temporary nature of emigration from Italy (Bandiera, Rasul, and Viarengo 2013; Foerster 1919; Hatton and Williamson 1998) suggests that there should have been a response. Moreover, as we discuss in the main text, the effects of the Messina-Reggio Calabria earthquake were in fact long lasting.

D.2 uses the ratio of total pre-1908 migration (computed using all pre-1908 migration in the same source used to compute emigration rates) to commune population, standardized to have mean zero and standard deviation one in the sample, as x_i in estimating equation (3). Communes at the average rate of pre-earthquake migration are estimated to have a statistically insignificant decline in migration of about the same magnitude as in Table 3. The point estimate of the interaction with network status suggests that higher pre-migration emigration blunts the decline in migration after the earthquake, though again the evidence is statistically insignificant.

Finally, we examine whether there was a heterogeneous response to the earthquake on the basis of a commune's district-level employment in construction. After the earthquake, there was an increase in demand for construction labor that might have reduced the incentive for individuals in the construction industry to emigrate. Indeed, there is evidence of an increase in construction wages in the region after previous earthquakes (Caputo 1908).[78] We check for heterogeneity along this dimension in Table D.3, which estimates equation (3) using a standardized version fo the district-level 1901 share of employment in construction as x_{ip}. Indeed, there is evidence in this table of areas with a greater share of construction employment reducing emigration in response to the shock. But a concern is that this simply reflects the fact that areas with a higher construction share were likely to have less employment as agricultural day laborers—the category of interest in the main text. In fact, it appears that this is what the results of Table D.3 capture. In Table D.4, we "horse race" the two characteristics, finding evidence of heterogeneous responses among areas with different shares of labor in agricultural day labor, but not in areas of different shares in construction labor.

[78] Such a mechanism is also discussed by Yang (2008) as explanations for a decline in migration after earthquakes in El Salvador.

Table D.1: Difference-in-differences results with 1905 earthquake

	Ellis Island				Official Data	
			Prime-Age Only			
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	All	Deaths	All	Deaths	All	Deaths
Panel A: Sicily and Calabria						
Severe x Post	−0.048	−0.027	−0.073	−0.052	−0.011	0.031
	(0.177)	(0.170)	(0.173)	(0.165)	(0.061)	(0.054)
Severe x Post x Severe 1905	−0.166	−0.185	−0.124	−0.143	−0.206	−0.248[c]
	(0.161)	(0.155)	(0.172)	(0.166)	(0.132)	(0.135)
Observations	5,610	5,610	5,547	5,547	6,109	6,109
R-squared	0.753	0.753	0.742	0.742	0.611	0.610
Panel B: Italy						
Severe x Post	−0.048	−0.027	−0.073	−0.052	−0.010	0.032
	(0.177)	(0.170)	(0.173)	(0.166)	(0.064)	(0.057)
Severe x Post x Severe 1905	−0.167	−0.187	−0.125	−0.144	−0.208	−0.249[c]
	(0.162)	(0.156)	(0.174)	(0.168)	(0.143)	(0.146)
Observations	39,717	39,717	37,494	37,494	61,164	61,164
R-squared	0.798	0.798	0.794	0.794	0.772	0.772
Panel C: Sicily and Calabria (150 km)						
Severe x Post	−0.041	−0.019	−0.072	−0.050	−0.058	−0.015
	(0.156)	(0.149)	(0.158)	(0.151)	(0.089)	(0.083)
Severe x Post x Severe 1905	−0.128	−0.148	−0.078	−0.097	−0.108	−0.152
	(0.145)	(0.139)	(0.163)	(0.158)	(0.115)	(0.119)
Observations	3,528	3,528	3,490	3,490	3,928	3,928
R-squared	0.744	0.744	0.745	0.745	0.628	0.626
Panel D: Calabria (150 km)						
Severe x Post	0.036	0.048	0.007	0.018	0.098	0.119
	(0.067)	(0.064)	(0.078)	(0.075)	(0.065)	(0.075)
Severe x Post x Severe 1905	−0.168	−0.183[c]	−0.116	−0.130	−0.212	−0.243
	(0.099)	(0.098)	(0.133)	(0.131)	(0.135)	(0.149)
Observations	2,079	2,079	2,060	2,060	2,391	2,391
R-squared	0.743	0.743	0.731	0.731	0.547	0.541

Significance levels: [a] p<0.01, [b] p<0.05, [c] p<0.1

Notes: Standard errors clustered on the district level are in parentheses. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post, except in the all-Italy specifications, which include log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table D.2: Difference-in-differences results with heterogeneity by network

	Ellis Island				Official Data	
			Prime-Age Only			
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	All	Deaths	All	Deaths	All	Deaths
Panel A: Sicily and Calabria						
Severe x Post	−0.062	−0.045	−0.082	−0.065	−0.057	−0.028
	(0.136)	(0.132)	(0.134)	(0.129)	(0.090)	(0.094)
Severe x Post x Network	0.059	0.062	0.016	0.019	0.068	0.063
	(0.058)	(0.059)	(0.053)	(0.055)	(0.070)	(0.076)
Observations	5,610	5,610	5,547	5,547	6,109	6,109
R-squared	0.755	0.755	0.743	0.743	0.615	0.614
Panel B: Italy						
Severe x Post	−0.071	−0.056	−0.086	−0.071	−0.064	−0.035
	(0.143)	(0.137)	(0.146)	(0.140)	(0.087)	(0.091)
Severe x Post x Network	0.013	0.015	0.006	0.009	−0.028	−0.038
	(0.043)	(0.045)	(0.039)	(0.040)	(0.147)	(0.157)
Observations	39,643	39,643	37,441	37,441	61,164	61,164
R-squared	0.799	0.799	0.795	0.795	0.772	0.772
Panel C: Sicily and Calabria (150 km)						
Severe x Post	−0.063	−0.046	−0.083	−0.067	−0.083	−0.052
	(0.127)	(0.123)	(0.127)	(0.123)	(0.083)	(0.085)
Severe x Post x Network	0.035	0.037	−0.026	−0.024	0.074	0.069
	(0.058)	(0.059)	(0.052)	(0.053)	(0.059)	(0.065)
Observations	3,528	3,528	3,490	3,490	3,928	3,928
R-squared	0.745	0.745	0.745	0.745	0.630	0.628
Panel D: Calabria (150 km)						
Severe x Post	−0.021	−0.016	−0.053	−0.048	0.007	0.014
	(0.055)	(0.054)	(0.053)	(0.052)	(0.052)	(0.054)
Severe x Post x Network	0.019	0.019	−0.064	−0.063	0.010	0.013
	(0.037)	(0.038)	(0.041)	(0.042)	(0.077)	(0.081)
Observations	2,079	2,079	2,060	2,060	2,391	2,391
R-squared	0.742	0.742	0.731	0.731	0.546	0.540
Panel E: Sicily (150 km)						
Severe x Post	0.112	0.131	0.071	0.090	−0.063	−0.031
	(0.313)	(0.301)	(0.325)	(0.313)	(0.136)	(0.118)
Severe x Post x Network	0.020	0.016	0.026	0.021	0.252[a]	0.212[b]
	(0.120)	(0.116)	(0.142)	(0.137)	(0.062)	(0.079)
Observations	1,449	1,449	1,430	1,430	1,537	1,537
R-squared	0.748	0.749	0.752	0.752	0.689	0.689

Significance levels: [a] $p<0.01$, [b] $p<0.05$, [c] $p<0.1$

Notes: Standard errors clustered on the district level are in parentheses. Network is defined as the ratio of migrants in 1908 and earlier relative to 1901 population, and is standardized to have mean zero and standard deviation one. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-time-post, except in Panel B, where we include log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table D.3: Difference-in-differences results with share of employment in construction

	Ellis Island				Official Data	
			Prime-Age Only			
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	All	Deaths	All	Deaths	All	Deaths
Panel A: Sicily and Calabria						
Severe x Post	0.033	0.039	0.006	0.012	−0.062	−0.053
	(0.104)	(0.103)	(0.107)	(0.106)	(0.107)	(0.106)
Severe x Post x Constr Share	-0.076^{b}	-0.067^{c}	-0.087^{b}	-0.078^{b}	−0.140	−0.121
	(0.035)	(0.035)	(0.033)	(0.033)	(0.087)	(0.086)
Observations	5,592	5,592	5,531	5,531	6,109	6,109
R-squared	0.752	0.752	0.742	0.742	0.612	0.611
Panel B: Italy						
Severe x Post	−0.021	−0.009	−0.041	−0.029	−0.064	−0.038
	(0.106)	(0.106)	(0.108)	(0.107)	(0.090)	(0.089)
Severe x Post x Constr Share	-0.186^{b}	-0.164^{c}	-0.177^{b}	-0.157^{c}	−0.091	−0.038
	(0.091)	(0.093)	(0.079)	(0.080)	(0.056)	(0.051)
Observations	37,846	37,846	35,689	35,689	61,164	61,164
R-squared	0.799	0.799	0.795	0.795	0.772	0.772
Panel C: Sicily and Calabria (150 km)						
Severe x Post	0.028	0.036	−0.003	0.005	−0.084	−0.072
	(0.106)	(0.106)	(0.107)	(0.107)	(0.081)	(0.082)
Severe x Post x Constr Share	−0.057	−0.047	-0.076^{c}	−0.066	−0.111	−0.090
	(0.043)	(0.043)	(0.040)	(0.040)	(0.070)	(0.071)
Observations	3,519	3,519	3,482	3,482	3,928	3,928
R-squared	0.744	0.744	0.746	0.746	0.629	0.627

Significance levels: ^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1
Notes: Standard errors clustered on the district level are in parentheses. Constr Share is the share of a district's 1901 male labor force employed in construction, and is standardized to have mean zero and standard deviation one. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times-post, except in Panel B, where we include log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table D.4: Difference-in-differences results with share of employment in construction and agricultural day labor

	Ellis Island				Official Data	
			Prime-Age Only			
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	All	Deaths	All	Deaths	All	Deaths
Panel A: Sicily and Calabria						
Severe x Post	0.027	0.033	−0.003	0.004	−0.049	−0.039
	(0.084)	(0.083)	(0.084)	(0.082)	(0.082)	(0.079)
Severe x Post x Ag Lab Share	0.335[a]	0.337[a]	0.317[a]	0.319[a]	0.116	0.124
	(0.119)	(0.121)	(0.107)	(0.108)	(0.119)	(0.114)
Severe x Post x Constr Share	0.025	0.035	0.009	0.018	−0.110	−0.089
	(0.058)	(0.059)	(0.051)	(0.052)	(0.094)	(0.093)
Observations	5,592	5,592	5,531	5,531	6,109	6,109
R-squared	0.752	0.752	0.742	0.742	0.613	0.612
Panel B: Italy						
Severe x Post	−0.564[a]	−0.557[a]	−0.587[a]	−0.580[a]	−0.446[c]	−0.439[c]
	(0.162)	(0.166)	(0.140)	(0.144)	(0.266)	(0.254)
Severe x Post x Ag Lab Share	0.434[a]	0.438[a]	0.438[a]	0.441[a]	0.262	0.276[c]
	(0.150)	(0.153)	(0.138)	(0.140)	(0.162)	(0.156)
Severe x Post x Constr Share	−0.016	0.007	−0.012	0.009	0.012	0.071
	(0.062)	(0.065)	(0.053)	(0.056)	(0.108)	(0.102)
Observations	37,846	37,846	35,689	35,689	61,164	61,164
R-squared	0.799	0.799	0.795	0.795	0.772	0.772
Panel C: Sicily and Calabria (150 km)						
Severe x Post	0.044	0.052	0.010	0.018	−0.063	−0.051
	(0.078)	(0.077)	(0.078)	(0.077)	(0.056)	(0.056)
Severe x Post x Ag Lab Share	0.237[b]	0.238[b]	0.230[b]	0.231[b]	0.127[a]	0.131[a]
	(0.098)	(0.099)	(0.093)	(0.094)	(0.041)	(0.042)
Severe x Post x Constr Share	0.049	0.060	0.028	0.039	−0.052	−0.030
	(0.056)	(0.057)	(0.053)	(0.053)	(0.071)	(0.072)
Observations	3,519	3,519	3,482	3,482	3,928	3,928
R-squared	0.745	0.745	0.747	0.747	0.631	0.629

Significance levels: [a] p<0.01, [b] p<0.05, [c] p<0.1

Notes: Standard errors clustered on the district are in parentheses. Constr Share is the share of a district's 1901 male labor force employed in construction, and is standardized to have mean zero and standard deviation one. Ag Lab Share is the share of the 1901 male labor force in agricultural labor (giornalieri di campagna) at the district level and is standardized to have mean zero and standard deviation one. Columns (1), (3), and (5) use unadjusted populations; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include commune fixed effects, province-year indicators, and log distance from Corleone-times post, except in Panel B, where we include log distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

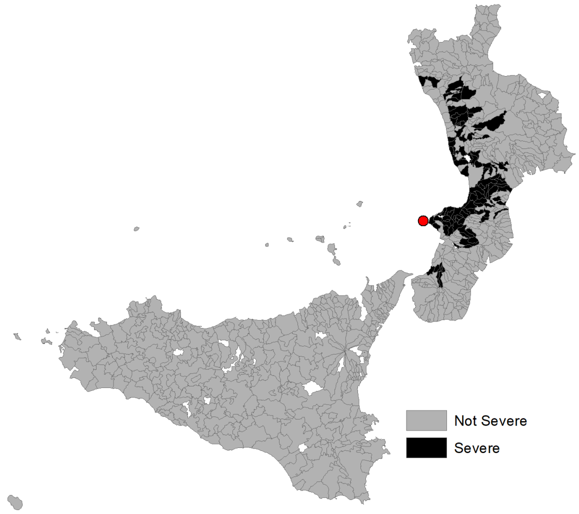


Figure D.1: Commune-level severity indicator, 1905 earthquake

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